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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL DIRECTOR

MINERAL RESOURCES

OF THE

UNITED STATES

ALBERT WILLIAMS, JR.

CHIEF OF DIVISION OF MINING STATISTICS AND TECHNOLOGY

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LETTER OF TRANSMITTAL.

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MINING STATISTICS AND TECHNOLOGY,
Washington, D. C., June 30, 1883.

SIR: I have the honor to transmit herewith a statistical report upon the present condition of the mining industries of the United States, prepared in accordance with an act passed at the first session of the Forty-seventh Congress, and under your instructions of August 5, 1882.

Very respectfully, your obedient servant,

ALBERT WILLIAMS, JR.,
Geologist-in-charge.

Hon. J. W. POWELL,
Director United States Geological Survey.

ACKNOWLEDGMENTS.

In view of the very large number of gentlemen who have directly assisted in the compilation of these statistics, or who have furnished information or have extended courtesies which have facilitated the work, it seems invidious to single out a few for personal acknowledgment. A mere mention of the names of those who have responded, often at considerable sacrifice of time and trouble, to the thousands of inquiries which have been addressed to them through the mails, would in itself occupy many pages. I desire, however, to testify to the uniform courtesy and interest displayed by miners, manufacturers, and dealers in mineral products; and also to the fact that in hardly one case in a hundred have these inquiries remained without an answer of one form or another. Special thanks are, however, due to—

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To Dr. R. W. Raymond, late United States Mining Commissioner, than whom no one is better acquainted with our mineral resources, the writer is especially indebted; as well as to many members of the American Institute of Mining Engineers, and of the State Geological Surveys, particularly those of New Jersey, Pennsylvania, and Alabama. State Commissioners and other officers have also furnished much information. Hon. Horatio C. Burchard, Director of the Mint, and Mr. Joseph Nimmo, jr., Chief of the Bureau of Statistics, have allowed free access to their material, and have kindly made original investigation of certain subjects. The Foreign Legations in this country have always responded most courteously to requests for recent mining statistics of their several Governments.

Messrs. Charles Kirchhoff, jr., editor of the *Engineering and Mining Journal*, of New York, who has had special charge of the statistics of copper, lead, and zinc; Mr. C. G. Yale, editor of the *Mining and Scientific Press*, San Francisco, who was placed in charge of the Pacific Division; and Mr. F. F. Chisolm, of Denver, who collected data for the Rocky Mountain region, have been indefatigable assistants. The material furnished by Messrs. Yale and Chisolm forms the basis of the discussion of the mining industries in their territory, and often appears without credit. Mr. Yale was largely aided by Dr. Henry DeGroot in the general collection and compilation of material, and desires to extend his special thanks to Mr. J. B. Randol, manager of the New Almaden quicksilver mine, for statistics of quicksilver production; to Messrs. Scofield and Tevis for information regarding petroleum; to Messrs. P. B. Cornwall and R. D. Chandler for statistics of coal; to Mr. John Barton, of the Union Pacific Salt Company, for data on salt; to Mr. F. E. Birge for information as to the copper industry of Arizona; and to Hon. A. J. Hatch, Surveyor-General of Nevada, for valuable matter regarding the minerals of that State.

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The names of the contributors of special technical or descriptive papers appear in connection with the articles furnished by them; and to the value of the latter the professional standing of the writers is in itself a sufficient testimony—Mr. Charles A. Ashburner, of the State Geological Survey of Pennsylvania, and Mr. F. E. Saward, editor of the *Coal Trade Journal*, on coal; Mr. James M. Swank, secretary of the American Iron and Steel Association, on iron; Mr. S. H. Stowell, editor of the *Petroleum Reporter*, on petroleum; Dr. Edward D. Peters, jr., Mr. James Douglas, jr., and Mr. J. E. Gignoux, on copper; Mr. O. H. Hahn, on lead; Mr. F. L. Clerc, on zinc; Prof. W. P. Blake, on nickel; Mr. F. W. Taylor, on cobalt; Prof. David T. Day, on manganese, chromium, and tungsten; Mr. Otto A. Moses, on phosphates; Mr. George F. Kunz, mineralogist for Tiffany & Co., on precious stones; Dr. R. W. Raymond, on the divining rod; Mr. C. O. Mailloux, on electro-metallurgy; Mr. R. L. Packard, on aluminum; Prof. F. A. Wilber, on fertilizers, marls, etc.; Mr. John A. Walker, secretary of the Dixon Crucible

Company, on graphite; Prof. Eugene A. Smith, Prof. E. W. Hilgard, Mr. M. C. Read, Mr. Ellsworth Daggett, on special topics; and Prof. John C. Smock, and Messrs. Whitman Cross, D. B. Huntley, Edward Stahl, and Joseph Perkins, compilers of the lists of occurrences of the useful minerals.

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A. W., Jr.

SUMMARY.

Coal.—The only statistics in which the trade is interested are those relating to the amount of coal which is mined for and reaches the market. There is besides a local and colliery consumption which is usually disregarded in statistics, and which ranges from 5 to 6½ per cent. on the total shipments. Of what may be called the commercial product, the quantities in 1882 were: Pennsylvania anthracite, 29,120,096 gross tons; bituminous, brown coal, lignite, and small lots of anthracite mined outside of Pennsylvania, 57,963,038 gross tons; total, 87,083,134 gross tons. The spot value of the commercial product was as follows: anthracite, $65,520,216; bituminous and other coals, $72,453,797; total, $137,974,013. During the first six months of 1883 the output was: Pennsylvania anthracite, 14,010,767 gross tons; bituminous and all other coals, 30,000,000 gross tons; total, 44,010,767 gross tons. The spot value of the commercial product during the first half of 1883 was: Pennsylvania anthracite, $31,524,226; bituminous and other coals, $37,500,000; total, $69,024,226. Including the local consumption, etc., the total product in 1882 may be stated at 92,219,454 gross tons; namely, 31,358,264 tons of Pennsylvania anthracite and 60,861,190 gross tons of other coals; and the value at the mines was: Pennsylvania anthracite, $70,556,094; bituminous coal, etc., $76,076,487; total, $146,632,581.

Iron.—The principal iron statistics for 1882 are as follows: Pig iron made, 4,623,323 gross tons; spot value, $106,336,429. Iron ore mined, 9,000,000 gross tons; spot value, $32,400,000. Domestic iron ore consumed, 8,700,000 gross tons; spot value, $31,320,000. Imported iron ore consumed, 589,655 gross tons. Total iron ore consumed, 9,289,655 gross tons. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $171,336,429. Anthracite consumed in all iron and steel works, including furnaces, 3,800,000 gross tons. Bituminous coal consumed in all iron and steel works, including furnaces, 6,600,000 gross tons. Coke consumed in all iron and steel works, including furnaces, 3,350,000 gross tons. Charcoal consumed in all iron and steel works, including furnaces, 107,000,000 bushels. Limestone consumed as flux, 3,850,000 gross tons; spot value, $2,310,000.

For the first six months of 1883 the totals are as follows: Pig iron made, 2,352,019 gross tons; spot value, $47,040,380. Iron ore mined (and consumed), 4,500,000 gross tons; spot value, $12,375,000. Imported iron ore consumed, 185,000 gross tons. Total iron ore consumed, 4,685,000 gross tons. Total spot value of all iron and steel in the first stage of manufacture, excluding all duplications, $71,000,000. Anthracite consumed in all iron and steel works, including furnaces, 1,810,000 gross tons. Bituminous coal consumed in all iron and steel works, including furnaces, 3,140,000 gross tons. Coke consumed in all iron and steel works, including furnaces, 1,780,000 gross tons. Charcoal consumed in all iron and steel works, including furnaces, 38,750,000 bushels. Limestone consumed as flux, 1,950,000 gross tons; spot value, $1,072,500.

Gold and silver.—The Mint authorities furnish the following statistics for 1882: Gold, $32,500,000; silver, $46,800,000; total, $79,300,000; or an increase of $1,600,000 over the output in 1881. For the first six months of 1883 the product is estimated at $16,250,000 gold, $23,400,000 silver, and $39,650,000 total; the rate of production being assumed to be the same as in 1882.

Petroleum.—The production of crude petroleum in the oil fields of Pennsylvania and New York in 1882 was 30,053,500 barrels of 42 gallons each, worth, at an average spot value of 78⅞ cents per barrel, $23,704,698. During the first six months of 1883 the yield was 11,291,663 barrels, worth, at an average spot value of $1.00⅛ per barrel, $11,305,778. In addition to the quantity above stated, California produced in 1882 about 70,000 barrels.

Copper.—The production of copper in 1882 was 91,646,232 pounds, worth, at an average value of 17½ cents per pound in New York, $16,038,091. For the first half of 1883 the production is estimated at 58,000,000 pounds, worth, at an average price in New York of 14.65 cents per pound, $8,500,000. The spot value of the copper at the point of production is a matter which cannot be stated with any accuracy; nor was any attempt made to ascertain the tons of copper ore mined. In 1882 3,325,000 pounds of bluestone, worth $191,187, were made; and in the first half of 1883 the manufacture of bluestone is estimated at 1,662,500 pounds, worth $95,593.

Lead.—In 1882 132,890 net tons of lead were produced, worth, at an average value of $95 per net ton on the eastern seaboard, $12,624,550. For the first half of 1883 the production is estimated at 70,000 net tons, worth, at $90 per ton, $6,300,000. In this case, as with copper, it is impossible to state the average spot value of the lead, or the tons of lead ore mined. A very large proportion of the lead ore smelted is argentiferous, and is worked for its silver contents and not for the value of the lead. In the census year ending May 31, 1880, the amount of white lead corroded was reported at 123,477,890 pounds, worth $8,770,699.

Zinc.—The production of metallic zinc in 1882 was 33,765 net tons, worth, at an average value of 5.4 cents per pound in New York, $3,646,620. The production during the first six months of 1883 is estimated at 18,000 net tons, worth, at an average value of 4⅝ cents per pound in New York, $1,665,000. In addition to the spelter and sheet zinc made in this country, there is also a large manufacture of zinc oxide made directly from the ore. As in the case of copper and lead, it is impossible to fix an average spot value for the product, and the collection of statistics of zinc ore mined has not been attempted. In the census year 1880 the amount of zinc oxide manufactured, including that made from scrap zinc, was reported at 20,121,761 pounds, worth $766,337.

Quicksilver.—In 1882 the production of quicksilver was 52,732 flasks (of 76½ pounds each = 4,033,998 pounds), worth, at an average price in San Francisco of 36⅞ cents per pound, $1,487,537. During the first six months of 1883 the production was 22,740 flasks (= 1,739,610 pounds), worth, at an average price of 35¼ cents per pound, $613,213. During the year 1882 700,000 pounds of vermilion were made in the United States, having a total value of $315,000.

Nickel.—The production of pure grain nickel in 1882 was 277,034 pounds, worth, at $1.10 per pound, $304,737. There was also a production of 50 per cent. copper-nickel alloy containing 4,582 pounds of nickel, worth $5,040. The total nickel production was therefore 281,616 pounds, worth $309,777. The only nickel reduction works in the United States were closed during the first half of 1883.

Cobalt.—The value of cobalt ores and matte for 1882 was about $15,000. The amount of cobalt oxide made was 11,653 pounds, worth $32,046.

Manganese.—The production of manganese ore in 1882 was 3,500 gross tons, and the spot value at the mines, estimated at $15 per ton, was $52,500.

Chromium.—The production of chrome iron ore in 1882 was about 2,500 net tons, worth, at an average price of $40 per ton in Baltimore, $100,000. The spot value cannot be ascertained.

Tin.—A trifling amount of tin ore was mined in 1882 and the first half of 1883, and production of metallic tin began on a small scale towards the close of the latter period.

Antimony.—The production of metallic antimony, so far as ascertained, was 60 tons in 1882, worth about $12,000.

Building stone.—It is estimated that the value of the building stone quarried in 1882 was $21,000,000.

Brick and tile.—It is estimated that the total value of the brick and tile made in the United States in 1882 was $34,000,000.

Lime.—There were 31,000,000 barrels (of 200 pounds each) made in 1882, having a total spot value of $21,700,000 at the kilns.

Cement.—The amount of artificial Portland cement made in 1882 was 85,000 barrels, worth, spot, $191,250. Of the cements manufactured from natural cement rock there were 3,165,000 barrels made, worth, spot, $3,481,500. The total production of cement was 3,250,000 barrels, worth $3,672,750.

Clays.—Complete statistics of the quantity of fire and potters' clay mined in 1882 were not obtained. The value of the whiteware made was over $5,000,000.

Precious stones.—The spot value of the precious stones found in 1882, before cutting, was between $10,000 and $15,000; after cutting, between $50,000 and $60,000.

Corundum.—It is estimated that 500 tons were mined in 1882, worth on an average only about $12.50 per ton, crude and unground; total, $6,250. The value of the ground corundum manufactured during the same year was about $135,000.

Grindstones.—The value of the grindstones made from domestic rock in 1882 is estimated by leading dealers at $700,000.

Pumice stone.—There were 70 net tons quarried in 1882, worth about $1,750.

Phosphates.—The production of washed phosphate rock in 1882 by the land mining companies of South Carolina was 191,305 gross tons; spot value, $1,147,830. By the river mining companies, 140,772 gross tons, spot value, $844,632. Total, 332,077 gross tons; spot value, $1,992,462.

Marls.—In New Jersey, 1,080,000 net tons of marl were dug in 1882. The average spot value at the pits is 50 cents per ton, making the total $540,000. There was a small yield of marls in some of the Southern States, the amount of which has not been ascertained.

Gypsum.—The most complete statistics for 1882 are those of the output of Michigan, namely, 37,821 net tons of land plaster and 135,655 barrels (of 300 pounds each) of stucco. The manufacture of plaster-of-paris on the Atlantic seaboard was 525,000 barrels (of 250 pounds each), chiefly made, however, from Nova Scotia stone. Colorado produced 10,350 sacks (of 100 pounds each). The production of California and some other States was not ascertained.

Salt.—The amount of salt made in 1882 was 6,412,373 barrels (of 280 pounds each=1,795,464,440 pounds), having a spot value of $4,320,140. During the first six months of 1883 the production is estimated at 3,206,186 barrels (=897,732,080 pounds), worth $2,160,070, the rate of production being assumed to be the same as in 1882.

Borax.—The production in 1882 was 4,236,291 pounds, having a spot value at the works of $338,903. For the first half of 1883 the output is estimated at 2,800,000 pounds, worth, spot, $224,000.

Sulphur.—Complete statistics were not obtained. The production in the census year was stated at 1,200,000 pounds, worth $21,000.

Barytes.—The amount of crude barytes mined in 1882 was 20,000 tons, worth at the point of production $160,000. The value of refined and ground barytes manufactured from the crude product above stated was about $440,000.

Mica.—The quantity of merchantable mica mined in 1882 is estimated by leading dealers at 75,000 pounds, worth $250,000. The production is rapidly increasing.

Soapstone.—The amount quarried in 1882 is estimated at 6,000 net tons, worth $90,000 at the quarries.

Quartz.—The amount of quartz mined in 1882 for glass making and abrading purposes is estimated at 75,000 net tons.

Asbestus.—Amount mined in 1882, 1,200 net tons, worth $36,000 at the point of production.

Graphite.—Amount mined in 1882, 425,000 pounds, worth, crude, at the point of production, $34,000. During the first six months of 1883 the production is estimated at 262,500 pounds, worth $21,000.

Carbonate of soda.—Over 1,600,000 pounds were produced in 1882 from native deposits.

Asphaltum.—The production in 1882 was 3,000 net tons, having a spot value of $10,500.

Alum.—No statistics. In the census year the amount of manufactured artificial alum was reported at 39,217,725 pounds, worth $808,165.

Copperas.—The amount of copperas manufactured in 1882 is estimated at 15,000,000 pounds, worth $112,500.

The production of the following-named substances was insignificant: Apatite, arsenic, bismuth, infusorial earth, iridium, lithographic stone, nitrate of soda, ozocerite, platinum, strontia.

No reliable statistics were obtained of the following substances: Buhrstones, chalk, feldspar, fluorspar, mineral paints, pyrites (for acid manufacture), sulphate of soda, talc (other than "soapstone").

None of the following substances are known to have been mined in 1882 or in the first half of 1883: Carbons, cryolite, rottenstone, wolfram.

Totals.—It is impossible to state the total mineral product in any form which shall not be open to just criticism. It is evident that the production statistics of such incongruous substances as iron ore, metallic gold and silver; the spot value of coal mined and the market value of metallic copper after having been transported hundreds of miles; the spot value of a crude substance like unground, unrefined barytes, and the value of a finished product like brick (in which the cost of manufacture is the leading item), such details cannot well be taken as items in a general summary. The statistics have been compiled with a view to giving information on those points which are of most interest and utility, and are presented in the form usual in the several branches of trade statistics. The result is that the values stated for the different products are necessarily taken at different stages of production or transportation, etc. Theoretically perfect statistics of mineral products would include first of all the actual net spot value of each substance in its crudest form, as taken from the earth; and yet for practical purposes such statistics would have little interest other than the fact that the items could be combined in a grand total in which each substance should be rated on a fairly even basis. The following groupings, therefore, are presented with a full realization of the incongruity of many of the items:

Values of the metallic products of the United States in 1882.

Pig iron, spot value	$106,336,429
Silver, coining value	46,800,000
Gold, coining value	32,500,000
Copper, value at New York City	16,038,091
Lead, value at New York City	12,624,550
Zinc, value at New York City	3,646,620
Quicksilver, value at San Francisco	1,487,537
Nickel, value at Philadelphia	309,777
Antimony, value at San Francisco	12,000
Platinum, value at New York City	1,000
Total	219,756,004

Values of some of the non-metallic products of the United States in 1882 (*all spot values, except chrome iron ore*).

Bituminous coal, brown coal, lignite, and anthracite mined outside of Pennsylvania	$76,076,487
Pennsylvania anthracite	70,556,094
Crude petroleum	23,704,698
Lime	21,700,000
Building stone	21,000,000
Salt	4,320,140
Cement	3,672,750
Limestone for iron flux	2,310,000
Phosphate rock	1,147,830
New Jersey marls	540,000
Crude borax	338,903
Mica	250,000
Crude barytes	160,000
Chrome iron ore, value at Baltimore	100,000
Soapstone	90,000
Manganese ore	52,500
Asbestus	36,000
Graphite	34,000
Sulphur	21,000
Cobalt ore and matte	15,000
Precious stones, uncut	12,500
Asphaltum	10,500
Corundum	6,250
Pumice-stone	1,750
Total	$226,156,402

Résumé of the values of the metallic and non-metallic mineral substances produced in the United States in 1882.

Metals	$219,756,004
Mineral substances named in the foregoing table	226,156,402
	445,912,406
Fire-clay, kaolin, potter's clay, common brick clay, terra-cotta, limestone used as flux in copper and lead smelting, iron ore used as flux in lead smelting, pyrites (for acid making), zinc white made directly from ore, marls (other than New Jersey), apatite, gypsum, tin ore, bismuth, arsenic, iridosmine, mill-buhrstone and stone for making grindstones, lithographic stone, talc (other than "soapstone"), quartz, feldspar, fluorspar, terra-alba, chalk, crude mineral paints, nitrate of soda, carbonate of soda, sulphate of soda, native alum, ozocerite, mineral soap, strontia, etc.—certainly not less than	8,000,000
Grand total	453,912,406

The grand total might be considerably reduced by substituting the value of the iron ore mined for that of the pig iron made; by deducting the discount on silver; and by considering lime, salt, cement, borax, etc., as manufactures. It will also be remarked that the spot values of copper, lead, zinc, and chrome iron ore are much less than their respective values after transportation to market.

MINERAL RESOURCES OF THE UNITED STATES.

ALBERT WILLIAMS, JR.,
Chief of Division of Mining Statistics and Technology.

COAL.

GENERAL VIEW OF THE COAL-MINING INDUSTRY.

Importance.—It is a somewhat trite but true statement that coal is the most important of all mineral substances in its bearing upon the material prosperity of any country, and it is none the less familiar that coal is the principal mineral product of the United States. Appropriately, therefore, the discussion of coal statistics forms the subject of the leading chapter of this report. Upon coal depends directly the great iron industry, as well as many others. The most prosperous countries are those which are the largest producers of coal, and thus the relative output and consumption form a direct standard of the relative progress of nations. In the United States the present annual production is 1.8 tons per capita, and the annual consumption is somewhat greater, notwithstanding the enormous quantities of wood and charcoal which are here used. This country is now second on the list of coal producers of the world, and it is a question of no very distant time when it shall have reached the first place in point of annual output. It possesses within its borders a larger coal-bearing territory than any other (at least with the possible exception of China, whose coal area is undetermined), and the production will no doubt continue to grow in increasing proportion. As the country fills up by immigration and by the natural increase of population there is an augmented demand for manufactured commodities of every description, and these cannot be supplied without the initial force given by coal.

Gross product and value in 1882.—The total output of coal in the United States in the calendar year 1882 may be stated at 92,219,454 tons of 2,240 pounds, of which 60,861,190 tons were bituminous coal and 31,358,264 tons were anthracite. These figures include the estimated local consumption at the collieries in the case of bituminous coal, and the complete returns of the Pennsylvania anthracite production, as given by the inspectors' reports. Taking an average of \$1.25 per ton for bituminous coal, and \$2.25 per ton for anthracite, as the value of the coal at the mines, the total spot value is found to be \$146,632,581, or nearly twice the assay value of the precious-metal output. The spot value of the bituminous coal is computed at \$76,076,487, and that of the anthracite at \$70,556,094. The actual price received for the coal was enormously greater than the total thus estimated, for the cost of transportation and handling rapidly increases the price. Reference to wholesale prices at various points, quoted on a subsequent page, will show how greatly the actual market price exceeds the original value at the point of production. In some of the Eastern States the spot value is slightly below the rates assumed in this computation, but there are many exceptions where the rates are equally in excess.

The coal which reached the market, or what is known as the commercial product, is somewhat less, and is stated in the tables on page 6, namely, 29,120,096 gross tons of anthracite, 57,963,038 gross tons of bituminous coal, and 87,083,134 gross tons total. In the coal trade the statistics of the commercial product only are taken into account.

Product in first six months of 1883.—The anthracite shipments have been as follows:

	Gross tons.	Cwts.
January	2,075,741	19
February	1,937,996	18
March	2,375,512	7
April	2,511,709	18
May	2,439,224	10
June	2,670,581	16
Total	14,010,767	8

The production of bituminous coal for the market during the same period may be safely estimated at 30,000,000 gross tons, making a total of 44,010,767 gross tons as the commercial product of the first half of 1883.

Classification of coals.—For statistical purposes it is practically impossible to draw a sharp line of demarcation between the varieties of coal. Throughout this discussion the figures relating to anthracite refer to the Pennsylvania anthracite alone; and under the head "bituminous" are grouped also the Tertiary brown coals and lignites, together with some semi-anthracite coals mined elsewhere than in Pennsylvania.

Collectors of coal statistics.—The section of statistics of bituminous coal for this report has been conducted under the personal supervision of Mr. Frederick E. Saward, the editor of the *Coal Trade Journal*, who from his long experience in the compilation of coal statistics is recognized as a leading authority upon the subject; and in the following pages the greater portion of the matter should be credited to him. Mr. Saward also furnished valuable material bearing upon the anthracite production; but in this branch of the subject, Mr. Charles A. Ashburner, geologist-in-charge of the anthracite work of the Second Geological Survey of Pennsylvania, has submitted so complete and compact a statement of the occurrences and product, that his contribution has been inserted in its entirety, and in the form in which Mr. Ashburner has prepared it. It is worth noting here that the results reached by these gentlemen agree very closely. The returns from the Rocky Mountain region and the Pacific coast are mainly due to the energetic canvass conducted by Messrs. F. F. Chisolm and C. G. Yale, respectively.

Difficulties connected with the collection of statistics.—The collection of coal statistics involves a number of difficult problems; and statisticians by using different sources of information, or by studying the same material from different points of view, have reached results considerably at variance, though the discrepancies are perhaps not so great as might have been looked for. The simplest and most obvious way of arriving at the production in many cases is to take the statistics of the transportation companies, carefully eliminating duplications of returns caused by the shipments over successive lines, and to add by estimate the local consumption and the small quantities which reach the market through unrecorded channels. A direct canvass of all the collieries and small irregular producers of the country is an almost hopeless task, requiring the expenditure of more time and money than the results can be regarded as worth, in view of the acknowledged fact that the best criterion of accuracy and completeness is the agreement or non-agreement of such returns with the already known statistics of the trade. It may also be said that direct returns from all sources can never be expected in the absence of a general and uniform system of mine inspection, and that figures collected in this way would even then have to be checked by the transportation data. Some idea of the difficulty of obtaining direct returns from the individual producers may be had by considering that in the last census the number of regular coal-mining establishments reported was 3,267, while what are known as "farmers' mines," which produce in the aggregate only about 1,000,000 tons, are in great numerical excess over the larger establishments. In the case of a few localities only, where the production is from a small number of mines, or the industry is in the hands of a central control, or where the system of mine inspection is in practical operation, is it possible to obtain satisfactory figures by the direct method.

THE COAL AREA OF THE UNITED STATES.

Arbitrary divisions.—East of the Rocky mountains the coal areas may be grouped under four principal divisions or districts, viz.:

1. The first division or district comprises the coal fields of the Appalachian mountains, covering an area of 875 miles in length, with a breadth varying from 30 to 180 miles. These fields cover large tracts of land in western Pennsylvania, eastern Ohio, the western corner of the State of Maryland, Virginia, West Virginia, and eastern Kentucky, and finally crossing into the State of Tennessee the coal fields end in the State of Alabama. The deposits of anthracite coal, situated in northeastern Pennsylvania, form the most important coal field, though the basin is not by any means the largest. Of bituminous coal, the State of Pennsylvania possesses large quantities, it being found in almost every county west of the Alleghany mountains.

2. The regions designated as comprising the second district cover land in the central part of the State of Michigan. The coal fields

spread over a large surface, but the seams are weak in many parts, and, moreover, the product leaves, here and there, much to desire in point of quality.

3. The third district stretches likewise over immense tracts of land which occupy very nearly two-thirds of the State of Illinois, in addition to an extensive portion of western Indiana and the western portion of the State of Kentucky.

4. The fourth district includes the western portion of the State of Iowa and the vast regions of Missouri. Thence it joins the coal fields of eastern Kansas and Territories of which the surveys are more or less incomplete.

5. Nebraska, Colorado, California, and Oregon have in more recent years been added as coal-producing States, as well as the Territories of Washington, Wyoming, Utah, and New Mexico. Regarding these scattered areas little definite knowledge as to their extent has yet been gained.

Total area.—To sum up, it is stated that the four first named coal-producing areas occupy 191,996½, or, in round numbers, 192,000 square miles, namely, 468½ square miles of anthracite, and 58,738 square miles of bituminous coal in the Alleghany regions, included in the first district; the second district, Michigan, is stated to comprise 6,700 square miles; and the third and fourth divisions, respectively, 43,000 and 87,000 square miles. These figures are exclusive of the important areas of the Rocky mountain and Pacific coast regions. The following areas have been reported, but are extremely doubtful: Colorado, 35,000; Montana, 60,000 (?); Wyoming, 20,000; Dakota, 100,000 (?) square miles.

The usually accepted dimensions of the coal fields which have been to more or less extent surveyed are as follows:

Area of the coal fields of the United States so far as known with any precision.

	Square miles.
New England basin	500
Pennsylvania anthracite	468½
Appalachian basin:	
Pennsylvania section	12,302
Maryland section	550
West Virginia section	16,000
Ohio section	10,000
East Kentucky section	8,983
Tennessee section	5,100
Alabama section	5,330
Michigan basin	6,700
Illinois basin:	
Illinois section	36,800
Indiana section	6,450
West Kentucky section	3,888
Missouri basin	26,887
Texas basin	4,500
Iowa	18,000
Nebraska	3,000

	Square miles.
Kansas	17,000
Arkansas	9,043
Virginia	185
North Carolina	310
Total, exclusive of the Rocky mountain and Pacific coast areas.	191,996½

THE WORLD'S COAL AREA AND OUTPUT.

To compare the present position of the United States with other countries, the following table, showing the extent of the foreign coal areas and the total output of the world in 1880 and 1881, has been compiled from various sources:

Countries.	Square miles of coal area.	Production, gross tons.	
		1880.	1881.
Great Britain	11,900	146,818,612	154,184,300
United States	*a* 192,000	65,218,585	76,679,491
Germany	1,770	52,047,832	61,540,475
France	2,086	19,412,112	19,909,057
Belgium	510	16,866,698	17,500,000
Austria	1,800	16,500,000	19,000,000
Russia	30,000	3,218,661	3,255,000
Spain	3,501	800,000	800,000
Nova Scotia	18,000	1,032,710	1,124,270
Australia	24,840	1,571,736	1,775,224
India	2,004	4,000,000	4,000,000
Japan	5,000	850,000	800,000
Vancouver's Island	390	282,128	325,000

Other reported areas: Chili, 50,000; Sweden, 90,000; Italy, 220,000; China, 4,000,000 square miles.

It should be remarked of the foregoing statement that many of the figures are doubtful estimates—as, for example, the 4,000,000 square miles of coal area in China—which is of course mere guesswork. The figures are, however, those generally accepted. Summing up these confessedly defective statistics, the following results are reached:

The world's product in 1880 .... gross tons..	328,619,074
The world's product in 1881 .... do....	360,892,817
Total coal area of the countries whose production is reported, exclusive of the unmeasured areas in the United States .... square miles..	293,801
Total coal area of the world, including the reported area of the countries which are not productive, or whose product cannot be ascertained .... square miles..	4,653,801

COAL PRODUCT OF THE UNITED STATES.

Figures of the output of bituminous coal have not been carefully collected or preserved, but in order to show the remarkably rapid growth of the coal industry in this country, the following schedule, from the best authorities obtainable, is presented:

a So far as known with any degree of certainty. This figure does not include the following doubtful estimates: Colorado, 35,000; Montana, 60,000 (?); Wyoming, 20,000; Dakota, 100,000 (?) square miles, which would raise the total to 407,000 square miles, nor the areas in California, Washington, Oregon, Arizona, New Mexico, and Utah.

Coal shipments in recent years.

[Gross tons of 2,240 pounds.]

Years.	Pennsylvania anthracite.	Bituminous and all other coals, including some small scattered lots of anthracite, mined outside of Pennsylvania.	Total.
1860	8, 513, 123	8, 000, 000	16, 513, 123
1865	9, 652, 391	8, 500, 000	18, 152, 391
1870	16, 182, 191	14, 000, 000	30, 182, 191
1875	19, 712, 472	27, 000, 000	46, 712, 472
1880	23, 437, 242	41, 781, 343	65, 218, 585
1881	28, 500, 016	48, 179, 475	76, 679, 491
1882	29, 120, 096	57, 963, 038	87, 083, 134

By the census reports of 1870, the coal produced in the States, from June 1, 1869, to June 1, 1870, was set down at 33,310,905 net tons. In the census of 1880, the tonnage for 1879–'80 was put at 71,067,576 net tons.

The total output should be at least 5 per cent. greater, if the correct returns of the coal used for steam and other purposes at and about the mines were included. As it is at present, in most cases only the shipments of coal are recorded.

Coal produced in the several States and Territories, not including the local colliery consumption.

[Gross tons of 2,240 pounds.]

States and Territories.	1880.	1881.	1882.
Pennsylvania, anthracite	23, 437, 242	28, 500, 016	29, 120, 096
Pennsylvania, bituminous	19, 000, 000	20, 000, 000	22, 000, 000
Illinois	4, 000, 000	6, 000, 000	9, 000, 000
Ohio	7, 000, 000	8, 250, 000	9, 450, 000
Maryland	2, 136, 160	2, 261, 918	1, 540, 466
Missouri	1, 500, 000	1, 750, 000	2, 000, 000
West Virginia	1, 400, 000	1, 500, 000	2, 000, 000
Indiana	1, 100, 000	1, 771, 536	1, 976, 470
Iowa	1, 600, 000	1, 750, 000	3, 500, 000
Kentucky	1, 000, 000	1, 100, 000	1, 300, 000
Tennessee	600, 000	750, 000	850, 000
Virginia	100, 000	100, 000	100, 000
Kansas	550, 000	750, 000	750, 000
Michigan	75, 000	100, 000	130, 000
Rhode Island	10, 000	10, 000	10, 000
Alabama	340, 000	375, 000	800, 000
Georgia	100, 000	150, 000	175, 000
Colorado	*a* 390, 183	*b* 631, 021	*c* 947, 749
Wyoming	275, 000	375, 000	*d* 631, 932
New Mexico	(?)	(?)	*e* 146, 421
Utah	225, 000	225, 000	250, 000
California	175, 000	125, 000	150, 000.
Oregon	30, 000	30, 000	30, 000
Washington	175, 000	175, 000	225, 000
Total	65, 218, 585	76, 679, 491	87, 083, 134

a Mr. Saward's estimate varies widely from this, being 575,000 long tons. The figure given in Fossett's "Colorado," and quoted by Mr. Chisolm, 437,005 short tons = 390,183 long tons, is confessedly under the mark; but as it is based on actual returns it is quoted here. The truth is probably between the two; but to average such discordant figures would be useless.

b As reported by Mr. Chisolm, 706,744 short tons = 631,031 long tons. Mr. Saward's estimate is 700,000 long tons.

c As compiled by Mr. Chisolm, 1,061,479 short tons = 947,749 long tons. Mr. Saward's estimate is 1,000,000 long tons.

d Actual returns, 707,764 short tons = 631,932 long tons. Mr. Saward's estimate for Wyoming is 650,000 long tons.

e Actual returns, 163,992 short tons = 146,421 long tons.

The following table is for the year ending May 31, 1880, and the quantities reported are tons of 2,000 pounds:

Census statistics of coal production of the United States.

States and Territories.	Tons produced 1870.	Tons produced 1880.	Number of collieries.	Men employed.		Capital invested.
				Miners.	Laborers.	
Alabama	11, 000	323, 972	19	772	667	$772, 858
Arkansas	....	14, 778	14	total men.	130	15, 600
California	....	236, 950	6	478	255	1, 239, 431
Colorado	....	462, 747	25	1, 133	227	5, 939, 250
Georgia	....	154, 644	2	185	237	441, 745
Illinois	2, 624, 163	6, 115, 377	590	12, 233	3, 204	10, 654, 261
Indiana	437, 870	1, 454, 327	216	2, 214	2, 212	2 304, 720
Iowa	263, 487	1, 461, 116	227	3, 797	958	2, 778, 937
Kansas	150, 582	771, 142	189	total men.	3, 617	767, 994
Kentucky	32, 938	946, 288	65	1, 960	709	1, 968, 537
Maryland	2, 345, 153	2, 228, 917	32	2, 797	805	13, 165, 557
Michigan	28, 150	100, 800	6	total men.	412	66, 800
Missouri	621, 930	556, 304	144	total men.	2, 599	389, 315
Montana	....	224	1	3	....	13, 550
Nebraska	1, 425	200	1	total men.	5	500
North Carolina	....	350	1	1	2	40, 170
Ohio	2, 527, 285	6, 008, 595	618	12, 123	3, 497	13, 652, 484
Oregon	....	43, 205	3	52	21	226, 523
Pennsylvania anthracite	15, 648, 437	28, 640, 819	275	20, 333	49, 049	154, 399, 796
Pennsylvania bituminous	7, 800, 386	18, 425, 163	666	total men.	33, 348	38. 709, 314
Rhode Island anthracite	14, 000	6, 176	1	13	18	27, 500
Tennessee	133, 418	495, 131	20	680	368	1, 708, 968
Virginia anthracite	....	2, 817	1	18	24	77, 040
Virginia bituminous	61, 803	43, 079	4	80	161	329, 000
Washington	....	145, 015	5	103	44	335, 421
West Virginia	608, 878	1, 839, 845	129	total men.	4, 497	5, 750, 674
Wyoming	....	589, 595	6	830	159	726, 398
Total	33, 310, 905	71, 067, 576	3, 266	49, 805	107, 225	256, 502, 373
Anthracite coal	15, 662, 437	28, 649, 812	....	....	....	....
Bituminous coal	17, 648, 468	42, 417, 764	....	....	....	....

ANTHRACITE.

DESCRIPTION AND PRODUCTION OF THE ANTHRACITE COAL FIELDS OF PENNSYLVANIA.

BY CHAS. A. ASHBURNER.

Anthracite counties.—The anthracite coal fields of Pennsylvania are contained in the following counties: Susquehanna, Wayne, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Northumberland, Dauphin, and Lebanon. Sullivan county contains the Loyalsock coal field, which produces anthracite different in its character from that contained in the other counties. A very small area is contained in the counties of Susquehanna, Wayne, and Lebanon, and from the latter two no coal is at present produced.

The main fields.—The region, exclusive of the Loyalsock basin (*a*), is divided into the following fields:

a The Anthracite Survey has not, as yet, made any examination of the Loyalsock basin; it has been included in the anthracite region on the basis of Mr. Franklin Platt's report (GG) on Sullivan county. The area of this basin is not known.

		Square miles.
Northern coal field		198
Eastern middle or Lehigh coal field		37
Western middle coal field		91
Southern coal field:		
Exclusive of Panther Creek basin	130	142.5
Panther Creek basin	12.5	
Total area		468.5

The areas assigned to the different fields are those which are at present generally accepted. The area of the Panther Creek basin is the only one which has as yet been measured by the State Geological Survey.

Northern field.—The northern field is contained, with the exception of the extreme northeastern end, in the counties of Lackawanna and Luzerne. The northeastern half, drained by the Lackawanna river, is generally known as the Lackawanna basin, and the southwestern half, through which the North Branch of the Susquehanna river flows, is known as the Wyoming basin.

The general geological structure of this field is that of a broad synclinal with comparatively low dips. The deepest part of the field is in the southwestern end, where the red ash coal bed, which is the lowest bed which has been proved here of workable thickness, occurs about 1,100 feet vertically below the surface.

In the vicinity of Carbondale there are 300 feet of Coal Measures, containing six individual coal beds, with an aggregate thickness of 26 feet. At Scranton, further to the southwest, the Coal Measures are 700 feet thick and contain eleven coal beds with an aggregate thickness of 72 feet. In the vicinity of Wilkes Barre there are 1,000 feet of Coal Measures, containing thirteen coal beds having an aggregate thickness of 94 feet, and near Nanticoke, over 1,000 feet of Coal Measures, with fifteen beds aggregating 102 feet in thickness.

The coal-bed thicknesses include slate and bony coal, which are intercalated with the different coal benches of the individual beds, so that the thickness assigned to the beds does not represent the actual thickness of coal which can be mined and sent to market. The individual beds vary so much in thickness within limited areas that it is difficult to assign an average thickness to any one without a more extended survey of the entire field than that which has at present been made by the State Survey. This remark applies equally to all the coal fields. For instance, in the representative section of the Panther Creek basin published by the Survey, there is shown a total thickness of coal beds of 126 feet, contained in twenty-one different beds. At one point in the Panther Creek basin, in the vicinity of the old Summit Hill mines, the Mammoth bed alone measures 114 feet, with 106 feet of coal. The northern field since 1829 has produced about 212,805,000 tons, which is 42 per cent. of the total production of the entire field to the end of 1882.

Lehigh field.—The eastern middle or Lehigh coal field is contained mostly in the southern part of Luzerne and northern part of Carbon counties. The principal basins contained in it are the upper Lehigh, Black creek, West Cross creek, Hazleton, and Beaver Meadow basins. They are narrow and comparatively shallow as compared with the other anthracite basins. The deepest parts of the Black Creek and West Cross Creek basins contain about 500 feet of Coal Measures above the lowest bed, with about 75 feet of coal divided into eight different beds.

The Hazleton basin contains about 700 feet of strata above the lowest coal bed, and there are about the same number of beds with an average thickness possibly a little greater than in the former basin. At one point in the Black Creek basin the Mammoth bed is between 60 and 90 feet thick over a large area, where the coal bed is quarried. The Lehigh basins, including the Panther Creek basin in the eastern end of the southern coal field, have produced up to the end of 1882 about 96,764,000 tons, or 19 per cent. of the total production of the field.

Western middle field.—The western middle coal field is contained in the counties of Schuylkill, Columbia, and Northumberland. The geological structure of this field is somewhat different from that of either the northern or the Lehigh fields. Although the outline of the bottom of the Coal Measures is continuous around the entire field, as it is in the northern field, yet it is broken up into a number of independent basins by prominent anticlinals, like the Lehigh field, but which do not separate the district into isolated areas underlaid by the Coal Measures as in the Lehigh. The dip of the coal in this field is generally much greater than in the northern field, while it may be considered to be nearly the same as the average dip of the Lehigh field. In the eastern half of this district there is a thickness of about 1,000 feet of Coal Measures over the Buck mountain, which is the lowest bed exploited and which probably corresponds to the red ash bed of the northern field. The total average thickness of all the coal beds here is probably about 110 feet, divided into thirteen individual beds. In the vicinity of Shenandoah the Mammoth bed measures over 100 feet in thickness. In the western half of this field there is a thickness of about 1,600 feet of Coal Measures above the Lower Lykens valley bed, which may probably here prove workable (*a*).

There is here an average thickness of about 120 feet of coal contained in sixteen different beds.

Southern field.—The southern coal field lies in the counties of Carbon, Schuylkill, and Dauphin, with a small area in Lebanon. The eastern end of the field, between the Lehigh and the Little Schuylkill rivers, is known as the Panther Creek basin, and has always been included in the Lehigh field, from the fact that most of the coal which has been mined from it has been shipped down the Lehigh river. That portion of the field west of the Little Schuylkill river is generally known as the Schuylkill coal field. More recently the same name has been applied to the western middle field, although not half of this latter field lies in Schuylkill county. The bulk of the coal, however, which is mined from it, has been shipped through the Schuylkill valley. The

a The Lower Lykens valley bed lies 219 feet below the Buck mountain.

deepest basins in the region are contained in this field. In many cases the individual basins are no broader than those of the western middle or eastern middle fields; consequently the highest dips are found in the southern field. At Tamaqua, which is on the Little Schuylkill river near the eastern end of the field, there is a thickness of Coal Measures of 2,300 feet, which contain twenty-one coal beds with an aggregate thickness of 126 feet, although, as has been stated, one of the beds, the Mammoth, is 114 feet thick, a short distance east of Tamaqua. In the vicinity of Pottsville there are about 3,300 feet of Coal Measures, which contain twenty-eight individual beds, with an aggregate average thickness of 154 feet. The western middle and southern coal fields, exclusive of the Panther Creek basin, which has been included in the Lehigh field, have together produced 199,806,000 tons up to the end of 1882, or 39 per cent. of the total production of the entire region.

Thickness of the Coal Measures.—The aggregate thickness assigned to the Coal Measures in the northern field is that determined near the center of the basin, where the strata are frequently nearly horizontal for several hundred feet, so that the thickness of the strata represents the depth of the coal basin. In the other three fields, however, on account of the steepness of the dip of the strata and the sharpness of the bottom of the basins, their depth is much greater than the thickness assigned to the strata. For instance, at Tamaqua, which may be considered a fair illustration, there are 2,300 feet of Coal Measures above the lowest coal bed; this bed, however, in the center of the Tamaqua basin, is 2,800 feet vertically below the surface of the ground.

Consumption and reserves of coal.—A number of estimates have been made as to the total contents of the anthracite basins, and their probable life. These have been based upon very general, and in many cases questionable, data, so that nothing is certainly known, from a systematic examination of the entire region, as to what the total contents are. Estimates will however be made by the State Geological Survey before the completion of the work. They have already been completed for the Panther Creek basin, whose area, as has been already noted, is 12.5 square miles.

This basin originally contained 1,032,957,000 gross tons. The area which had been exhausted, and was under exploitation, at the end of 1882, originally contained 92,189,000 tons. Out of this area there have been taken 54,116,000 tons. My report of progress (*a*) of the survey in this basin will show the distribution of the coal mined out, or that which was shipped to market as fuel, that which was consumed at the collieries, and that which was thrown on the culm banks as waste, either from containing too much bone or slate, or from being too fine to burn. The amount of coal which still remains in this basin is divided into vertical zones of 500 feet. This has been done in order to show how much coal can probably be mined in different parts of the basin by shafts driven

a The statistical tables to follow will be published in Mr. Ashburner's first report of progress of the anthracite survey, Vol. I., southern coal field, Panther Creek basin.

to different depths. This same system will be carried out over the entire region.

Chronology of the anthracite industry.—The most important historical events connected with the development of the anthracite coal fields may be noted as follows:

1820. Lehigh Coal and Navigation Company began mining and shipping coal from Summit Hill region. Canal opened Mauch Chunk to Easton, 1829. White Haven to Mauch Chunk, 1837.

1825. Schuylkill canal was completed from Mount Carbon to Philadelphia.

1829. Delaware and Hudson Canal Company began transporting coal from Carbondale region.

1831. Nesquehoning railroad and plane built.

1831. Morris canal opened Philipsburgh to Newark; opened to Jersey City, 1836. Leased by Lehigh Valley Railroad Company, 1872.

1832. Little Schuylkill Railroad began transporting coal from Tamaqua region.

1833. Shamokin Division, Northern Central Railway, originally opened. Reorganized 1851. Leased to Northern Central Railway, 1863.

1833. Delaware Division Pennsylvania canal opened.

1834. Wyoming and State canals opened.

1835. First geological survey of the anthracite coal fields commenced.

1837. Shipments of coal began from Beaver Meadow region.

1837. Shipments of coal began from Pine Grove via Union canal.

1837. Morris and Essex railroad opened. Leased to Delaware, Lackawanna, and Western Railroad Company, 1869.

1838. Shipments of coal began from Hazleton region.

1839. Summit Branch railroad opened. Leased to Summit Branch Railroad Company, 1866.

1839. Shipments of coal began from Shamokin region westward.

1839. Shipments of coal began from Lykens Valley region westward.

1840. Shipments of coal began from Buck mountain region.

1840. Quakake railroad opened. Extended and opened to Mount Carmel, 1862.

1841. First geological survey of the anthracite coal fields completed.

1842. Philadelphia and Reading Railroad Company began transporting coal through to Port Richmond.

1846. Shipments of coal began from Wilkes-Barre region via Lackawanna and Summit railroad planes, and Lehigh canal.

1850. Pennsylvania Coal Company began business.

1852. Central Railroad of New Jersey, opened from Elizabeth to Easton. Third rail from Hampton Junction laid 1856.

1854. Delaware, Lackawanna, and Western Railroad Company began mining and shipping coal.

1855. Lehigh Valley Railroad Company began transporting coal to Philipsburgh. Opened to Perth Amboy in 1875.

1856. Trevorton Railroad opened.

1857. Belvidere Delaware Railroad Company began transporting coal.

1857. North Pennsylvania railroad opened. Leased to Philadelphia and Reading Railroad Company May 1, 1879.

1858. Lackawanna and Bloomsburgh railroad opened. Leased to Delaware, Lackawanna, and Western Railroad Company, 1873.

1858. Mining began in McCauley Mountain region.

1868. Lehigh and Susquehanna railroad opened to Philipsburgh. Leased to Central Railroad Company of New Jersey, 1871.

1869. Pennsylvania and New York railroad opened to Waverly.

1870. Sunbury, Hazleton, and Wilkes-Barre railroad opened. Leased to Pennsylvania Railroad Company, 1878.

1871. Erie Railway Company began mining and shipping coal.
1872. Nesquehoning Valley railroad and tunnel into Panther Creek basin opened.
1873. Philadelphia and Reading Coal and Iron Company began mining and shipping coal.
1874. Lehigh and Wilkes-Barre Coal Company began operations.
1879. Philadelphia and Reading Railroad Company leased Delaware and Bound Brook railroad, May 1.
1880. Second geological survey of the anthracite coal fields commenced August.

Production.—A number of statistical tables have been prepared by different authorities to show the past production of the anthracite region; the one which I have adopted for the use of the State Geological Survey, and which has been published in the Panther Creek Atlas to accompany Vol. I. (AA), Southern Coal Field Report, has been compiled by Mr. P. W. Sheafer for the years 1820 to 1868, inclusive, and since 1868 by Mr. John H. Jones, accountant of the anthracite transporting companies. This table, published below, does not include the coal sold to the local trade and consumed for fuel at the collieries. This amount in the past has been variously estimated to be from 8 to 10 per cent. of the total tonnage reported as shipped to market. At the present time it would seem to range from 5 to 6½ per cent. in the different parts of the region. Although the amount of coal burned within the region has increased from year to year, yet the percentage of the total amount mined, which has been so used, has unquestionably diminished at the same time. The statistics of Messrs. Sheafer and Jones show that up to the end of 1881 there had been shipped from the region 438,580,394 tons; if to this 9 per cent. be added for local consumption and colliery fuel, the total production up to 1882 would amount to 478,052,629 tons. The production reported by the mine inspectors for 1882 is 31,281,066 tons; so that the total output of the anthracite mines to January 1, 1883, has been 509,333,695 tons (*a*).

It is difficult to appreciate this enormous tonnage. Assuming that a ton of coal, of 2,240 pounds in the bed, contains on an average over the entire region 25 (*b*) cubic feet, 509,333,695 tons would form a solid wall of coal 100 feet wide and 100 feet high for a distance of about 241 miles, or it would form a solid wall along the line of the Pennsylvania railroad between Philadelphia and New York 100 feet wide and 268 feet high.

The amount of coal which still remains to be mined has been vari-

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a This does not include the production of the Loyalsock basin, which is given in a later table, and which has produced in the aggregate 491,020 tons.

b An average ton of coal made up of the different sizes as it is sent to market contains about 40 cubic feet. The average specific gravity of the coal shipped from the Panther Creek basin as determined from a number of specimens collected from different parts of the basin is 1.6307, which makes 101.64 pounds in one cubic foot of coal, or 22.038 cubic feet in one ton (2,240 pounds), or 1,976.586 tons in one acre of coal one foot thick. I have used 25 cubic feet in the above calculation, since that is the number generally accepted, and as the coal in the western part of the region is considered to be of lower specific gravity than in the eastern part (Panther Creek basin), where the State Geological Survey has only as yet made such determinations.

ously estimated, but all the estimates have been based upon insufficient facts, and until the completion of the State survey little can be certainly known. I have roughly estimated, however, that the region originally contained about 25,000,000,000 tons. This is between the extreme estimates which have been made.

Shipments of coal from the anthracite fields of Pennsylvania from 1820 to 1882, inclusive, with the amount and percentage of the total shipped from each region.

Schuylkill region.			Lehigh region.		Wyoming region.		Total.	
Years.	Tonnage.	Per cent.	Tonnage.	Per cent.	Tonnage.	Per cent.	Tons.	Years.
1820	....	....	365	....	....	....	365	1820
1821	....	....	1,073	....	....	....	1,073	1821
1822	1,480	39.79	2,240	60.21	....	....	3,720	1822
1823	1,128	16.23	5,823	83.77	....	....	6,951	1823
1824	1,567	14.10	9,541	85.90	....	....	11,108	1824
1825	6,500	18.60	28,393	81.40	....	....	34,893	1825
1826	16,767	34.90	31,280	65.10	....	....	48,047	1826
1827	31,360	49.44	32,074	50.56	....	....	63.434	1827
1828	47,284	61 00	30,232	39.00	....	....	77,516	1828
1829	79,973	71.35	25,110	22.40	7,000	6.25	112,083	1829
1830	89,984	51.50	41,750	23.90	43,000	24.60	174,734	1830
1831	81,854	46.29	40,966	23.17	54,000	30.54	176,820	1831
1832	209,271	57.61	70,000	19.27	84,000	23.12	363,271	1832
1833	252,971	51.87	123,001	25.22	111,777	22.91	487,749	1833
1834	226,692	60.19	106,244	28.21	43,700	11.60	376,636	1834
1835	339,508	60.54	131,250	23.41	90,000	16.05	560,758	1835
1836	432,045	63.16	148,211	21.66	103,861	15.18	684,117	1836
1837	530,152	60.98	223,902	25.75	115,387	13.27	869,441	1837
1838	446,875	60.49	213,615	28.92	78,207	10.59	738,697	1838
1839	475,077	58.05	221,025	27.01	122,300	14.94	818,402	1839
1840	490,596	56.75	225,313	26.07	148,470	17.18	864,379	1840
1841	624,466	65.07	143,037	14.90	192,270	20.03	959,773	1841
1842	583,273	52.62	272,540	24.59	252,599	22.79	1,108,412	1842
1843	710,200	56.21	267,793	21.19	285,605	22.60	1,263,598	1843
1844	887,937	54.45	377,002	23.12	365,911	22.43	1,630,850	1844
1845	1,131,724	56.22	439,453	21.33	451,836	22.45	2,013,013	1845
1846	1,308,500	55.82	517,116	22.07	518,389	22.11	2,344,005	1846
1847	1,665,735	57.79	633,507	21.98	583,067	20.23	2,882,309	1847
1848	1,733,721	56.12	670,321	21.70	685,196	22.18	3,089,238	1848
1849	1,728,500	53.30	781.556	24.10	732,910	22.60	3,242,966	1849
1850	1,840,620	54.80	690,456	20.56	827,823	24.64	3,358,899	1850
1851	2,328,525	52.34	964,224	21.68	1,156,167	25.98	4,448,916	1851
1852	2,636,835	52.81	1,072,136	21.47	1,284,500	25.72	4,993,471	1852
1853	2,665,110	51.30	1,054,309	20.29	1,475,732	28.41	5,195,151	1853
1854	3,191,670	53.14	1,207,186	20.13	1,603,478	26.73	6.002,334	1854
1855	3,552,943	53.77	1,284,113	19.43	1,771,511	26.80	6,608,567	1855
1856	3,603,029	52.91	1,351,970	19.52	1,972,581	28.47	6,927,580	1856
1857	3,373,797	50.77	1,318,541	19.84	1,952,603	29.39	6,644,941	1857
1858	3,273,245	47.86	1,380,030	20.18	2,186,094	31.96	6,839,369	1858
1859	3,448,708	44.16	1,628,311	20.86	2,731,236	34.98	7,808,255	1859
1860	3,749 632	44.04	1,821,674	21.40	2,941,817	34.56	8,513,123	1860
1861	3,160,747	39.74	1,738,377	21.85	3,055,140	38.41	7,954,264	1861
1862	3,372,583	42.86	1,351,054	17.17	3,145,770	39.97	7,869,407	1862
1863	3,911,683	40.90	1,894,713	19.80	3,759,610	39.30	9,566,006	1863
1864	4,161,970	40.89	2,054,669	20.19	3,960,836	38.92	10,177,475	1864
1865	4,356,959	45.14	2,040,913	21.14	3,254,519	33.72	9,652,391	1865
1866	5,787,902	45.56	2,179,364	17.15	4,736.616	37.29	12,703,882	1866
1867	5,161,671	39.74	2.502,054	19.27	5,325,000	40.99	12,988,725	1867
1868	5,330,737	38.62	2,502,582	18.13	5,968,146	43.25	13,801,465	1868
1869	5,775,138	41.66	1,949,673	14.06	6,141,369	44.28	13,866,180	1869
1870	4,968,157	30.70	3,239,374	20.02	7,974,660	49.28	16,182,191	1870
1871	6,552,772	41.74	2,235,707	14.24	6,911,242	44.02	15,699,721	1871
1872	6,694,890	34.03	3,873,339	19.70	9,101,549	46.27	19,669,778	1872
1873	7,212,601	33.97	3,705,596	17.46	10,309,755	48.57	21,227,952	1873
1874	6,866,877	34.09	3,773,836	18.73	9,504,408	47.18	20,145,121	1874
1875	6,281,712	31.87	2,834,605	14.38	10,596,155	53.75	19,712,472	1875
1876	6,221,934	33.63	3,854,919	20.84	8,424,158	45.53	18,501,011	1876
1877	8,195,042	39.35	4,332,760	20.80	8,300,377	39.85	20,828,179	1877
1878	6,282,226	35.68	3,237,449	18.40	8,085,587	45.92	17,605,262	1878
1879	8,960,829	34.28	4,595,567	17.58	12,586,293	48.14	26,142,689	1879
1880	7,554,742	32.23	4,463,221	19.05	11,419,279	48.72	23,437,242	1880
1881	9,253,958	32.46	5,294,676	18.58	13,951,383	48.96	28,500,017	1881
1882	9,459,288	32.48	5,689,437	19.54	13,971,371	47.98	29,120,096	1882
Total	183,323,672	39.19	88,920,568	19.01	195,456,250	41.80	467,700,490	

The Schuylkill region includes the western middle coal field and that portion of the southern coal field west of Tamaqua. The Lehigh region includes the eastern middle coal field and that portion of the southern coal field east of Tamaqua, known as the Panther Creek basin. The Wyoming region includes the Wyoming and Lackawanna basins, which together form the northern coal field.

Shipments of coal from the anthracite coal fields of Pennsylvania, arranged in periods of ten years, from 1820 to 1882, inclusive.

Years.	Schuylkill region.	Lehigh region.	Wyoming region.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1820 to 1830	276, 043	207, 881	50, 000	533, 924
1831 to 1840	3, 485, 041	1, 503, 527	951, 702	5, 940, 270
1841 to 1850	12, 214, 676	4, 782, 781	4, 895, 606	21, 893, 063
1851 to 1860	31, 823, 494	13, 082, 494	19, 075, 719	63, 981, 707
1861 to 1870	45, 987, 547	21, 452, 773	47, 321, 666	114, 761, 986
1871 to 1880	70, 823, 625	36, 906, 999	95, 238, 803	202, 969, 427
1881 and 1882	18, 713, 246	10, 984, 113	27, 922, 754	57, 620, 113
Grand total	183, 323, 672	88, 920, 568	195, 456, 250	467, 700, 490

Anthracite coal tonnage of the different transportation companies for the years named.

[Compiled upon the basis of distribution established by the Anthracite Board of Control for 1878, by Mr. John H. Jones.]

	1870.	1871.	1872.	1873.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Philadelphia and Reading Railroad Company	4, 169, 707	5, 330, 863	5, 645, 103	5, 868, 848
Lehigh Valley Railroad Company	3, 608, 587	2, 880, 263	3, 850, 118	4, 121, 734
Central Railroad Company of New Jersey	1, 606, 469	1, 985, 550	2, 253, 614	2, 698, 119
Delaware, Lackawanna, and Western Railroad Company	2, 117, 612	1, 730, 242	2, 520, 330	2, 952, 941
Delaware and Hudson Canal Company	2, 318, 073	1, 955, 737	2, 882, 479	2, 732, 267
Pennsylvania Railroad Company	1, 225, 733	912, 835	1, 168, 084	1, 519, 711
Pennsylvania Coal Company	1, 136, 010	848, 635	1, 266, 762	1, 297, 604
New York, Lake Erie, and Western Railroad	....	55, 596	83, 288	36, 728
Total	16, 182, 191	15, 699, 721	19, 669, 778	21, 227, 952

	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Philadelphia and Reading Railroad Company	5, 568, 601	4, 782, 311	4, 931, 754	6, 842, 105
Lehigh Valley Railroad Company	3, 989, 821	3, 285, 225	3, 985, 351	4, 447, 881
Central Railroad Company of New Jersey	2, 706, 007	2, 465, 902	2, 778, 096	2, 837, 500
Delaware, Lackawanna, and Western Railroad Company	2, 353, 539	2, 833, 670	1, 998, 654	2, 089, 523
Delaware and Hudson Canal Company	2, 290, 791	2, 843, 229	1, 809, 190	1, 787, 470
Pennsylvania Railroad Company	1, 642, 474	1, 772, 719	1, 623, 335	1, 530, 594
Pennsylvania Coal Company	1, 396, 326	1, 426, 377	1, 143, 922	1, 118, 011
New York, Lake Erie, and Western Railroad	197, 562	303, 039	230, 709	175, 095
Total	20, 145, 121	19, 712, 472	18, 501, 011	20, 828, 179

Anthracite coal tonnage of the different transportation companies, etc—Continued.

	1878.	1879.	1880.	1881.	1882.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Philadelphia and Reading Railroad Company	5,112,219	7,442,617	5,933,923	6,940,283	7,000,113
Lehigh Valley Railroad Company	3,403,318	4,405,958	4,394,533	5,721,870	5,933,740
Central Railroad Company of New Jersey	2,264,979	3,825,553	3,470,141	4,085,424	4,211,052
Delaware, Lackawanna, and Western Railroad Company	2,180,673	3,867,405	3,550,348	4,388,970	4,638,717
Delaware and Hudson Canal Company	2,046,235	3,014,117	2,674,705	3,211,496	3,203,168
Pennsylvania Railroad Company	1,362,674	1,682,106	1,864,032	2,211,363	2,332,974
Pennsylvania Coal Company	957,032	1,427,150	1,138,466	1,475,380	1,469,821
New York, Lake Erie, and Western Railroad	278,132	477,783	411,094	465,230	330,511
Total	17,605,262	26,142,689	23,437,242	28,500,016	29,120,096

Production of the Loyalsock field, Sullivan county.

	Gross tons.
1871	23,122
1872	51,527
1873	32,058
1874	36,268
1875	16,522
1876	30,000
1877	23,000
1878	37,000
1879	50,000
1880	50,000
1881	64,325
1882	77,198
Total	491,020

The collieries.—The following table gives a list of the working collieries reported by the mine inspectors, with their location, name of operator during 1882, and total production (*a*) in tons during the years 1881 and 1882, respectively. The different fields have been variously divided into smaller districts, although the work of the State Geological Survey has not progressed sufficiently far to enable me to propose any final subdivision of the different fields. The division of the field, which has been provisionally accepted by the State Survey, is that proposed more particularly for the convenience of the coal trade by Mr. John H. Jones.

a The tonnage reported from the collieries in the first, second, and third Schuylkill districts and the eastern Carbon and Luzerne district, all of which are marked by the numbers 1, 2, 3, or 5, has been reported as the shipment and not the production. In these districts the local and colliery consumption has been taken to be 6 per cent. of the shipment, so that in order to obtain the total production of each colliery 6 per cent. must be added. This has not been done in the table for the reason that the figures as they are reported agree with the official records, and it is desirable that they should be published here in that form. In the table giving the total production and shipment from the mine inspectors' districts 6 per cent. has been added to the total shipment of these four districts, Nos. 1, 2, 3, and 5, to obtain the total production. The colliery and local consumption of the eastern Carbon and Luzerne district in 1881 amounted to 5½ per cent. instead of 6 per cent., as reported for 1882.

Production by collieries.

1.—CARBONDALE DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
5	Filer Nos. 1 and 2	Winton borough	Filer & Levy	132, 720	87, 418
5	Pierce	Archbald borough	John Hosie & Son	130, 000	129, 706
5	Eaton	do	Jones, Simpson & Co.	108, 193	102, 911
5	Jermyn No. 1 shaft	Jermyn borough	Delaware and Hudson Canal Company.	118, 481	115, 953
5	Jermyn Slope	do	do	34, 480	57, 701
5	Erie	Glenwood borough	Hillside Coal and Iron Company.	79, 411	92, 437
5	Keystone Tunnel	do	do		663
5	Belmont	Carbondale	Cowan & Daning	4, 856	56, 671
5	Elk Creek	Fell township	Brennan & Bridget	17, 838	(*a*) 788
5	Forest City	Clifford township	Susquehanna Coal Company. Hillside Coal and Iron Company.	19, 856	14, 465
5	Olyphant No. 2	Olyphant borough	Delaware and Hudson Canal Company.	105, 239	93, 264
5	Grassy Island	do	do	142, 282	119, 612
5	White Oak	Archbald borough	do	123, 480	109, 132
5	Carbondale No. 1 Shaft.	Carbondale	do	25, 923	33, 631
5	Carbondale No. 3 Shaft.	do	do	6, 182	4, 572
5	Coal Brook	do	do	220, 639	187, 900
5	Racket Brook	Carbondale township	do	175, 339	157, 225
				1, 444, 919	1, 364, 049

a Burned.

2.—SCRANTON DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
5	National	Lackawanna township.	William Connell & Co.	124, 004	121, 682
5	Meadow Brook	Scranton, twentieth ward.	do	116, 431	123, 979
5	Bridge	Scranton, fourteenth ward.	Bridge Coal Company	56, 700	68, 585
5	Mount Pleasant	Scranton, fourteenth ward.	William T. Smith	123, 716	126, 926
5	Capouse	Scranton, twenty-first ward.	Lackawanna Iron and Coal Company.	276, 840	326, 340
5	Pine Brook	Scranton, seventh ward.	do	13, 481	14, 223
5	Fairlawn	Scranton, seventh ward.	Fairlawn Coal Company	53, 056	38, 633
5	Jermyn Ridge No. 3 / Jermyn's Green / Jermyn No. 3 Shaft	Scranton, thirteenth ward.	*b* Delaware, Lackawanna, and Western Railroad Company, and Delaware and Hudson Canal Company.	181, 514	91, 500 / 91, 158
5	Green Ridge	Dunmore	O. S. Johnson & Co.	186, 831	151, 511
5	Roaring Brook	do	Edward Spencer & Son	90, 000	Local sales.
5	Elk Hill	Dickson City borough.	Elk Hill Coal and Iron Company.	50, 107	55, 963
5	Shaft No. 2	Dunmore	Pennsylvania Coal Company.	53, 407	55, 701
5	Gypsy Grove, Nos. 3 and 4 Shafts.	do	do	113, 596	117, 662
5	Pyne	Lackawanna township.	Delaware, Lackawanna, and Western Railroad Company.	167, 667	181, 082
5	Taylor	do	do	149, 358	153, 846
5	Archibald	do	do	79, 565	99, 638
5	Sloan	do	do	119, 126	100, 243
5	Continental	do	do	48, 213	149, 878

b Jermyn's Green Ridge in list for 1881 is the same as Jermyn No. 3, and Jermyn No. 3 Shaft in list for 1882. This colliery was worked in 1882 during alternate months by the operating companies named.

Production by collieries—Continued.

2.—SCRANTON DISTRICT—Continued.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
5	Hampton	Lackawanna township.	Delaware, Lackawanna, and Western Railroad Company.	190, 471	172, 282
5	Bellevue	....do	......do	165, 486	160, 729
5	Scranton Slope	....do	......do	....	36, 193
5	Dodge	....do	......do	140, 917	137, 515
5	Central	Scranton, fifteenth ward.	......do	138, 769	172, 110
5	Hyde Park	Scranton, fifth ward.	......do	142, 670	118, 950
5	Diamond Shaft No. 2	Scranton, twenty-first ward.	......do	181, 224	152, 974
5	Diamond Slope No. 2	Scranton, twenty-first ward.	......do	81, 401	71, 013
5	Diamond Tripp Slope.	Scranton, twenty-first ward.	......do	69, 017	67, 948
5	Brisbin	Scranton, twenty-first ward.	......do	145, 251	122, 374
5	Cayuga	Scranton, third ward.	......do	107, 014	109, 923
5	Von Storch	Scranton, second ward.	Delaware and Hudson Canal Company.	237, 756	231, 595
5	Leggitt's Creek	Scranton, first ward.	......do	137, 289	154, 398
5	Marvin	Scranton, first ward.	......do	165, 628	149, 522
5	Lucas	Scranton, second ward.	Lucas Coal Company	....	1, 500
5	Pancoast Shaft and Slope.	Dickson City borough.	Pancoast Coal Company	....	63, 707
5	Troop or Jermyn No. 4.	....do	John Jermyn	....	8, 390
				3, 846, 505	3, 999, 673

3.—PITTSTON DISTRICT.

5	Everhart	Jenkins township	Waddell & Co	56, 861	44, 954
5	Tompkins	Pittston borough	G. R. Wilson & Co	13, 882	1, 500
5	Fairmount	Pittston township	A. Morris & Co	53, 878	57, 986
5	Twin	Pittston borough	Pittston Coal Company	33, 546	49, 500
5	Seneca	....do	Pittston Coal Company, abondoned July 1, 1882.	54, 270	21, 973
5	Beaver	do	Waterman & Beaver	16, 029	19, 587
5	Butler	Pittston township	Butler Coal Company	63, 326	56, 000
5	Mozier	Hughestown	... do	52, 200	67, 985
5	Heidelberg (shaft)	Pittston township	Lehigh Valley Coal Company.	2, 000	55, 500
5	Phœnix	Marcy township	Phœnix Coal Company	36, 112	31, 417
5	Hillside	Pleasant Valley	Hillside Coal and Iron Company.	62, 624	58, 031
5	Columbia	Marcy township	Grove Brothers	15, 605	25, 825
5	Slope No. 2	Jenkins township	Pennsylvania Coal Company.	49, 504	49, 435
5	Slope No. 4	....do	......do	71, 962	66, 155
5	Shaft No. 5	....do	......do	71, 270	70, 776
5	Shaft No. 6	....do	......do	56, 874	57, 930
5	Shaft No. 7	....do	......do	94, 625	77, 840
5	Shaft No. 11	... do	..... do	36, 280	29, 530
5	Shaft No. 4	....do	..... do	90, 515	77, 771
5	Shaft No. 1	Hughestown borough.	......do	29, 477	31, 163
5	Shaft No. 8	... do	......do	60, 686	66, 855
5	Tunnel No. 1	Pittston township	..... do	40, 878	39, 008
5	Slope No. 6	Hughestown borough.	......do	27, 826	28, 056
5	Shaft No. 9	Pittston	..... do	69, 323	81, 712
5	Shaft No. 10	Hughestown	..... do	126, 130	125, 106
5	Shaft No. 12	Pleasant Valley	......do	76, 975	56, 805

Production by collieries—Continued.

3.—PITTSTON DISTRICT—Continued.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
5	Shaft No. 13	Old Forge township	Pennsylvania Coal Company.	24,135	16,113
5	Barnum No. 1	Marcy township	do	173,287	169,231
5	Barnum No. 2	do	do		81,178
5	Saw	Pittston township	do	68,801	58,733
5	Stark	Lackawanna township.	do	73,263	76,521
5	Greenwood	do	Pennsylvania Anthracite Company.	149,013	140,023
5	Sibley	Old Forge township	do	76,871	76,420
5	Spring Brook	Moosic, Lackawanna township	Hillside Coal and Iron Company.	90,590	69,700
5	Eagle	Pittston borough	Northern Coal Company		4,219
5	Stetler	Marcy township	S. N. Stetler & Co		35,125
4	Exeter	West Pittston	Lehigh Valley Coal Company.	209,000	111,500
				2,227,618	2,187,163

4.—WILKES-BARRE DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
4	Prospect	Plainsville	Lehigh Valley Coal Company.	224,227	223,633.00
4	Mineral Spring	do	do	79,930	80,467.07
4	Midvale	do	do	55,808	52,256.00
4	Henry	do	do	122,937	123,411.00
4	Diamond	Wilkes-Barre	Lehigh and Wilkes-Barre Coal Company.	179,216	100,645.66
4	Hollenback	do	do	238,051	227,929.04
4	Empire	do	do	308,282	266,178.11
4	Hartford	Ashley	do	213,155	216,762.04
4	Sugar Notch No. 9	Sugar Notch	do	166,802	162,976.06
4	Sugar Notch No. 10	do	do	134,388	87,802.03
4	Nottingham	Plymouth	do	371,198	334,921.10
4	Reynolds	do	do	162,173	160,249.08
4	Wanamie	Wanamie	do	121,377	133,660.50
4	Mill Creek	Mill Creek	Delaware and Hudson Canal Company.	165,283	172,350.14
4	Pine Ridge	Plainsville	do	135,612	126,422.18
4	Laurel Run	do	do	164,174	140,718.06
4	Baltimore Slope	Wilkes-Barre	do	102,990	99,042.02
4	Baltimore Tunnel	do	do	144,485	79,940.05
4	Conyngham	do	do	38,775	108,886.00
4	Plymouth No. 2	Plymouth	do	124,277	213,444.04
4	Plymouth No. 3	do	do	199,811	158,669.06
4	Plymouth No. 4	do	do	101,287	113,342.00
4	Plymouth No. 5	do	do	204,415	189,386.00
4	Breaker No. 1	Nanticoke	Susquehanna Coal Company.		155,276.15
4	Breaker No. 2	do	do	766,750	329,611.10
4	Breaker No. 5	do	do		302,212.90
4	Breaker No. 3, or Grand Tunnel.	do	do	85,927	117,066.70
4	Avondale	Plymouth	Delaware, Lackawanna, and Western Railroad Company.	168,989	187,119.17
4	Boston	do	do	105,561	94,341.15
4	Warrior Run	Warrior Run	A. J. Davis	60,000	51,811.00
4	No. 1 Kingston	Kingston	Kingston Coal Company	141,199	183,103.10
4	No. 2 Kingston	do	do	252,887	250,106.12
4	Gaylord	Plymouth	Gaylord Coal Company	163,010	168,804.08
4	Franklin	Wilkes-Barre	Franklin Coal Company	145,229	160,305.29
4	Wyoming	Plainsville	Wyoming Valley Coal Company.	214,475	222,646.00
4	Forty Fort	Forty Fort	do	112,331	120,477.00
4	Enterprise	Plainsville	Andrew Langdon & Co	137,930	145,456.12
4	East Boston	Kingston	W. G. Payne & Co	112,000	115,000.00
4	Black Diamond	do	Haddock & Steele	84,783	82,946.00
4	Maltby	do	C. S. Maltby	98,538	30,551.60

Production by collieries—Continued.

4.—WILKES-BARRE DISTRICT—Continued.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
4	Harry E	Kingston	Wyoming Valley Coal Company.	12,831	54,527.00
4	Red Ash No. 1	Wilkes-Barre	Red Ash Coal Company	92,599	97,454.05
4	Red Ash No. 2	do	do		69,204.11
4	Raubville	Kingston	Waddell & Walter	40,770	64,100.00
4	Dodson	Plymouth	Plymouth Coal Company.	98,648	121,477.17
4	Salem	Shickshinny	Salem Coal Company	52,450	47,450.00
4	Hillman	Plainsville	H. Baker Hillinan	52,000	50,000.00
4	Chauncey	Plymouth	T. P. Macfarlane	24,515	23,593.00
4	R. S. Poole	Wilkes-Barre	R. S. Poole	19,450	13,182.00
4	Mocanaqua	Hartville	West End Coal Company.	10,980	88,711.05
4	Bennett		Thos. Waddell & Co		26,226.17
				6,812,505	6,947,847.67

5.—GREEN MOUNTAIN BASIN.

6	Pond Creek	Pond Creek	Pond Creek Coal Company	32,822	
6	Upper Lehigh Nos. 1, 2, and 3.	Upper Lehigh	Upper Lehigh Coal Company.	217,909	198,579
6	Upper Lehigh No. 4	do	do	169,833	166,601
				420,564	365,180

6.—BLACK CREEK BASINS.

6	Sandy Run	Sandy Run	M. S. Kemmerer & Co	136,085	181,759
6	Highland No. 1	Highland	G. B. Markle & Co	99,009	104,358
6	Highland No. 2	do	do	98,866	124,472
6	Oakdale No. 1	Jeddo	do	111,433	117,205
6	Oakdale No. 2	do	do	104,512	126,600
6	Council Ridge No. 2	Eckley	J. Leisenring & Co	155,572	176,795
6	Council Ridge No. 5	do	do	98,979	160,632
6	Cross Creek No. 1	Drifton	Coxe Bros. & Co	214,629	223,929
6	Cross Creek No. 2	do	do	266,734	237,998
6	Cross Creek No. 3	do	do	15,891	30,373
6	West Cross Creek No. 1.	Gowen	do	37,510	55,229
6	Ebervale Nos. 1 and 2	Ebervale	Evervale Coal Co	122,266	147,105
6	Ebervale Nos. 3, 5, and 6.	do	do	76,559	110,278
6	Black Ridge	Conyngham	Black Ridge Coal Co	21,754	63,694
6	Hollywood	Hollywood	Calvin Pardee & Co	125,141	125,841
6	Lattimer No. 1	Lattimer	Pardee Bros. & Co	124,755	112,179
6	Lattimer No. 2	do	do	129,999	126,853
6	Milnesville No. 6	Milnesville	Stout Coal Co	87,381	39,750
6	Milnesville No. 7	do	do	55,024	81,043
6	Harleigh	Harleigh	McNair & Co	94,755	88,667
				2,176,854	2,434,760

7.—HAZLETON BASIN.

6	Hazleton	Hazleton	Ario Pardee & Co	77,059	92,106
6	Laurel Hill	do	do	138,440	91,556
6	Hazleton No. 3	do	do	32,289	57,081
6	Hazleton No. 6	do	do	154,072	156,237
6	Cranberry	do	do	124,153	121,888
6	East Crystal Ridge	do	do	61,382	56,088
6	Sugar Loaf	do	do	53,121	44,252
6	South Sugar Loaf	do	do	45,916	54,519

Production by collieries—Continued.

7.—HAZLETON BASIN—Continued.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
6	East Sugar Loaf No. 1.	Stockton	Linderman, Skeer & Co.		62,363
6	East Sugar Loaf No. 4.	....do	......do	102,413	....
6	East Sugar Loaf No. 5.	....do	......do		131,027
6	East Sugar Loaf No. 2.	....do	......do	37,499	64,606
6	East Sugar Loaf No. 3.	....do	......do	89,583	83,851
6	Buck Mountain	Buck Mountain	Buck Mountain Coal Co.	120,719	108,906
6	Mount Pleasant	Mount Pleasant	Pardee, Sons & Co	146,691	143,373
6	Humboldt	Humboldt	Linderman, Skeer & Co	96,240	87,730
				1,279,577	1,355,583

8.—BEAVER MEADOW BASIN.

6	Colerain	Beaver Meadow	Wm. T. Carter & Co	138,187	153,360.00
6	Spring Mountain No. 1.	Jeansville	J. C. Haydon & Co	102,075	....
6	Spring Mountain No. 4.	......do	......do	....	119,568.00
6	Spring Mountain No. 5 and Drift.	......do	......do	113,025	....
6	Spring Mountain No. 7.	......do	......do	....	122,811.00
6	Tresckow	Tresckow	E. B. Leisenring & Co	116,561	135,605.00
6	Spring Brook No. 5	Yorktown	Geo. H. Myers & Co	83,685	86,400.00
6	Spring Brook No. 6	......do	......do	94,994	98,674.00
6	Beaver Brook	Frenchtown	C. M. Dodson & Co	98,028	99,367.00
2	Honeybrook No. 1	Audenried	E. B. Leisenring	81,116	51,381.36
2	Honeybrook No. 4	......do	......do	164,940	163,580.09
2	Honeybrook No. 5	......do	......do	124,302	108,419.09
				1,116,913	1,139,165.54

9.—EAST MAHANOY DISTRICT.

2	Ellangowan	Lanigan's	Philadelphia and Reading Coal and Iron Company.	240,977	244,120.67
2	Elmwood	Mahanoy City	.... do	282	20,841.27
2	Knickerbocker	Yatesville	......do	113,555	92,168.31
2	Mahanoy City	Mahanoy City	......do	114,339	113,339.71
2	North Mahanoy	......do	......do	71,190	52,710.04
2	Schuylkill	... do	......do	81,925	83,972.49
2	St. Nicholas	St. Nicholas	......do	111,031	106,400.22
2	Tunnel Ridge	Mahanoy City	......do	74,654	70,008.09
2	Coplay	......do	Lentz & Bowman	68,777	75,958.00
2	Glendon	......do	J. C. Haydon & Co	95,481	111,436.00
2	Primrose	......do	Primrose Coal Company	55,193	56,460.00
2	Coal Run	St. Nicholas	Suffolk Coal Company	127,400	136,191.53
2	Staffordshire	......do	Jones & Oliver	11,422	7,881.36
2	West Lehigh	Mahanoy City	Fisher, Hazzard & Co	46,757	47,666.36
2	Webster	......do	L. S. Baldwin	24,119	25,381.00
2	North Star	......do	Reynolds & Roberts	24,000	8,465.85
				1,261,202	1,253,000.90

Production by collieries—Continued.

10.—WEST MAHANOY DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
2	Boston Run	Boston Run	Philadelphia and Reading Coal and Iron Company.	46,705	80,470.44
2	Conner	Girardville	......do	137,251	138,293.44
2	Girard	....do	......do	69,567	104,647.36
2	Hammond	....do	......do	95,274	93,838.58
2	Indian Ridge	Shenandoah	......do	143,562	144,602.00
2	Plank Ridge	....do	......do	107,195	108,257.71
2	West Shenandoah	....do	......do	122,264	103,776.58
2	Shenandoah City	....do	......do	84,819	116,213.40
2	Bear Run	Saint Nicholas	......do	19,221	43,751.31
2	Gilberton	Gilberton	......do	52,988	77,090.40
2	Girard Mammoth	Raven's Run	......do	14,273	47,832.62
2	Turkey Run	Shenandoah	......do	114,298	127,763.53
2	Bear Ridge No. 1	Mahanoy City	Myers, McCreary & Co	63,196	69,283.80
2	Bear Ridge No. 2	....do	......do	74,425	65,491.27
2	Packer No. 1	W. Mahanoy township.	Lehigh Valley Coal Company.	81,564	61,700.00
2	Packer No. 2	....do	......do	126,510	98,434.09
2	Packer No. 3	....do	......do	170,078	158,595.44
2	Packer No. 4	....do	......do	200,682	218,127.85
2	Cambridge	Shenandoah	Cambridge Coal Company	9,065	10,939.00
2	Cuyler	Raven's Run	Heaton Brothers	177,954	175,949.36
2	Draper	Gilberton	Oliver Diston	117,132	114,631.49
2	Kohinoor	Shenandoah	R. Heckscher & Co	175,861	162,000.00
2	Lawrence	Mahanoy Plane	Jacob S. Lawrence	112,200	95,368.00
2	Stanton	Maizeville	Miller, Hock & Co	57,854	68,733.00
2	Kehley's Run	Shenandoah	Thomas Coal Company	....	79,616.00
2	William Penn	W. Mahanoy township.	William Penn Coal Company.	222,252	228,000.00
2	Laurel Ridge	Mahanoy City	John A. Dutter	11,016	24,104.40
2	Oak Dale	Shenandoah	E. L. Powell	10,000	10,000.00
3	Mount Carmel Shaft.	Mount Carmel	Philadelphia and Reading Coal and Iron Company.	184,358	182,139.31
3	Bast	Big Mine Run	......do	91,785	90,160.80
3	Keystone	Locust Dale	......do	7,726	2,709.27
3	Merriam	Locust Summit	......do	93,589	116,771.71
3	Potts	Locust Dale	......do	96,240	83,941.22
3	North Ashland	Dark Corner	......do	119,300	111,035.71
3	Preston Nos. 1 and 2.	Girardville	......do	63,491	68,028.67
3	Preston No. 3.	....do	......de	88,576	86,078.80
3	Tunnel	Ashland	......do	17,404	49,094.76
3	North Franklin No. 2	Treverton	......do	93,310	86,382.49
3	Reliance	Mount Carmel	......do	104,964	118,840.71
3	Locust Spring	Locust Gap	......do	90,508	95,447.76
3	Locust Gap	..do	Greaber & Shepp	86,000	73,204.67
3	Ben Franklin	Doutyville	Baumgartner & Douty	32,158	31,006.71
3	Monitor	Locust Gap	George W. Johns & Bro	126,062	131,546.49
3	Black Diamond	Mount Carmel	William Schwenk & Co	7,368	21,329.49
3	Hazel Dell	Centralia	Skyes & Jones	29,000	7,638.04
3	Mount Carmel	Mount Carmel	Montelius, Righter & Co.	135,612	170,642.80
3	Big Mine Run	Big Mine Run	Jeremiah Taylor & Co	134,525	132,362.49
3	Continental	Centralia	Lehigh Valley Coal Company.	62,506	16,541.76
3	Montana No. 1	....do	Daniel Beaver	73	Abandoned.
3	Gordon	Barry township	William Cleaver & Co	29,917	23,368.44
3	Rausch Gap	Valley View	Israel Nye	1,195	1,088.18
3	Monroe	Montana	A. H. Church	42,941	35,854.04
3	Pioneer	Ashland	David Vaughn & Co	958	440.00
3	Logan	Centralia	Lewis A. Riley & Co	117,525	231,169.00
3	Centralia	....do	......do	10,662	88,283.00
3	Bear City	....do	John Q. Williams	2,450	2,000.00
3	Morris Ridge	Ashland	Isaac May & Co	45,507	55,490.27
3	Bellmore	Mount Carmel	S. S. Bickle	....	6,805.31
				4,532,916	4,946,912.97

Production by collieries—Continued.

11.—SHAMOKIN DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
3	Bear Valley	Shamokin	Philadelphia and Reading Coal and Iron Company.	73, 174	69, 634. 36
3	Burnside	Carbon Run	do	50, 918	68, 048. 09
3	Big Mountain	Shamokin	Patterson & Llewellyn	178, 959	168, 769. 67
3	Excelsior	Excelsior	Excelsior Coal Co	142, 481	125, 464. 62
3	Enterprise	do	Enterprise Coal Co	141, 820	121, 019. 76
3	Henry Clay	Shamokin	J. Langdon & Co	114, 935	91, 674. 80
3	Peerless	do	Cruikshank & Co	46, 016	47, 824. 80
3	Sterling	Carbon Run	Kendrick & Co	95, 036	99, 389. 80
3	Royal Oak	Shamokin	Tillet & Brother	4, 802	3, 850. 00
3	Buck Ridge	do	May, Audenried & Co	30, 015	66, 555. 13
3	Cameron	do	Mineral R. R. & Mining Co.	175, 655	164, 596. 49
3	Luke Fidler	do	do	140, 291	124, 973. 67
3	Pennsylvania	do	do	118, 837	125, 167. 04
3	Hickory Ridge	Coal Run	do	22, 311	23, 640. 67
3	Lancaster	do	Smythe & Keyser	30, 806	22, 751. 67
3	Carson	Shamokin	M. E. Robinson	14, 416	8, 070. 18
3	Greenback	Greenback	H. J. Tondy	30, 358	42, 514. 67
				1, 410, 830	1, 373, 945. 42

12.—PANTHER CREEK DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
6	Breaker No. 3	Nesquehoning	Lehigh Coal and Navigation Company.	136, 150	114, 692. 67
6	Breaker No. 4	Jamestown	do	54, 324	127, 411. 36
6	Breaker No. 5	Andrewsville	do	73, 240	71, 585. 36
6	Breaker No. 6	do	do	91, 551	79, 866. 44
6	Breaker No. 9	Coaldale	do	59, 133	....
1	Breaker No. 8	do	do	140, 365	107, 423. 80
1	Breaker No. 10	Bull Run	do	86, 463	116, 259. 44
1	Breaker No. 11	do	do	81, 525	76, 955. 00
1	Greenwood	Tamaqua	Raabe & Fey	2, 776	2, 480. 00
1	West Lehigh	do	Wood & Pearce	16, 500	12, 000. 00
				742, 027	708, 674. 07

13.—EAST SCHUYLKILL DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
1	Pine Dale	Middleport	Lewis Lorenz	6, 600	1, 827. 76
1	Pine Forest	Saint Clair	Philadelphia and Reading Coal and Iron Company.	41, 549	42, 486. 09
1	Eagle	do	Geo. W. Johnson & Bro	49, 361	28, 594. 31
1	Beechwood	Mount Laffee	Philadelphia and Reading Coal and Iron Company.	39, 706	31, 920. 40
1	Wadesville	Wadesville	do	110, 874	15, 233. 18
1	Eagle Hill	New Philadelphia	do	70, 084	69, 811. 44
1	Pottsville	Pottsville	do	16, 478	42, 625. 85
1	Palmer Vein	New Philadelphia	Alliance Coal Company	28, 000	35, 596. 00
1	Saint Clair	Saint Clair	Atkinson & Lessig	3, 524	4, 858. 22
1	Sharpe Mountain	Pottsville	Thomas Wren	2, 540	1, 265. 44
1	Monitor	Wadesville	John H. Denning	1, 854	2, 840. 00
1	Peach Orchard	Saint Clair	do	1, 362	261. 00
1	do	do	Thomas Burke	235	9. 00
1	Middle Lehigh	New Boston	Mill Creek Coal Company.	153, 924	146, 432. 04
1	East Lehigh	Mahanoy City	Mitchel & Symonds	10, 116	8, 461. 09
1	Repplier	New Castle	J. F. Quinn	3, 106	4, 250. 71
1	Mammoth	Broad Mountain	Mahany & Co	750	....
1	Furnace	Saint Clair	John Wylam	129	50. 00
1	Keim & Repp	Mill Creek	Samuel B. Myers	165	151. 00
1	Garfield	....	Tim Cockhill	252	....
1	North Dale	Middleport	Alliance Coal Company	....	2, 968. 00
1	Oak Hill	Mount Laffee	Martin Devlin	....	320. 44
1	New Castle	New Castle	B. F. Palm & Son	....	659. 00
1	Corinda	Wadesville	George Morgan	....	919. 00
1	Oakwood	New Castle Station	John Botham & Co	....	1, 000. 00
1	Morning Star	do	Whyms & Morgan	....	560. 00
1	....	....	Theodore Hellman	637	....
				541, 246	443, 099. 97

Production by collieries—Continued.

14.—WEST SCHUYLKILL DISTRICT.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
1	Gate Vein	Minersville	George Wilson		31.00
1	Mine Hill Gap	do	Philadelphia and Reading Coal and Iron Company.	48,902	51,540.40
1	Thomaston	Heckersville	do	82,975	70,784.27
1	Richardson	Glen Carbon	do	58,388	66,381.00
1	Glendower	do	do	51,465	1,220.53
1	Phœnix Park No. 2	Phœnix Park	do	33,011	32,963.80
1	Phœnix Park No. 3	do	do	22,163	30,676.13
1	Black Mine	Llewellyn	J. D. Curtz Crook	16,357	5,620.00
1	Ellsworth	New Castle	John R. Davis	11,933	15,036.00
1	Black Valley	Minersville	Ed. Hoskins	1,942	1,966.76
1	Dundas	do	Davis & Co	5,000	9,681.76
1	Jugular	New Castle	Jacob S. Hepner	869	1,049.76
1	Swatara	Swatara	Philadelphia and Reading Coal and Iron Company.	53,124	41,725.22
1	Otto	Branch Dale	do	55,905	11,422.40
1	Black Heath	Minersville	Wm. Harris	21,132	6,245.13
1	Chandler	do	Patrick Keenan	100	
1	Lewis Tract	do	George Harris	207	
1	Swatara	Swatara	John D. Felty	1,046	882.22
1	Chandler Tract	Minersville	William Lloyd	9	
1	Wolf Creek Big Diamond.	Wolf Creek	James F. Donahoe	8,000	5,860.00
1	Wolf Creek Diamond.	Minersville	John A. Lawrence	5,624	2,205.38
1	Forestville	Forestville	Philadelphia and Reading Coal and Iron Company.	7	11,443.00
1	Middle Creek	Swatara	do	2	4.872.00
1	Kirk Line	Thomastown	P. O'Conner		219.00
1	Chrystal	New Castle	Joseph Brady		5,149.49
1	Jonestown	Primrose	T. F. Guinn		350.00
1		Wolf Creek	George Kantner		729.00
				478,161	378,054.25

15.—LORBERRY DISTRICT.

1	Colket	Donaldson	Philadelphia and Reading Coal and Iron Company.	43,221	31,484.36
1	East Franklin	Upper Rausch Creek	do	19,179	25,051.85
1	Lower Rausch Creek	Tremont township	Miller, Graeff & Co	85,382	62,682.76
1	Tremont Lands	Tremont	Peter Laux	131	Abandoned.
1	Woods	do	Geo. S. Woods	1,054	887.09
				148,967	120,106.06

16.—LYKENS VALLEY DISTRICT.

1	Lincoln	Tremont township	Levi Miller & Co	146,899	165,678.31
1	Ka'mia	Orwin	Phillips & Sheafer	83,167	201,100.22
3	West Brookside	Porter township	Philadelphia and Reading Coal and Iron Company.	374,533	289,892.09
3	Williamstown	Williamstown	Summit Branch Railroad Company.	279,790	342,218.40
3	Short Mountain	Lykenstown	Short Mountain and Lykens Valley Coal Company.	198,188	195,095.44
3	Big Run Gap	Williams Valley	James Fennel	2,628	2,498.00
				1,085,205	1,196,482.46
	Total reported as shipped from collieries			29,525,909	30,213,697.31
	Total reported as consumed at collieries			1,011,672	1,067,369.14
	Total production hard anthracite			30,537,581	31,281,066.45

Production by collieries—Continued.

17.—LOYALSOCK BASIN.

No. of inspector's district.	Name of colliery, 1882.	Location.	Operator, 1882.	Production, 1881.	Production, 1882.
				Tons.	*Tons.*
	Bernice	Bernice, Sullivan county.	State Line and Sullivan Railroad Company.	64,000	77,198.00
	Total production anthracite coal fields			30,601,581	31,358,264.45

Total production and shipments from the mine inspectors' districts for the years 1881 *and* 1882, *with the colliery and local consumption.*

Districts and inspectors.	1881.			1882.		
	Shipment.	Colliery and local consumption.	Total production.	Shipment.	Colliery and local consumption.	Total production.
1. First Schuylkill, Samuel Gay, inspector	1,726,069	103,566	1,829,635	1,623,157.05	97,389.42	1,720,546.47
2. Second Schuylkill, Robert Mauchline, inspector	4,248,666	254,980	4,503,646	4,403,892.51	264,233.55	4,668,126.06
3. Third Schuylkill, James Ryan, inspector	4,181,679	250,904	4,432,583	4,323,051.25	259,383.07	4,582,434.32
4. Middle Carbon and Luzerne, G. M. Williams, inspector	6,624,061	397,444	7,021,505	6,659,761.95	399,585.72	7,059,347.67
5. Eastern Carbon and Luzerne, Patrick Blewitt, inspector	7,310,042	402,222	7,712,264	7,439,385.00	446,363.10	7,885,748.10
6. Southern Carbon and Luzerne, James E. Roderick, inspector	4,752,781	285,167	5,037,948	5,061,192.29	303,671.54	5,364,863.83
Totals	28,843,298	1,694,283	30,537,581	29,510,440.05	1,770,626.40	31,281,066.45

Production of the anthracite coal fields of Pennsylvania in 1882, *by counties.*

Counties.	Tons.
Susquehanna	15,332.90
Lackawanna	6,071,716.04
Luzerne	13,355,315.83
Carbon	867,594.83
Schuylkill	7,176,489.44
Columbia	669,870.22
Northumberland	2,552,546.64
Dauphin	572,200.55
	31,281,066.45
Sullivan	77,198.00
	*a*31,358,264.45

a Mr. Ashburner's contribution and statistics end here.

Anthracite inspection districts.—In order to systematically attend to the matter of proper ventilation, etc., the Pennsylvania anthracite region is divided into six inspection districts, as follows:

First. Pottsville district, embracing collieries the production of which is known in market as Schuylkill and Lorberry coal. Mr. Samual Gay, mine inspector.

Second. Shenandoah district, embracing collieries in the Shenandoah and East Mahanoy regions, of the Schuylkill coal field. Mr. Robert Mauchline, mine inspector.

Third. Shamokin district, embracing those collieries located in the western part of Schuylkill, eastern Northumberland, and Dauphin counties. Coal sold as Lykens valley, Shamokin, and Mahanoy. Mr. James Ryan, mine inspector.

Fourth. Wilkes-Barre district includes the collieries in the northern coal field in the middle district of Luzerne county. Mr. G. M. Williams, mine inspector.

Fifth. Scranton district includes those collieries in the Lackawanna, Scranton, and Pittston regions, located in eastern Luzerne, and in Lackawanna county. Mr. P. Blewitt, mine inspector.

Sixth. Lehigh district includes collieries in Carbon, and in the southern part of Luzerne counties. Mr. G. Roderick, mine inspector.

Owners of the land.—On the anthracite coal fields of Pennsylvania the land is owned by large corporations, whose respective interests are shown in the following table:

Company.	Schuylkill.		Middle.		Wyoming.	
	Acres.	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*	*Per cent.*
Lehigh Valley	....	....	18,036	24	6,934	4
Lehigh and Wilkes-Barre	7,600	8	7,000	8	7,400	5
Delaware and Hudson	....	....	....	....	20,042	12
Delaware, Lackawanna, and Western	....	....	....	....	3,500	3
Pennsylvania Coal Company	....	....	....	....	10,000	6
Philadelphia and Reading Coal and Iron Company	65,306	70	23,250	32	....	....
Philadelphia Rai road Company	6,000	6	9,000	9	5,823	6
Girard estate	....	....	6,000	8	....	....
Gilbert & Co	....	....	1,373	2	....	....
Alliance Coal Mining Company	3,172	3	....	....	....	....
All others	11,362	13	15,981	17	73,021	64
Total	93,440	100	80,640	100	126,720	100

The Pennsylvania railroad interest includes Shamokin coal, Lykens Valley coal, and some Wyoming coal. Reading is of the various grades of Schuylkill. Lehigh valley is three-fourths Lehigh and the balance Wyoming. Central Railroad of New Jersey is about equally divided between Lehigh and Wyoming. Delaware and Hudson; Delaware, Lackawanna, and Western Company; Pennsylvania Coal Company, all from the Wyoming region. "Erie" coal is from Wyoming.

Distance from market.—All the carrying companies mentioned above have lines extending to tidewater, whose respective interests are shown in the following table:

From—	By—	Miles.
Pottsville to New York	Canal	226
Pottsville to Philadelphia	do	106
Pottsville to Philadelphia	Rail	93
Mauch Chunk to New York	Lehigh canal	172
Mauch Chunk to New York	Rail	126
Mauch Chunk to Philadelphia	Canal	124
Mauch Chunk to Philadelphia	Rail	89
Carbondale to New York	Rail and canal	208
Scranton to New York	Rail	143
Wilkes-Barre to New York	do	192
Wilkes-Barre to Mauch Chunk	do	55
Wilkes-Barre to Baltimore	Canal	246
Shamokin to Baltimore	Northern Central railroad	158

The Philadelphia and Reading ship at Philadelphia and Elizabethport, New Jersey; the Lehigh Valley ship at Perth Amboy, New Jersey; the Central Railroad of New Jersey ship at Elizabethport and Port Johnston, New Jersey; the Delaware, Lackawanna, and Western Railroad Company ship at Hoboken, New Jersey; the Delaware and Hudson Canal Company ship at Rondout, New York; the Pennsylvania Railroad Company ship at South Amboy, New Jersey; the Pennsylvania Coal Company ship at Newburgh, New York. In addition to the points of shipment named above there is a large trade done in the distribution of coal to interior points.

Distribution of the anthracite.—The following schedule has been prepared in regard to the distribution of the output:

General distribution of anthracite coal in 1881.

	Tons of 2,240 pounds.
COMPETITIVE.—Including tonnage passing out of capes of Delaware, to New York harbor, to points on Hudson river, Long Island sound, and the Atlantic coast north of Point Judith	12,169,030
WESTERN.—Including tonnage to points in the United States west of Buffalo and the Detroit river, Erie, Pittsburgh, and Baltimore	2,079,134
CANADIAN.—Including all tonnage by lake and rail to points in the Dominion of Canada	694,428
SOUTHERN.—Estimated tonnage to all points in Delaware, Maryland, and the territory bounded by the Ohio and Mississippi rivers on the north and west and the Gulf of Mexico on the south	800,000
PACIFIC COAST	15,000
LOCAL.—Embracing all coal consumed in Pennsylvania, New York, and New Jersey	12,742,424
Total tonnage in 1881	28,500,016

Working time.—Many persons are of the opinion that it is possible to work the anthracite mines each and every work-day in the year, and make calculations as to the probable output on this opinion. The mining engineer of the Reading Company puts a practical veto on this notion, for he figures up that the average number of working days, deducting for lost time from restriction by agreement, holidays, funerals, pay-days, etc., during the four years 1878–'79–'80–'81, was 193.8, or 61.86 per cent., reckoning 312 working days for the year. This engineer estimates that 240 working days out of 312 are all that can prudently be counted on in coal mining; that there will always be an average of at least 72 days' lost time for accidents, holidays, funerals, etc., when the mines cannot be worked.

Percentage of the various sizes.—At one of the largest establishments in the anthracite coal field the percentages of the various sizes shipped to market in 1882 were carefully recorded, with the following result:

Percentage of marketable sizes of anthracite.

Sizes.	Quantity.		Per cent.
	Tons.	*Cwts.*	
Lump	93,794	14	13.5
Steamboat	2,227	16	.3
Broken	143,068	05	20.6
Egg	88,385	07	12.8
Stove	97,194	01	14.0
Chestnut	155,604	03	22.4
Pea	113,920	03	16.4
Total	694,194	09	100.0

Tons are net tons of 2,000 pounds.

The tendency is toward a larger proportion of prepared sizes, as distinguished from lump coal, for the reason that the small sizes sell for a price so much higher that it is remunerative to break up the coal. The introduction of base-burning coal stoves has had much to do with the increased demand for small coals; chestnut coal, that sold at one dollar to one dollar and a half per ton less than stove-coal ten years ago, now ranges at the same, or a slightly higher, rate.

Wages for digging anthracite.—The following is the schedule adopted by the operatives in the Lehigh coal field of Pennsylvania:

The basis is the average price of coal at tidewater in New York harbor, and on this basis, as the price rise or falls, wages are paid. At $5 per ton as the average for coal, the price per car is 87 cents; miners' wages per week, $12.60; and laborers' wages, $10.80 for first-class, and $9.90 for second-class miners' laborers. Driving gangways, $6.12 per yard for timbered, and $5.35 not timbered. Driving chutes, $2.87 per yard; cross-cuts, $1.91 per yard. Cross-holes from gangway to airway, $3.85 per yard. Airway, 25 square feet, per yard, $3.25. Outside labor, first-class, $9.60 per week; second-class, $9; third-class, $8. On contract, on Mammoth vein coal, per ton of 48 cubic feet, 42½ cents.

Price of coal.	Per cent. below basis.	Car prices.	Miners' wages.	Laborers' wages.
$5 00	0	87.1	$12 60	$10 80
4 90	1	86.2	12 47	10 69
4 80	2	85.3	12 35	10 58
4 70	3	84.5	12 22	10 47
4 60	4	83.6	12 10	10 36
4 50	5	82.7	11 97	10 26
4 40	6	81.9	11 84	10 15
4 30	7	81.0	11 72	10 04
4 20	8	80.1	11 59	9 93
4 10	9	79.2	11 46	9 82
4 00	10	78.3	11 34	9 72
3 90	11	77.5	11 21	9 61
3 80	12	76.6	11 09	9 50
3 70	13	75.7	10 96	9 39
3 60	14	74.9	10 83	9 29
3 50	15	74.0	10 71	9 18
3 40	16	73.1	10 58	9 07
3 30	17	72.3	10 45	8 96
3 20	18	71.4	10 33	8 85
3 10	19	70.5	10 20	8 74
3 00	20	69.6	10 08	8 64

The *Coal Trade Journal*, of New York, says: "To many persons it may be a surprise to learn that wages in the Wyoming division of the anthracite coal fields of Pennsylvania are quite as high as when coal sold at $1 and more per ton higher than it does at present. In witness of the correctness of this statement we present the following figures:

"1874, December.—Coal sold at average of $5.25 at tidewater. Wages per car were $1.11½.

"1875, January 1.—All except Wyoming went on strike because of a reduction in wages of 10 per cent. Coal sold at average of $5.50 because of scarcity. Wages per car were $1.00½.

"1876, September 1.—Coal had gradually sold down to an average of $3.05. Wages were reduced 10 per cent., or to 90½ cents.

"1877, March 1.—Prices fell off, until on this date they were at an average of $2.90, and a 15 per cent. reduction was made in wages, making per car 77 cents.

"1879.—Prices gradually fell off to an average of $2.30 in November. An advance in wages was given on December 1 of 10 per cent., making them per car 85 cents.

"1880.—Prices improved until May, 1880, when the average was $3.55, and an advance of 10 per cent. was given on the 1st of the month, making the rate per car 93 cents.

"1882.—July 1 an advance was given of 10 per cent. to make good half-time working, although the average realized for coal was not 10 per cent. greater than in the year preceding. Wages per car therefore $1.02.

"1883.—Rate at present may average $4 per ton, and wages are $1.02. Eight years ago average was $5.50 for coal, and wages $1.00½ per car."

In regard to the cost of mining a ton of coal in the anthracite regions, a statement recently appeared in one of the local papers showing the average cost of mining in the upper Wyoming region. It was put at $1.15 per ton. This did not include royalty, nor did it include the cost of preparing the coal for market. Even the figures named were acknowledged to be low, and obtained by active competition in large production, and omitting many items of repairs, etc.

Miscellaneous anthracite statistics.—The following table shows the number of collieries, number of persons employed, production, etc., in the several counties of the anthracite coal fields of Pennsylvania, compiled from returns made to the office of the Secretary of Internal Affairs for Pennsylvania for the year ended December 31, 1882:

Counties.	Number of collieries.	Average number days in operation during the year.	Total number persons employed.	Amount paid in wages during the year.	Number of tons of coal produced during the year.
Carbon	11	223	2, 691	$955, 398 15	813, 699. 05
Columbia	5	227	1, 479	522, 490 91	550, 043. 02
Dauphin	3	270	1, 655	631, 580 00	539, 812. 00
Lackawanna	52	208	14, 580	5, 997, 419 88	5, 406, 405. 10
Luzerne	120	214	31, 631	13, 313, 627 72	12, 680, 611. 05
Northumberland	31	231	7, 253	2, 876, 558 82	2, 449, 340. 15
Schulkill	116	225	21, 100	8, 354, 540 17	6, 782, 972. 07
Sullivan	1	240	200	89, 327 00	75, 900. 00
Susquehanna (*a*)	......	......	......	......	......
	339	227¼	80, 589	32, 740, 942 65	29, 298, 782. 44

a The production, etc., of the mines located in Susquehanna county were included in the returns of operators in Lackawanna, and are enumerated in the statistics of the latter county.

Few of the mine inspectors report full details, and there is no uniformity in the returns. The inspector for the district producing the largest amount of anthracite coal, in the year 1882—the eastern or Scranton—gives the following résumé:

Operators.	Gross tons mined.	Employés.	Days worked.	Tons mined per employé.
Pennsylvania Coal Company	1, 433, 281	2, 385	249¾	423½
Delaware, Lackawanna and Western Railroad Company	2, 098, 198	5, 558	219⅔	415⅓
Delaware and Hudson Canal Company	1, 505, 663	3, 847	223⅓	415⅓
Miscellaneous operators	2, 136, 743	7, 407	......	......
Add 6 per cent. for home consumption	448, 433	......	......	......
Total	7, 922, 318	......	......	......

95 shafts; total depth, 21,406 feet.
51 slopes; total length, 31,533 feet.
71 breakers.
278¾ miles track laid with iron inside.
70⅜ miles track laid with iron outside.
75 fans for ventilating purposes.
22 furnaces for ventilating purposes.
4 steam jets for ventilating purposes.

Price of anthracite in 1883.—Opening rates for anthracite coal were made in March, 1883.

	Lump.	Broken.	Egg.	Stove.	Chestnut.
Free-burning coal ..	$3 90	$3 90	$4 00	$4 20	$4 20
Hard Lehigh coal ...	5 00	4 45	4 40	4 30	4 40

These rates were per gross ton, free on board vessels in New York harbor. There was no change in the circulars until July 1, when rates were made as follows:

	Lump.	Broken.	Egg.	Stove.	Chestnut.
Free-burning........	$3 90	$3 90	$4 15	$4 45	$4 45
Hard Lehigh	5 25	4 45	4 50	4 50	4 60

Western prices were made April 18, and were as follows at Buffalo on board vessels: Lump (none sold); grate, $5.10; egg, $5.20; stove, $5.45; chestnut, $5.45. There was no change until July 1, when rates were: Grate, $5.35; egg, $5.45; stove, $5.70; chestnut, $5.85—all gross tons.

The shipping season on the lakes opened twenty-four days later in 1883 than in 1882.

Using waste anthracite.—The utilization of hitherto waste products has attracted the attention of the scientist and the man of business, and much good has resulted therefrom. In no branch of industry is there so much waste as in the mining and preparation of anthracite coal. There is taken out perhaps 60 per cent. of the contents of the seam, and of that quantity there is 15 or 20 per cent. wasted in the preparation of the coal into the various sizes for market.

A recent investigation of the dirt banks at the collieries owned by the Philadelphia and Reading Coal and Iron Company showed that they contained at least 60,000,000 tons. Of this about 40,000,000 tons can be utilized for fuel. This includes marketable sizes of coal ranging from buckwheat to small stove. It is the intention of the company, as soon as the jig houses now building for the treatment of this coal dirt are finished, to assort the sizes and send them to market.

This company at present burns the "culm" or waste under two hundred boilers, and at fifteen or more collieries. At very few of their collieries have they been burning what is known as good coal for years. They burn "slag," the result of the slate pickers' labors, in which of course there is a great deal of good coal. Among the collieries which burn culm are the Pottsville shaft, Brookside, and Schuylkill. About a year ago the company determined to generate steam with culm instead of coal. The Schuylkill colliery has eight boilers, and these consume from ten to twelve tons of coal per twenty-four hours. Immediately behind the breaker stood the culm bank. The boilers were built up against the bank, and their furnaces were furnished with sheets of perforated iron instead of bars. Each of them was also furnished with a blower, of the steam jet pattern. From all accounts culm raises steam more quickly than coal, which is the great desideratum among engine drivers. The fireman opens the door of a furnace and going to the culm bank, not 10 feet distant, throws in shovelfull after shovelfull from the bank. Large pieces of rock and slate find their way into the furnace, as well as other material of somewhat more favorable heat-producing qualities. The rock and slate come come out of the fire in much the same condition as they go in, a little cracked, and the rock perhaps shriveled, but by no means consumed by the action of the fire. The other parts of the bank are burnt to ashes.

It is said that the Philadelphia and Reading Railroad Company will have one hundred dirt-burning locomotives on its line by the first of January, 1884. The cost of hauling 100 tons one mile, during six months, averaged 17½ per cent. less with dirt-burning engines than it did with regular anthracite coal burners. All the locomotives are using the Wootten boiler in burning the "culm."

The following table, in the several columns, shows the theoretical values of the various coals used, also the amount of heat obtained in the Wootten and ordinary boilers in generating steam. The amount of work done by the two sorts of boilers used for these trials is also expressed in pounds of water evaporated from 212° Fahr., by burning one pound of coal.

Heat-producing value of anthracite.

Description of coal.	Total heat units in fuel used.	Heat units utilized.	Pounds water evaporated.	Per cent. of total heat utilized.
1. Anthracite, waste	11,275	7,823	8.09	69.4
2. Anthracite, marketable	11,913	7,813	8.08	65.5
3. Anthracite, marketable	11,275	5,647	5.84	50.0
4. Bituminous, waste	12,764	8,209	8.49	64.3
5. Bituminous, marketable	13,402	9,302	9.62	69.4
6. Bituminous, marketable	13,402	7,397	7.65	55.2
7. Bituminous, marketable	13,[illegible]63	9,138	9.45	68.3
8. Bituminous, marketable	13,731	7,416	7.67	54.0
9. Lignite, 20 per cent. water	7,871	3,316	3.43	42.1

A mixture of anthracite slack or "culm," with bituminous coal, has been used in New England with good practical results, and great economy; several thousand boilers are now generating steam with this fuel, *Mining anthracite by stripping.*—The coal formation in the vicinity of Hazleton is often found near the surface, and operations are going on to remove the earth and stone, so that the coal may be taken out without the risk that occurs in the underground workings. At present, the work of stripping, a term applied to the mining of coal by first removing the earth surface, is carried on at Bear Ridge, Colerain, Yorktown, Beaver Brook, Milnesville, and Hollywood collieries. At the last-named place, operated by Calvin Pardee & Co., the work is of the most extensive character, at least 300,000 tons of coal being exposed to view, which can be removed without the necessity of very skilled labor or any great danger. It is stated that at least 50 per cent. of the coal is lost by what is known as robbing the mine, but by the mode of stripping, as here practised, every pound of coal can be saved and worked at much less expense and danger. When a sufficient amount of coal has been uncovered, mining operations are commenced. The coal is loosened by blasting, and drills and picks are the tools used. In one of the workings the coal is about 25 feet in thickness, and there twenty men are employed as miners. They take out about sixty wagons of coal a day, the wagon loads averaging two tons each when cleaned. This labor is being done almost entirely by Hungarians, and they are industrious and make good wages.

Other anthracite localities.—Anthracite is found in other portions of the United States besides the fields of Pennsylvania, notably in Gunnison county, Colorado, Rhode Island, Virginia, and in the Los Cerillos mountains of New Mexico. Small bodies of coal, which might be termed anthracite, the result of local alteration, are met with not infrequently, as on the Pacific coast and in Texas; but, broadly speaking, Pennsylvania is *the* anthracite-producing State, and, in comparison with its resources, the anthracite found beyond its limits is of insignificant amount.

Of one of the reported anthracite localities in Virginia, that in Augusta county, recent tests with the diamond drill would seem to prove the presence of anthracite. Three holes were put down by the Pennsylvania Diamond Drill Company in North River gap, two on the Pyron land to a depth of 914 feet, and one on the Davis land to a depth of 167 feet.

Result of borings in Augusta county, Virginia.

Near the surface	10 feet of fire clay.
At 25 feet	13 inches of coal.
At 40 feet	21 inches of coal.
At 56 feet	36 inches of coal.
At 70 feet	8 feet of coal.
At 125 feet	5 feet of coal.

Thence to 914 feet, where red sandstone was struck, several minor seams of coal were passed through. The coal is said by those who have seen it to be true anthracite coal.

BITUMINOUS COAL.

GENERAL STATISTICS.

Largest coal-producing counties.—According to Bulletin No. 273, of the Tenth Census, the total production of bituminous coal in the year ending May 31, 1880, was 42,417,764 tons (of 2,000 pounds), and of this 22,167,999 tons, or about one-half, was from the following counties, each of which produced over 500,000 net tons:

No.	Counties.	States.	Tons.
1	Allegheny	Pennsylvania	4, 426, 871
2	Westmoreland	do	3, 297, 390
3	Fayette	do	2, 318, 728
4	Alleghany	Maryland	2, 198, 073
5	Clearfield	Pennsylvania	1, 722, 711
6	Washington	do	968, 042
7	Saint Clair	Illinois	956, 265
8	Tioga	Pennsylvania	938, 517
9	Perry	Ohio	913, 974
10	Clay	Indiana	772, 423
11	Trumbull	Ohio	722, 265
12	La Salle	Illinois	714, 787
13	Will	do	611, 311
14	Cambria	Pennsylvania	590, 075
15	Columbiana	Ohio	515, 602
16	Bradford	Pennsylvania	500, 965

The following counties east of the 100th meridian produced during the same period over 250,000 net tons each of bituminous coal:

No.	Counties.	States.	Tons.
1	Mercer	Pennsylvania.	485, 276
2	Sangamon	Illinois	427, 616
3	Bourbon	Kansas	403, 519
4	Belmont	Ohio	399, 747
5	Kanawha	West Virginia.	368, 901
6	Meigs	Ohio	359, 225
7	Fayette	West Virginia.	353, 678
8	Stark	Ohio	347, 820
9	Fulton	Illinois	331, 449
10	Hocking	Ohio	331, 170
11	Jefferson	do	324, 070
12	Athens	do	310, 750
13	Blair	Pennsylvania.	293, 834
14	Clarion	do	286, 846
15	Somerset	do	286, 456
16	Mahaska	Iowa	283, 836
17	Elk	Pennsylvania.	281, 151
18	Peoria	Illinois	273, 540
19	Madison	do	272, 927
20	Tuscarawas	Ohio	255, 495

The sixteen counties of the first class furnished 54.9 per cent., and the twenty counties of the second class 16.6 per cent. of the entire product, leaving 28.5 per cent. to be spread over the remaining 278 counties. Allegheny county, Pennsylvania, produced over one-tenth, and the three leading counties of Pennsylvania nearly one-quarter of the entire product.

Production of bituminous coal during the census year ending May 31, 1880, *compared with the one ending May* 31, 1870, *for mines east of the* 100*th meridian.*

	Per cent.
Gain in number of mines	122.0
Gain in yearly tonnage	135.0
Gain in value of yearly product	44.0
Gain in value of material used	133.0
Gain in amount paid as wages	46.0
Gain in total number of employés	133.0
Gain in total capital	54.0
Decrease in value per ton	39.0
Gain in tons raised per man per year	3.0
Decrease in yearly earnings	36.0
Decrease in cost of labor per ton	38.0
Decrease in cost of material per ton	1.0
Gain in per cent. of value of the product paid for labor	0.7
Gain in per cent. of value of the product paid for materials	3.9
Decrease in per cent. of value of the product left for royalty, interest, profits, etc	4.6
Gain in number of counties reporting	68.0

General averages.—The following series of averages, compiled from the census returns from bituminous coal mines east of the 100th meridian, are of interest:

States.	Average price per ton of product of regular mines, at mine.	Average cost of labor per ton.	Average cost of material per ton.	Average amount left for royalty, profit, etc., per ton.	Per cent. of capital used for working capital.	Per cent. of capital in plant.	Per cent. of capital in real estate.
Alabama	$1 47	$1 02	$0 15	$0 30	15.80	38.37	45.83
Arkansas	2 27	1 41	08	78	....	....	....
Georgia	1 50	55	06	89	6.96	70.40	22.64
Illinois	1 44	99	13	32	11.16	30.27	58.57
Indiana	1 48	97	11	40	15.37	34.09	50.54
Iowa	1 71	1 08	17	46	9.84	30.97	59.19
Kansas	1 96	99	06	91	....	....	....
Kentucky	1 20	73	10	37	14.17	37.60	48.23
Maryland	1 16	61	09	46	6.85	6.50	86.64
Michigan	2 23	1 45	08	70	....	....	....
Missouri	1 91	1 18	10	63	....	....	....
Nebraska	3 75	1 50	05	2 20	....	....	....
North Carolina	1 14	57	14	43	....	....	....
Ohio	1 29	86	16	27	9.08	25.13	65.79
Pennsylvania	1 01	60	10	31	9.14	19.13	71.73
Tennessee	1 27	68	10	49	3.86	24.38	71.76
Virginia	2 29	1 76	29	24	8.05	40.43	51.52
West Virginia	1 10	72	14	24	6.61	26.80	66.59
Total	1 22	76	12	34	9.10	21.61	69.28

Bituminous coal averages—Continued.

States.	Average royalty paid per ton.	Average yearly earnings of man, net.	Average per cent. of year worked.	Average per cent. of year idle, except from strikes.	Average per cent. of year lost in strikes.	Tons raised per man per day.	Tons raised yearly per man.	Per cent. ratio of product to maximum capacity.
Alabama	$0 16	$220 07	91.54	2.78	5.68	.71	216.15	71.50
Arkansas	....	166 80	....	....	....	....	118.22	25.73
Georgia	125	192 71	100.00	....	....	1.17	349.87	93.67
Illinois	09	382 25	78.15	17.32	4.53	1.65	385.64	44.10
Indiana	15	318 85	74.34	21.36	4.30	1.47	328.91	46.59
Iowa	23	316 45	69.52	24.14	6.34	1.41	293.57	37.01
Kansas	....	215 41	....	....	....	....	216.63	66.93
Kentucky	14	261 68	62.00	23.60	4.40	1.84	342.61	38.42
Maryland	11	400 49	69.93	17.60	12.47	3.10	651.23	49.15
Michigan	....	385 22	....	....	....	....	265.96	71.08
Missouri	....	259 81	....	....	....	....	219.88	48.57
Nebraska	....	....	....	....	....	....	....	....
North Carolina	....	....	....	....	....	....	....	....
Ohio	17	320 69	77.90	13.55	8.55	1.60	373.03	49.06
Pennsylvania	14	337 97	75.73	17.28	6.99	2.47	560.14	68.65
Tennessee	25	332 28	91.15	8.79	06	1.78	487.90	66.28
Virginia	13	287 51	61.06	38.94	....	89	163.05	38.32
West Virginia	15	295 37	69.05	23.57	7.38	1.97	407.82	43.55
Total	14	328 72	75.70	17.62	6.68	1.90	431.53	54.36

CONDITION OF THE COAL-MINING INDUSTRY IN THE STATES AND TERRITORIES.

ALABAMA.

The coal fields of Alabama cover 10,680 square miles. The product is bituminous, but each vein differs from the other in quality, some being poor, some good, and some unexcelled by any coal in the world.

The existence of coal in Alabama has been known since the settlement of the State. The first writer who brought the subject into prominence was Prof. W. S. Porter, who wrote in 1827. Professor Brumby studied with care the coal formations in the State, and wrote of their great value as far back as 1838. Other geologists examined and reported on the coal formations in the State from year to year until 1849, in which year Professor Tuomey, of Alabama, wrote his excellent work, giving an account of the immense amount of coal and of its valuable qualities. Notwithstanding the fact that the coal was known to be so good, but little attention was paid to it previous to the war. The few attempts to mine it that were made ended in disaster, as there was little or no demand, no manufacturers to consume it, and but little capital to put into anything save cotton plantations and negroes to till them.

When the war broke out, the South was compelled to have coal, and mines were opened in Alabama and worked with success, the excellent quality of coal being then clearly demonstrated to the great benefit of the Confederate Government. Soon after the close of the war several companies were formed to mine coal, but the results were not favorable;

the demand had to be built up; the pioneers in the business did not find it profitable; some could not find a market; others struck poor veins of coal, and the result in either case was failure. The day had not come for Alabama coal, nor for the Cahaba, the Newcastle, the Spencer mines, and others. Perhaps the first real success in profitable mining in the State was made by Messrs. T. H. Aldrich & Co., who leased a mine and worked and continue to work the Montevallo coal, a coal superior to any coal in the United States as a grate coal, fully equal to English cannel coal. In 1872 only 10,000 tons of coal were mined in Alabama. In 1879 the Pratt Coal and Coke Company went to work operating the Pratt seam for steam, coke, and gas purposes, and the Helena seam for grate and coke purposes; this was a new era in the coal business of the State, and much credit is due to Mr. H. F. DeBardeleben, the originator and principal owner of this company, who had the foresight to see the future that awaited the coal industry in Alabama.

The Warrior coal field is the particular portion of the coal area in the State which has received most attention, and it may be expected to produce the largest amount of coal. There has been a new trade developed in this Alabama coal, at Mobile. In fact supplies have been sent to New Orleans, where it competes with the Pittsburgh coal coming down the Ohio and Mississippi rivers. This coal should also supply the West Indies and Central America.

There are three troughs or synclinal basins in the Warrior coal field, with local wrinkles, each one resembling in form a long shallow tray, with seams dipping at the edges and ends, but nearly horizontal in the center. The first extends from near Birmingham, going westerly, to a point near the Warrior river, in the great Sequatchie fold, which extends from Tennessee southwesterly, in a straight line with Sequatchie valley, in that State, and its continuation, Brown's valley, in Alabama, crossing the Black Warrior river at a point near the mouth of Five-mile creek. The second extends from this Sequatchie fold, or its continuation, to Byler's Ridge, which forms the shed between the water of the Black Warrior and West Sipsy, a tributary of the Tombigbee. The third extends from Byler's Ridge to the western edge of the coal field, and is the smallest and least important of the three coal basins mentioned.

In the first two basins, which may be designated, respectively, the Birmingham basin and the Jasper basin, there are not less, according to Prof. E. A. Smith, State Geologist of Alabama, than 2,600 feet of coal measures, including between thirty and thirty-five seams of coal, five of which have been extensively mined.

The appended analyses will serve to show the character of the coal in this coal field:

	Pratt.	Williams.	Jaggers.	Lost creek.
Volatile matter	31.48	26.17	29.04	33.78
Fixed carbon	61.60	66.02	56.53	57.00
Water	1.50	1.52	3.09	2.26
Ash	5.42	6.28	11.38	6.95
Sulphur	.92	.60	.57	.73

The following statement of the output has been made:

	Gross tons.
1873	40,000
1874	45,000
1875	60,000
1876	100,000
1877	175,000
1878	200,000
1879	250,000
1880	340,000
1881	375,000
1882	800,000

ARIZONA.

In the Gallup coal field, on the line of the Atlantic and Pacific railroad, are seams of coal up to 6 feet in thickness. The seams thus far proved are: One of 4 feet; one, 4 feet 8 inches; one, 5 feet 10 inches; one, 6 feet. They are horizontal or nearly so, and the coal is easily worked. The coal is brought to the surface by mules working a whim, and is sold for $3 a ton at the mines. Shipments have been made to points along the line of the railroad, as far as Albuquerque, New Mexico. The coal is bituminous in character and compact. It is not a coking coal, but for steam purposes it is excellent, and for railroad use cannot be surpassed. Heretofore the fuel used has been red cedar at $10 per cord.

ARKANSAS.

The coal field of Arkansas has an area of 12,000 square miles, in twelve counties. The coal found is semi-bituminous or semi-anthracite. A bed of semi-bituminous coal nine feet thick is reported in Sebastian county. The Spadra semi-anthracite is the only coal that is known in market to any extent, and an account of its location, etc., will prove interesting: "This name is given to a deposit of semi-anthracite coal, 3 feet thick, found at Spadra, in Johnson county, 105 miles from Little Rock, now being worked by the Spadra Coal and Iron Company. It lies almost horizontal, with a slight dip to the north. It crops out on the river bank, and is traceable along the river front. On digging anywhere, the same vein, from 3½ to 4 feet thick, is invariably struck within 55 feet of the level of the river front. The product is about 5,000 tons. The existence of a second vein, which is, as near as can be ascertained, about 30 feet below the one now working, is a matter of development. The coal can be placed at Little Rock at $3.25 a ton; at the mouth of the Arkansas river, $3.75 a ton; at New Orleans, $5 a ton; at Saint Louis, $6.75 per ton."

The only coal to compete with on the lower Mississippi, from the mouth of the Arkansas to New Orleans, 600 miles—which section of country consumes about one million of tons per annum—is the bituminous coal principally furnished by Pittsburgh.

The mines of the Ouita Coal Company, producing an excellent variety of this semi-anthracite, are 72 miles from Little Rock; the vein is 32 inches thick. Analysis gave 80.46 fixed carbon; 12.66 volatile matter; ash, 5.11; water, 1.77; color of ash, light brown.

Professor Owen gives an analysis of the coal in the First Geological Report on Arkansas, page 130. It was also analyzed by Mr. I. A. Liebig, and by Mr. L. C. Bierwirth, with the following results:

	Owen.	Liebig.	Bierwirth.
Moisture	0.5	1.524	0.680
Volatile and combustible gases	7.9	7.527	10.521
Fixed carbon	85.6	85.481	83.719
Ashes	6.0	5.468	5.080
Total	100.	100.	100.
Specific gravity	1.335	1.3408	1.3112

COLORADO.

The deposits of coal in Colorado are of great extent, and are found in almost every section of the State. The coal area has been variously estimated at from 20,000 to 50,000 square miles. The known and partially developed coal fields cover about 1,500 square miles, while the area of the Laramie, Fox Hills, and Colorado Cretaceous formations which are coal-bearing comprises about one-third of the surface of the State, or approximately 35,000 square miles.

Coal mining in Colorado is yet in its first stages, the development of the mines keeping pace with the growth of the State. Except in the immediate neighborhood of Golden, no depth has as yet been attained, only those veins having been opened to any extent which crop on the surface. The rapid growth of the manufacturing and railroad interests in the State has of late created a large demand for fuel, which has caused the opening of a number of new mines and the resumption of work on many old and abandoned claims.

North of the divide and east of the mountains whence Denver draws its principal supply of fuel, coal is found in Jefferson, Boulder, and Weld counties, in which region some twenty mines are being worked. The leading ones are the Marshall, Fox, Welch, Boulder Valley, Northrop, Stewart, Superior, Mitchell, Garfield, Briggs, and the Star. The coal from this district is a free-burning lignite of jet black color, high luster, and of a specific gravity averaging about 1.33. As a rule it is wholly destitute of any fibrous or woody structure, and contains less than .4 per cent. sulphur. The proportion of ash varies from 2 to 8 per cent., averaging about 4.5. It is in general use for domestic purposes, for locomotives, and for blacksmithing. The veins which are worked vary in width from 3 to 12 feet, and average about 6 feet.

The following analyses show the characteristics of the coal from the various mines of northern Colorado:

Golden:

	No. 1.	No. 2.
Water	13.43	13.67
Volatile matter	37.15	34.75
Fixed carbon	45.57	47.58
Ash	3.85	4.00
	100.00	100.00

From the Murphy mine on Ralston creek, Jefferson county:

Water	13.83
Volatile matter	35.88
Fixed carbon	44.44
Ash	5.85
	100.00

From the Marshall mine at Langford, Boulder county:

Water	12.00
Volatile matter	26.00
Fixed carbon	59.20
Ash	2.80
	100.00

From the Erie mine at Erie, on Coal creek, Weld county:

Water	14.80
Volatile matter	34.50
Fixed carbon	47.30
Ash	3.40
	100.00

The coal mines of northern Colorado stand second in the list of producers, their output being exceeded only by the mines of southern Colorado, which section includes the mines of Las Animas county.

The middle division includes the counties of Park, Fremont, and El Paso. In El Paso county the only mines worked to any extent are those owned by the Denver and New Orleans Railroad Company at Franceville. The coal is an average grade lignite, slacking readily upon exposure to the atmosphere, but suitable for all domestic and heating purposes. The product of these mines has only become available since the completion of the Denver and New Orleans Railroad in July, 1882. Since that time active work has been prosecuted, and the output has rapidly increased. The following was the monthly output in 1882:

	Pounds.
July	2,243,425
August	5,432,100
September	9,836,440
October	9,830,236
November	10,017,700
December	10,017,700
Total	47,377,601

In all, 23,694 net tons.

The following is an analysis of the coal:

Water	12.90
Volatile matter	39.10
Fixed carbon	46.00
Ash	12.00
Total	100.00

In Park county the coal mines are at Como, and are owned by the Denver, South Park, and Pacific Railroad Company. They produce a good coking coal, a small part of which is made into coke, but the greater part is consumed by the railway company. The bank is known as the Lechner, and averages about 6 feet in width.

The principal mines in Fremont county are the Oak Creek No. 1, Oak Creek No. 2, and the Coal Creek. The coal is semi-bituminous, and when mixed with bituminous coals from El Moro makes an excellent coke. Its composition is shown by the following analyses of Cañon coal:

No. 1.

Water	4.50
Volatile matter	34.20
Fixed carbon	56.80
Ash	4.50
	100.00
Sulphur	0.35

No. 2.

Water	5.49
Volatile matter	39.33
Fixed carbon	51.01
Ash	4.17
	100.00
Sulphur	0.35

The mines are owned and worked principally by the Denver and Rio Grande Railroad Company and the Atchison, Topeka, and Santa Fé Railroad Company. The coal ranks first in the State for all domestic purposes, and is largely used in Denver, while Cañon City and Pueblo derive their supply almost entirely from these mines.

The southern division includes the counties of Las Animas, Huerfano, La Plata, and Dolores, and is by far the largest producer in Colorado. The coal of Las Animas county is, as a rule, bituminous, and large quantities are made into coke for the use of smelters in Colorado and New Mexico.

Its composition is shown by the following analyses:

Analyses of Cucharas coal.

	4-foot seam.	7-foot seam.
Water	3.23	2.97
Volatile matter	40.93	40.08
Fixed carbon	49.54	48.67
Ash	6.30	8.28
	100.00	100.00
Sulphur	0.62	0.65

Analyses of El Moro coal.

	No. 1.	No. 2.	No. 3.
Water	0.26	1.66	1.34
Volatile matter	29.66	34.48	35.79
Fixed carbon	65.76	60.08	54.75
Ash	4.32	3.78	8.12
	100.00	100.00	100.00

The following is an analysis of coke produced at El Moro:

Volatile matter	1.85
Fixed carbon	87.47
Ash	10.68
	100.00
Sulphur	0.85

The El Moro vein is from 10 to 12 feet thick, is nearly horizontal, and its productive capacity is now about 2,000 tons per day, but this amount could be greatly increased.

The Cucharas deposit is situated near Walsenburg in Huerfano county. One vein only has been heretofore developed. This is 7 feet thick, and the coal is very similar to the Cañon City coal, affording an excellent fuel for steam and domestic purposes.

The mines of Las Animas, Huerfano, and Fremont counties are mainly owned and operated by the Colorado Coal and Iron Company, a corporation which is closely allied to the Denver and Rio Grande Railroad Company. The growth of the industry in these counties is shown by the following statement of the product of the Colorado Coal and Iron Company since 1872. The product of the last two years includes the output of the company's mines at Crested Butte, Gunnison county, amounting in 1881 to but a few tons, and in 1882 to 38,909 tons:

	Net tons.
1873	12,187
1874	18,092
1875	15,278
1876	20,316
1877	44,410
1878	82,140
1879	120,102
1880	221,378
1881	350,944
1882	511,239

The coal veins of La Plata county are said to be the largest yet discovered in Colorado, and vary from 12 to 90 feet in thickness. The Durango vein is said to be 13 feet thick, the Peacock 75, and the California considerably over 75 feet. The coal produced by these veins is an excellent lignite, which in some cases is sufficiently bituminous to produce good coke. The distance of Durango from any but a restricted market will for a long time retard the development of the coal veins in its neighborhood. At present the mines supply the small local demand, and about one-quarter of the quantity of fuel used by the Durango branch of the Denver and Rio Grande railroad, the greater portion being derived chiefly from the mines at Monero, New Mexico.

The coal veins at Rico, in Dolores county, vary from 2 to 6 feet in width, and produce excellent coking coal, but the limited demand for home consumption—about 2,500 tons annually—prevents their full development.

The northwestern division embraces Gunnison, Pitkin, Summit, Routt, and neighboring counties. The most extensive developments are at Crested Butte, Gunnison county. In some respects this is the most important coal bed in the State, producing as it does the best coking coal, and, with the exception of the limited beds in the Los Cerillos mountains, New Mexico, is the only true anthracite coal found west of the Alleghanies.

The bituminous coal occurs in four veins of 4 feet, 5 feet, 6 feet, and 10 feet thickness, the 10-foot vein only being opened to any great extent. The following analyses will show the composition of the different varieties of Crested Butte coal, and the quality of the coke manufactured from the bituminous variety:

Analyses of Crested Butte bituminous coal.

	No. 1.	No. 2.	No. 3.	No. 4.
Water	3.70	.72	1.10	.44
Volatile matter	30.97	23.44	23.20	24.17
Fixed carbon	61.07	71.91	72.60	72.30
Ash	4.47	3.93	3.10	3.09
	100.21	100.00	100.00	100.00

Analysis of Crested Butte anthracite.

Water	1.588
Volatile matter	5.862
Fixed carbon	89.780
Ash (red)	2.770
	100.000

The following is an average of a large number of analyses made at different times and by different chemists:

Water	1.20
Volatile matter	5.16
Fixed carbon	90.24
Ash (red)	3.40
	100.00

Analyses of Anthracite Mesa coal.

	3-foot vein.	6-foot vein.
Water and volatile matter	5.17	6.29
Fixed carbon	90.65	89.89
Ash	4.18	3.82
	100.00	100.00

The comparative values of coke from El Moro, Crested Butte, and Connellsville, Pennsylvania, may be readily seen by an examination of the following analyses:

	Water and volatile matter.	Fixed carbon.	Ash.	Sulphur.
El Moro	1.85	87.47	10.68	0.85
Crested Butte	1.35	92.03	6.62	....
Connellsville	....	87.26	11.79	0.75

The anthracite coal is here found over an extensive territory, but only a portion of it is easily mined and of good quality. The best quality of it is found at the head of Anthracite creek, near Irwin, and on Slate river, within a short distance of Crested Butte. Large beds of anthracite coal have been discovered on the North Fork of the Gunnison river, but as far as known from present development, the quality of the coal is inferior to that found near Crested Butte.

The Cutler banks in Uncompahgre county, on the divide between the Cimarron and the Uncompahgre, produce a medium-grade lignite, suitable especially for domestic and railway purposes. There are four principal veins, 21 feet, 14 feet, 12 feet, and 6 feet in width. They have as yet been only partially opened, but their proximity to the Utah extension of the Denver and Rio Grande railroad will cause their early development.

Analysis of coal from Cutler banks.

Water	7.26
Volatile matter	43.42
Fixed carbon	41.72
Ash	7.60
	100.00

This coal does not coke.

A vein of semi-anthracite coal occurs in the cañon of the Uncompahgre, about 5 miles north of Uncompahgre park. The vein is about 2½ feet in width, and some small amounts of the product are freighted to Ouray. The composition is shown below:

Water	1.86
Volatile matter	10.70
Fixed carbon	77.32
Ash	10.12
	100.00

The anthracitic character of this coal is thought to be due to the igneous dikes in the vicinity of the outcrops.

Coal veins are known to exist in Pitkin county, near Rock creek; at Garfield, in Chaffee county, and in Summit, Routt, and Grand counties, but their remoteness from market, and the absence of any demand, make them valueless at present. The completion of the Denver, Utah, and Northwestern railroad through the North Park will create a demand which will put the veins in Summit, Grand, and Routt counties on the list of active producers.

The production of coal in Colorado has steadily increased since the mines in Boulder and Jefferson counties were first opened. In the decade from 1860 to 1870 considerable quantities of coal were mined for domestic uses in Golden, Denver, Boulder, Black Hawk, and Central, the principal supply coming from the mines near Golden, and on Ralston creek, 10 miles north. The Marshall coal bank assumed importance as a producer in 1865, although previous to that time the ranchmen in the neighborhood had hauled away small quantities of coal. The completion in the summer of 1870 of the Denver Pacific railroad from Cheyenne to Denver, the Kansas Pacific, and the Colorado Central from Denver to Golden, created a large demand upon the mines of Jefferson and Boulder counties. The completion of the Boulder Valley railroad from Brighton to Boulder, in 1873, opened to market the mines of Weld and Boulder counties, where the present coal-mining towns of Erie and Canfield now stand.

The following table shows the growth of coal mining near Golden:

	Net tons.
1864	*a* 500
1865	*a* 1,200
1866	*a b* 6,400
1867	*a b* 17,000
1868	*a b* 10,500

a Estimated. *b* Includes product of Marshall mine, Boulder county.

	Net tons.
1869	*a b* 8,000
1870	*a b* 13,500
1871	*a b* 15,860
1872	*a b* 14,200
1873	*a b* 14,000
1874	*a b* 15,000
1875	*b* 23,700
1876	*a b* 28,750
1877	*a* 30,000
1878	31,400
1879	33,435
1880	36,500
1881	37,625
1882	46,264

The amount of coal shipped from the mines in the vicinity of Erie and Canfield, from the completion of the Boulder Valley road in 1872 to 1877, is shown by the following figures, as furnished by the auditor of the Denver Pacific railroad:

	Net tons.
1872	54,340
1873	43,790
1874	44,280
1875	59,860
1876	68,600

The estimates of the production of the northern division for the years 1877 and 1879 are taken from Fossett's "Colorado," which is generally accepted as an authority in statistical matters. The average thickness of all the beds composing the Jefferson county coal field is from 30 to 35 feet. These beds have been explored to a depth of over 600 feet—the deepest coal mining in the Far West. At this depth the coal is dense, hard, free from mechanical moisture, and of superior quality as fuel, resembling anthracite in many of its properties.

All the coal mined in northern Colorado is used on the divisions of the Union Pacific railroad in Colorado, the Denver, Utah, and Pacific railroad, and in Denver and the agricultural mining towns north of the divide. The capacity of the various mines at Erie, Canfield, Louisville, and Langford, on January 1, 1883, has been estimated by Major McDowell, of Erie, to be as follows:

Erie and Canfield:

	Tons daily.
Star mine	100
Jackson mine	150
Northrop mine	150
Briggs mine	12
Garfield mine	36
Stewart mine	150
Superior mine	18
Mitchell mine	200
Erie mine	200

a Estimated. *b* Includes product of Marshall mine, Boulder county.

Louisville:

	Tons daily.
Louisville or Welch mine	500

Langford:

Marshall mine (2 slopes)	300
Fox mine (1 slope)	100
Black Diamond mine	25

The mines at Franceville, which are owned by the Denver and New Orleans Railroad Company, have only recently been opened to any extent, and their capacity is not yet known. The vein is about 9 feet thick, and produces at present about 150 tons daily. The coal is used for fuel on the Denver and New Orleans railroad, and is burned in considerable quantities in Colorado Springs and Denver.

The coal from the mines at Trinidad, Walsenburg, and Cañon City is used by the locomotives of the Denver and Rio Grande railroad, by the Colorado Coal and Iron Company at Pueblo, the Atchison, Topeka, and Santa Fé railroad, and in large quantity at Denver for domestic purposes, and exclusively at Cañon, Pueblo, and other southern towns. Until the opening of the bituminous coal banks at Crested Butte, the product of the Trinidad mines was used for making gas in all the gas works in Colorado, and the largest portion of the coke used in western smelters is yet made from it.

The coal from the bituminous mines at Crested Butte is now exclusively used in gas-making in Pueblo, Denver, Leadville, Gunnison, and other cities in Colorado.

The Colorado Coal and Iron Company have erected a number of coking ovens at the latter point, and since the opening of the Denver and Rio Grande railroad to Salt Lake City are shipping considerable quantities of coal and coke to Utah. Small quantities of Crested Butte coal are used east of the continental divide, but the principal part of the product is consumed in Gunnison and other western counties.

Mr. Chisolm, in summing up the production statistics of the State, writes: "The statement of the product of Colorado since 1865 is the result of close and careful research. Every doubtful element in the estimate has been eliminated, and the total for each year is, if anything, probably lower than the actual output. Prior to 1872 the output is estimated entirely; after that year it is partly estimated and partly derived from reliable sources. For the years 1877, 1878, and 1880, the product is adopted entirely from Fossett. The output in 1882 and for the first six months of 1883 is that given by my returns."

Coal product of Colorado from 1864 *to* 1883.

	Net tons.
1864. Jefferson and Boulder counties	500
1865. Jefferson and Boulder counties	1,200
1866. Jefferson and Boulder counties	6,400
1867. Jefferson and Boulder counties	17,000
1868. Jefferson and Boulder counties	10,500

			Net tons.
1869.	Jefferson and Boulder counties		8,000
1870.	Jefferson and Boulder counties		13,500
1871.	Jefferson and Boulder counties		15,860
1872.	Jefferson and Boulder counties	14,200	
	Weld county	54,340	
			68,540
1873.	Jefferson and Boulder counties	14,000	
	Weld county	43,790	
	Las Animas and Fremont counties	12,187	
			69,977
1874.	Jefferson and Boulder counties	15,000	
	Weld county	44,280	
	Las Animas and Fremont counties	18,092	
			77,372
1875.	Jefferson and Boulder counties	23,700	
	Weld county	59,860	
	Las Animas and Fremont counties	15,278	
			98,838
1876.	Jefferson and Boulder counties	28,750	
	Weld county	68,600	
	Las Animas and Fremont counties	20,316	
			117,666
1877			160,000
1878.	Northern division	87,825	
	Central division	73,137	
	Southern division	39,668	
			200,630
1879.	Northern division	182,630	
	Central division	70,647	
	Southern division	69,455	
			322,732
1880.	Northern division	123,518	
	Central division	136,020	
	Southern division	126,403	
	Northwestern division	1,064	
	Unreported mines	50,000	
			a 437,500
1881.	Northern division	156,126	
	Central division	174,882	
	Southern division	269,045	
	Northwestern division	6,691	
	Unreported mines	100,000	
			706,744
1882.	Northern division:		
	Mines near Erie and Canfield	88,000	
	Louisville	90,000	
	Langford	92,000	
	Golden	30,000	
			300,000
	Central division:		
	Mines near Franceville	23,694	
	Como	60,000	
	Cañon City	160,000	
			243,694

a This is widely at variance with Mr. Saward's estimate of 575,000 long tons, and is confessedly below the truth.

		Net tons.
Southern division:		
Mines near El Moro and Trinidad	370,185	
Walsenburg	96,200	
Rico	2,000	
Durango	5,900	
		474,285
Northwestern division:		
Mines near Crested Butte	43,500	
		43,500
		1,061,479
1883—first six months:		
Northern division:		
Mines near Erie and Canfield, estimated	41,500	
Louisville	50,198	
Langford	32,827	
Golden	8,776	
		133,301
Central division:		
Mines near Franceville	35,880	
Como	31,572	
Cañon City	129,305	
		196,757
Southern division:		
Mines near El Moro and Trinidad	180,696	
Walsenburg	40,751	
Durango and Rico	5,500	
		226,947
Northwestern division:		
Mines near Gunnison and Crested Butte	38,474	
		38,474
Total		595,479

The wages paid in coal mining vary from 90 cents to $1.50 per ton of coal mined.

The value of the State's product in 1882 may be averaged at $2.25 at the mines—a total of $2,388,328. The price of coal at retail in Denver varies from $3 to $9 per ton for Gunnison anthracite, the average price of lignite being $4.50 per ton.

The average number of men employed in coal mining is 1,781.

During the first six months of 1883 the amount of coke made in Colorado was as follows:

			Net tons.	Pounds.
Colorado Coal and Iron Company:				
Trinidad	50,411	400		
Crested Butte	9,185	1,400		
			59,596	1,800
Trinidad Coal and Coking Company, Trinidad			13,892	692
Grand View Mining and Smelting Company, Rico			720	
Total			74,209	492

DAKOTA.

In Dakota coal occurs in quite extensive beds, which have remained entirely undeveloped. Some slight work has been done on a 1,600-acre tract of coal land on Hay creek, near the Black Hills; and in 1880 it was proposed to construct a railroad to the coal field, about 30 miles north of Deadwood, but the project failed of realization. In 1874 Government land office reports estimated the coal area of the Territory at 100,000 square miles, but this is probably excessive.

IDAHO.

Bituminous coal and lignite, some of which burns tolerably well, have been found at many points in Idaho. Beds of these varieties of coal have been discovered on Reynolds's creek, Owyhee county, where a tunnel, after being driven a distance of 30 feet, exposed a vein of coal 12 feet in thickness. Should this deposit prove to be heavy, and of even a moderately good quality, the find will greatly benefit this portion of the Territory, as it abounds in valuable mines, and contains but little timber, scarcely any of which is fit for lumber.

A fine variety of lignite has been found at many different points in the vicinity of Boisé City. The "float" picked up, no regular beds having yet been discovered here, resembles cannel coal, and is said to burn well. As wood is becoming scarce, the discovery of a good mineral fuel in this neighborhood is already a desideratum. Similar "float," and in some places quite heavy deposits of lignite, have been met with along the foot-hills from a point 50 miles southeast of Boisé City all the way to the Lewis and Snake rivers. This lignite burns in grates freely, emits much heat, leaves but little ash, and has little sulphur. Small quantities of lignite, with siliceous fossil wood, are met with in the auriferous placers of Boisé basin. These have only mineralogical interest.

The present product of Idaho is insignificant, and no record of the scattering lots of a few tons each which have been mined is obtainable.

ILLINOIS.

The valuable features of the coal found in this State are that there is plenty of it, that it is very widely distributed over the State, and that it is readily accessible. Although it is generally necessary to mine it by means of shafts, the coal is reached at so reasonable a depth from the surface that its mining is done without unusual expense. The number of railroads traversing all parts of this State, with good level grades and without curves, furnish an abundance of cheap transportation, and there is a large market for the coal that is produced.

The valuable iron-smelting Big Muddy coal, found in the southern part of the State, and extensively used at Saint Louis, as well as some of a fair quality in other localities, would lead to the hope of yet finding coal of a better quality than much of that which is now mined.

The United States Census of 1880 reports the production of coal in Illinois at 6,115,337 tons. To those accustomed to the large production of the mines of Pennsylvania, these figures may appear small, but it should be considered that the coal business in the West is yet in its infancy. In La Salle county there are three seams of coal, the upper 4½ to 5 feet thick, the middle usually 6 feet, and the lower 4 feet. The most popular in the market is the middle, as it makes a dense fire, and the coal is largely used for steam and domestic uses.

Twenty-five counties of Illinois are now engaged in mining coal The total area of 32 counties embraced within the boundaries of the coal field is 18,864 square miles. If we deduct over one-half of this area for portions of the district where coal will never be found, because of the seams being washed out by the streams and rivers, or from the failure of the seam from any other cause, we shall have at least 9,000 square miles of a 4-foot seam of coal. In every acre of land bearing a 4-foot seam there are 5,000 tons of coal, or 3,205,000 tons to the square mile, or a total of 28,845,000,000 tons.

Saint Louis, Missouri, obtains a large supply of bituminous coal from the Belleville district, in Saint Clair county, Illinois. This county shows a very large coal area, and the output in 1882 was 865,685 tons. The coal seam is 7 feet in thickness, and contains 55.2 fixed carbon and 33.8 volatile matter. There are some very large mining concerns in this district, the most prominent being the Carbondale Coal and Coke Company. A large business was done in making coke last year, 260,000 tons having been received at Saint Louis. Peoria county is reported as having turned out 419,087 tons of coal in 1882. The Streator coal field is also an important district, and the output last year was 721,559 tons.

The output of coal in Illinois is likely to largely increase; the growth in ten years is shown in the fact that whereas the census of 1870 gave credit for a production of 2,624,163 tons in this State, that for 1880 gave a tonnage of 6,115,377 tons. The mine inspectors give an estimated return for 1882 at 9,115,653 tons. Having these facts in hand, a return of the output since 1873 is not without interest:

	Gross tons.
1873	3,500,000
1874	3,000,000
1875	3,500,000
1876	3,500,000
1877	3,500,000
1878	3,500,000
1879	3,500,000
1880	4,000,000
1881	6,000,000
1882	9,000,000

Analyses of some Illinois coals.

Designation.	Water.	Ash.	Volatile matter.	Fixed carbon.
Bloomington, McLean county	7.90	4.96	34.02	53.12
Blair Bluff, Henry county	12.60	9.90	28.96	48.54
Barclay, Sangamon county	10.80	17.10	27.32	44.78
Carbondale, Jackson county	6.36	7.40	26.40	59.84
Catlin, Vermillion county	7.80	12.70	31.08	48.42
Danville, Vermillion county	9.60	14.64	31.20	44.56
DuQuoin, Perry county	8.86	7.00	23.54	60.60
Elmwood, Peoria county	7.60	9.50	27.60	55.30
Farmington, Fulton county	8.52	11.72	29.28	50.48
Grape Creek, Vermillion county	9.74	10.60	28.34	51.32
Kewanee, Henry county	15.60	7.14	27.60	49.66
Lincoln, Logan county	10.92	14.84	27.60	46.64
Lombardville, Stark county	9.42	7.46	31.38	51.74
Mt. Carbon, Jackson county	6.12	2.70	24.68	66.50
Oglesby, La Salle county, second vein	12.12	7.72	30.84	49.32
Oglesby, La Salle county, third vein	10.06	3.72	30.34	55.88
Peru, La Salle county, second and third veins	10.30	4.54	33.90	51.26

INDIAN TERRITORY.

At Savanna and Lehigh are located the coal mines which supply the great system of roads operated by the Gould combination. From these mines all the roads in Texas are supplied with fuel, including the Galveston, Harrisburg, and San Antonio; Gulf, Colorado, and Santa Fé; and Houston and Texas Central roads, which are not in the Gould combination. The coal is in great demand by gas companies, being shipped to Atchison, Topeka, and Lawrence, Kansas; Kansas City, Missouri; and Dallas, Fort Worth, Waco, San Antonio, and all principal Texas cities.

The following analyses will show the comparative value of the Savanna coal:

	Water.	Volatile.	Carbon.	Ash.
Pittsburgh coal	1.04	36.75	57.80	4.41
Savanna, Ind. T., coal	2.90	36.79	56.41	3.99

At Savanna the Atoka Coal Mining Company now has two mines partially developed, with a capacity of 1,000 tons daily, but will have the output increased to 2,000 tons per day by September 1, 1883. The coal is from 4 to 4 feet 8 inches in thickness, and very firm, with fire-clay bottom and soapstone top. The mines are slopes, and from 4 to 8 tons can be brought up at each trip, or every three or five minutes a half car-load of coal is brought to the surface. The machinery for this work is very powerful, and the entire equipment first class in every particular. At this place the company has under lease and controls fully 30,000 acres of fine coal land.

At Lehigh, about eight miles west of Atoka, a station on the Missouri, Kansas, and Texas railroad, and only 60 miles from the Texas line, the company have two mines partially opened, which produce about 600 tons daily. The capacity of these mines will be doubled by September 1, 1883. These mines are worked on the long-wall plan, the coal being but 4 feet thick and of a different nature from that found at Savanna, being similar to that found in Illinois, opposite Saint Louis.

The cost of producing this coal is much greater than in the Eastern States, but the company has been obtaining for it from \$2.50 to \$2.75 per ton. The superior quality of Savanna coal has attracted the attention of coke men, and an experimental oven is to be built for the purpose of giving it a thorough test in the manufacture of coke, for which it seems to be suitable.

INDIANA.

The area of the Indiana Coal Measures approximates one-fifth of the entire State, and embraces the counties of Perry, Spencer, Warwick, Posey, Vanderberg, Gibson, Pike, Dubois, Daviess, Knox, Martin, Sullivan, Greene, Clay, Vigo, Parke, Vermillion, and Fountain. The most important coals, from a manufacturing point of view, are those known as the "lower block," 3 feet 8 inches thick; the "main block," 4 feet 4 inches thick, and "upper block," 1 foot 10 inches thick. Block coal has a laminated structure, and is composed of alternate thin layers of vitreous dull-black coal and fibrous mineral charcoal. It splits readily into sheets, breaking with difficulty in the opposite direction. On burning, it scarcely swells or changes form, and never cakes or runs together. What the celebrated English chemist, Mushet, said about a certain Welsh coal, is equally applicable to the block coal of Indiana. To the purity of splint coal it unites all the softness and combustibility of wood, and the effects produced by it in the blast furnace, either as to the quality or quantity of iron, are claimed to exceed everything in the manufacture of that metal with charcoal. From careful analyses it is ascertained that this coal gives from 56 to 62 per cent. of fixed carbon, a small amount of water, and a small amount of ash. Dr. E. T. Cox, the geologist, gave this coal an exceptional character as an iron-smelting fuel, and reports a ton of pig iron as being made with 4,250 pounds of block coal.

The coal in Clay county is favorably known as an iron-smelting fuel, and its qualities are thus described: "There are two veins of coal, the upper averaging about 3 feet 10 inches in thickness and the lower averaging about 4 feet. The roof is principally sand rock, slate, and slate and sand rock mixed. Fire and potters' clay of good quality underlie the coal. The average depth to the first vein is about 45 feet from the surface, and the second or lower vein is found at an average depth of 75 to 80 feet. The coal is free from slate and sulphur. It burns freely, and leaves a soft, fine white ash, similar to wood ash, and no clinkers." For domestic and steam purposes, the coal is largely used in all the cities and towns, both of this and adjoining States, as transportation facilities are of the most extended character.

In the block-coal zone of the Indiana coal fields there are as many as eight seams of non-caking coal, four of which are of good workable thickness over a portion of the field. These are I, G, F, and A, which together have a maximum thickness of 15 feet; and by including the other four seams we have 6 feet more, making a total of 21 feet of block coal.

The coal of Parke county is favorably reported on for the manufacture of iron. It is a block coal, averaging 5 feet in thickness, weighing 77 pounds to the cubic foot, and gives by analysis 62.5 fixed carbon, 31.00 volatile matter, 4.05 water, and 2 per cent. of ash. The estimated area is about 300 square miles of workable coal.

The "upper block," at Washington, in Daviess county, is extensively mined, and meets with a ready market at Saint Louis and all the towns on the Ohio and Mississippi railroad. Its specific gravity is 1.294; a cubic foot weighs 80.87 pounds; by analysis it yields: fixed carbon, 60.00; ash, 4.50; volatile matter, 35.50. The coal worked is known as L, a 5-foot seam of bituminous, an excellent caking coal, free from impurities, which may be handled and stocked without much loss. It has been used for gas-making at Saint Louis, and is a 3-foot 10-inch seam of very pure coal, jet black, of cubical fracture, and bears a good reputation as a fuel for general uses.

All the coals of the Indiana field belong to the class known as bituminous. The principal varieties may be designated as follows:

Caking coal, long flame, gas and smith coal, fat coal.

Semi-caking coal, long flame.

Block coal, non-caking coal, long flame, dry burning coal, furnace coal.

Semi-block coal, long flame.

Cannel coal, long bright flame, dry burning, gas coal.

The following analyses will serve to show the character of the Indiana coals:

	Fixed carbon.	Volatile matter.	Water.	Ash.
Founi n county	54.5	36.0	5.0	4.5
Vandr berg county	48.5	42.0	3.5	6.0
Warwick county	49.5	41.5	3.5	5.5
Posey county	51.0	39.5	4.0	5.5
Sullivan county	55.0	40.0	3.5	1.5
Daviess county	53.5	36.0	5.5	5.0
Vermillion county	46.0	44.0	5.5	4.5
Parke county	46.5	46.0	4.0	3.5
Montgomery county	52.0	41.5	3.0	3.5
Clay county	61.5	32.5	3.5	2.5
Owen county	57.5	38.5	2.0	2.0
Greene county	63.0	29.5	7.0	0.5

The coal of Pike and adjoining counties has attracted much attention within the past year. Coal can be mined here cheaper than in any other coal field in the State, as the mines are nearly level, and free of water, being approached from the large ravines that extend through this section. The coal of this new district is not of the best quality, but it will compare very favorably with the majority of coals in the State. The seams are generally level. Most of the openings are drifts. The seam is reached in some places by slopes, and in some few places shafts are sunk. The seam is shallow in the ravines, but there is a very heavy body of rock over it in the large hills that extend over this entire region. This area is reached by two new railways—the New Albany and Saint Louis Air-Line road, and the Evansville and Indianapolis railway.

In order to show the progress of coal mining in this State, the following statement of the production during recent years is appended:

	Gross tons.
1873	1,000,000
1874	812,000
1875	800,000
1876	950,000
1877	1,000,000
1878	1,000,000
1879	1,196,490
1880	1,500,000
1881	1,771,536
1882	1,976,470

The report of the mine inspector for last year shows that whereas the mines in 1881 numbered but 86, they had increased to 214, but the output is not so much larger; there will doubtless be considerable increase during 1883, from the improvements made last year.

In Census Bulletin No. 273 the following results are reached from a study of 100 typical Indiana mines, classified on the basis of power used:

Comparison of results in coal mining in Indiana.

Class 1.—Mines using no power to supplement manual labor.
Class 2.—Mines using the power of animals only.
Class 3.—Mines using boiler-power not exceeding 100 horse-power.
Class 4.—Mines using boiler-power exceeding 100 horse-power.

	Class 1.	Class 2.	Class 3.	Class 4.	Total.
Number of mines in class	12	36	48	4	100
Aggregate maximum yearly capacity, net tons	42,808	430,082	2,000,000	314,820	2,787,710
Product census year, net tons	9,807	143,657	1,144,243	122,617	1,420,324
Value of census year's product at mines	$13,291	$214,924	$1,705,166	$186,704	$2,120,085
Average yearly product, net tons per mine	817	3,991	23,839	30,654	14,203
Average value per ton at mine	$1 35	$1 50	$1 49	$1 52	$1 49
Average cost of labor per ton mined	$0 87	$0 84	$0 97	$1 11	$0 97
Average number of days worked by each man	162	155	230	246	222
Average earnings per man, census year	$202 00	$244 00	$346 00	404 00	$337 00
Average per diem wages earned	$1 25	$1 57	$1 50	$1 64	$1 52
Average product per man per day worked, net tons	1.44	1.88	1.55	1.48	1.56
Average horse-power to mine	....	2.4	44.0	153.0	28.1
Tons mined per horse-power yearly	....	1,663	592	200	505
Per cent. of value of product paid for labor	64	56	65	73	65
Per cent. of value of product paid for materials	5.0	14.6	7.0	7.0	7.8
Per cent. of value of product for profits, including interest, repairs, and royalty	31.0	29.4	28.0	20.0	27.2
Average number of hands to mine, all classes of labor, including superintendence	3.5	13.7	67.0	84.0	40.9

From which is deduced "the proposition that large mining establishments, which employ power and labor-saving machinery, can pay higher wages and give more steady employment to labor than smaller ones."

IOWA.

In Iowa that group or series of strata known as the Coal Measures is probably from 300 to 500 feet in thickness. Although the Coal Measures are generally spoken of as horizontal, there is a general inclination or dip to the south and west, or more properly towards the southwest. There are many places where, in limited districts, the strata may seem to be horizontal, or may even show an inclination to dip to the east, but the general tendency of all the coal-bearing, as well as other formations, is to dip to southwest. Geologists have divided the Coal Measures of Iowa into three groups, viz., the upper, middle, and lower Coal Measures. Each of these formations embraces a great many strata of various kinds of rock which are usually associated with the seams of coal of the particular measure to which they belong. The strata belonging to the Coal Measures are a succession of sandstone, limestone, sandy shale, carbonaceous shale, marl, and coal. In some places the Coal Measures are barren of any seam of coal of sufficient thickness to be worked with profit, and in some places the coal is wanting altogether; but as a general rule each of these measures carries a seam of coal that is one of the chief characteristics of that measure wherever it may exist. The upper Coal Measures lie wholly to the southward and westward of the Des Moines river. The eastern or outcropping edge of this upper horizon may be approximately traced by a line drawn from about the center of Appanoose county, in the southwestern part of the State, northwestwardly through Chariton, Guthrie, Center, and Audubon. Therefore its position is wholly in the southwest part of the State. This measure consists principally of limestone, with some fine-grained sandstone, marly shale, and coal. This formation carries only one seam of coal, which averages about 18 inches in thickness. The middle Coal Measure projects northwestwardly an average of about 25 miles beyond the edge of the upper one and the lower Coal Measure, occupying the region of the Des Moines river, some 50 miles in width, and following the river through the counties of Webster, Boone, Dallas, Polk, Warren, Marion, Mahaska, Wapello, and Van Buren. This Coal Measure contains all the larger beds of coal, and in fact about all the coal of any consequence there is in the State. The eastern edge of the lower Coal Measure, and also of the coal field of the State, extends from the southeast corner of Van Buren county north, lapping over into Lee county, in places a distance of 4 or 5 miles. Running north through Jefferson and Henry counties in the same manner, extending through Washington county to a point on Crooked creek, close to the southwest corner of Franklin township, following the creek northwestwardly some

15 or 20 miles and about 3 miles west of the city of Washington, thence west to the east line of Keokuk county, thence following almost a direct course to the Iowa river at the point where the river crosses the east line of Marshall county, thence up the river to a point about 2 miles below Iowa Falls, then west to the north line of Webster county, following the line as above described, and the northern and eastern boundaries of the Coal Measures will be found. North and east of the line it is useless to look for coal in Iowa, with the exception of the small deposit in Scott county, 8 miles west from Davenport, and from 2 to 3½ miles north of Buffalo, where there is a small district of almost one township which bears a seam of coal averaging about 3 feet in thickness. In this district are located ten mines—one slope, and nine shafts. The deepest one is 64 feet. The mines in this locality give employment in the winter season to about 125 men. This pocket of coal is not connected with any other portion of the coal field of the State, as the sub-Carboniferous rocks come to the surface between this body of coal and the Iowa coal fields, as above described; showing that there can be no connection between the two.

The production of coal has increased in this State in a very rapid ratio, as the following tabular statement will prove:

Output of coal in Iowa.

	Gross tons.
1873	350,000
1874	500,000
1875	1,000,000
1876	1,500,000
1877	1,500,000
1878	1,500,000
1879	1,600,000
1880	1,600,000
1881	1,750,000
1882	3,500,000

KENTUCKY.

The greater portion of Kentucky, excepting only those strips of territory contiguous to the Louisville and Nashville, Cincinnati Southern, and a few other roads which have been in operation for some time, is essentially an undeveloped wilderness, but one which contains perhaps greater possibilities than any other region of corresponding area in the United States. The State is divided naturally into three districts—eastern or mountainous, the central or blue-grass, and the western or Green River. The eastern district contains a coal field over 10,000 square miles in area, which, with the western field, gives the State a coal area of over 12,700 square miles, exceeding the area of the Pennsylvania coal fields, or the entire coal area of Great Britain and Ireland. This coal is mostly bituminous, and is considered among the best known for manufacturing purposes. In addition to the bituminous coal in the eastern district, there is also the largest area of cannel coal in America. This coal is from 3 to 4 feet thick, and of superior quality. There was very little coal mining done in Kentucky before the war. In 1870 the total amount mined was stated in the census report for that year to be 150,580 tons, which in 1875 was increased to 500,000 tons, and in 1882 to 1,260,300 tons. In the western field the most persistent and uniform coal of the series is D, or No. 9; it is from 4 to 6 feet thick, averaging 5 feet. It is an excellent coal for grate and furnace, and gives a good coke. A lot of slack from this vein, from the Saint Bernard mines, Earlington, washed and coked, gave a bright, firm coke. There is also coal sent out via the Kentucky and Cumberland rivers, and the Ohio, from Boyd and Lawrence counties, besides local use. The eastern coal field is credited with 500,000 tons for 1882.

Details of the production of the western coal field are given below:

Production of the western coal field of Kentucky.

	1880.	1881.	1882.
	Tons.	*Tons.*	*Tons.*
Mines on Henderson division of Louisville and Nashville ..	192, 047	283, 281	269, 600
Mines on Paducah and Elizabethtown railroad...............	234, 963	261, 000	274, 700
Mines on Green river...	100, 000	100, 000	96, 000
Mines on Ohio river, below Green river	82, 000	80, 000	60, 000
Mines on Ohio river above Green river........................	80, 000	80, 000	60, 000
Total	689, 010	804, 281	760, 300

The Straight Creek Coal Company in Carter county is working the Colton seam, 5 feet in thickness, in the eastern coal field. In Pulaski county, a company is operating quite largely a seam of 46 to 48 inches of good coal. The Mount Sterling and the Lexington Mining Companies are also developing land in Carter county. The railways are becoming large carriers of coal, and they are tending to greatly enlarge its distribution; this in turn tends to develop the coal resources of the State. In Greenup county are valuable coals for all purposes. A few sample analyses are appended:

	No. 1.	No. 2.	No. 3.	No. 4.
Volatile matter ...	39. 00	47. 36	36. 90	33. 48
Fixed carbon......	56. 00	50. 64	58. 30	60. 52
Moisture	5. 00	2. 00	4. 80	6. 00

The first and fourth are valuable for steam, and the second and third are good cannel coals. Prof. J. R. Proctor, State geologist, says: "The eastern Kentucky coal fields are even superior to those of western Kentucky, and are 10,000 square miles in extent. Coal is found in every county in a line between the Ohio river and the Tennessee State line. The thickness varies from 24 to 54 inches. In the northern part of this district are immense deposits of iron ore, and in close conjunction with coal beds. The completion of the Chesapeake and Ohio railroad, with its connections will afford greater advantages for the manufacture of iron than are possessed by the corresponding region beyond the Ohio river. In Bath county, and farther south, is the Red river car-wheel iron."

The recent survey has demonstrated the fact that the valuable deposits of coking coals which have added such wealth to Pennsylvania and West Virginia have been traced and identified in the valleys of the Cumberland, the Kentucky, and the Big Sandy, with a thickness of 7 or 8 feet. It is claimed that the analysis of the State chemist shows the coal to be equal if not superior to that of Connellsville or New river, and this will give a great impetus to the development of the region in which it lies. A statement of the output is annexed:

Total coal production of Kentucky since 1873.

	Gross tons.
1873	300,000
1874	360,000
1875	500,000
1876	650,000
1877	850,000
1878	900,000
1879	1,000,000
1880	1,000,000
1881	1,100,000
1882	1,300,000

MARYLAND.

The Cumberland (George's creek) coal field, located in Alleghany county, at the western extremity of the State of Maryland, supplies an important proportion of the semi-bituminous coal reaching the seaboard markets. The connections with the tidewater markets are: (1) via the Baltimore and Ohio railroad from the town of Cumberland, 178 miles, and Piedmont, 206 miles west from Baltimore. (2) The Chesapeake and Ohio canal, from Cumberland to Georgetown, 184 miles, and Alexandria, 191 miles. The boats carry 110 tons, and make the trip in four to five days. The canal is owned by the State of Maryland, and is managed by a board of public works. (3) The Pennsylvania State Line branch, which taps the Cumberland and Pennsylvania railroad near Mount Savage (this gives an outlet to the Pennsylvania railroad and its connections for South Amboy, New Jersey). (4) The George's Creek and Cumberland railroad, from the mines near Lonaconing to Cumberland, thence by canal; and to the Pennsylvania railroad.

The coal is bituminous, of superior quality. The vein worked is said to be 14 feet in thickness, but the full extent is seldom taken out, the roof being insecure. The mines are located at various distances from the shipping ports, say from 1½ to 20 miles from Piedmont, and from 11 to 33 miles from Cumberland. The entire length of this coal field is from

50 to 60 miles; viz., from the headwaters of George's creek, near Frostburg, about 15 miles to the northeast of Piedmont, to those of the north branch of the Potomac, some 30 miles to the southeast. The width of this valley averages 6 miles from outcrop to outcrop of the lower seams of coal. It is narrowest at the northern end, and widens out considerably at the southern. The total thickness of the coal-containing strata is about 1,400 feet, but this thickness does not pervade the entire area, as to the south of Piedmont and Bloomington the erosion has been greater, and it is only a few isolated hills that contain the upper seams of coal, and notably the "big" or 14-foot seam.

In the entire thickness there are many seams of coal, but there are only five or six of a thickness of 3 feet or over, as follows, commencing with the lowest, known as the "Parker" and "Bluebaugh" veins at the northern end of the region, and which lie near the bottom of the formation, and are crossed by the river and railroad at Piedmont:

About 150 feet above is the 6-foot seam.

About 300 feet above is the 3-foot (Savage).

About 380 feet above is the 5-foot 8-inch seam.

About 600 feet above is the 5-foot 9-inch seam.

About 850 feet above is the 14-foot or "Big vein."

The coal from the smaller veins will hardly come into use to a great extent while that from the larger continues to be offered at so low a rate as at present.

The Baltimore and Ohio railroad began carrying this coal in 1842; the Chesapeake and Ohio canal in 1850; the Pennsylvania State Line branch in 1872. The George's Creek and Cumberland railroad was completed in December, 1880.

The total business since the beginning, in 1842, to the end of 1882 foots up 41,439,452 tons, divided as below:

	Tons.
Baltimore and Ohio railroad	26,622,700
Chesapeake and Ohio canal	13,171,416
Pennsylvania railroad	1,645,336

Within the past ten years business has fluctuated as below:

Maryland coal shipments since 1873.

Years.	Baltimore and Ohio.	Chesapeake and Ohio.	Pennsylvania State Line	Total.
1873...	1,780,710	778,802	114,589	2,674,101
1874 ..	1,576,160	767,064	67,671	2,410,895
1875 ..	1,302,237	879,838	160,698	2,342,773
1876 ...	1,070,775	632,440	131,866	1,835,081
1877....	818,450	584,996	170,884	1,574,330
1878....	924,254	609,204	145,864	1,679,322
1879....	1,075,198	501,247	154,261	1,730,709
1880....	1,319,589	603,125	213,446	2,136,160
1881....	1,478,502	504,818	278,598	2,261,918
1882....	1,085,249	269,782	185,435	1,540,466

During the first six months of 1883 the mining in the coal field in this State has been carried on steadily. The season for contracting opened late, and the competition with other districts was active and bitter, so that prices were reduced to a low figure. To put the average at Georgetown, D. C., at $3 per gross ton and at Baltimore at $3.15 is a fair estimate of the actual rates. The tonnage is large this year, as compared with last, for the reason that in 1882 there was a strike against a reduction in wages from March 15 to September 20. At present wages, 50 cents per gross ton, the men are doing well, as they are fully employed.

MISSOURI.

The Coal Measures of Missouri comprise an area of about 22,995 square miles, including 160 square miles in Saint Louis county, 80 in Saint Charles, and a few outlying spots in Lincoln and Warren; the remainder in northwest and western Missouri. This includes 8,406 square miles of upper or barren measures, about 2,000 square miles of exposed middle, and 12,420 of lower measures.

The boundary between the middle and lower coal is not well defined, but is limited by a thick-bedded, coarse, micaceous sandstone, sometimes of no great extent, at other times of great thickness. It is supposed to enter the State in the west part of Bates county, and to pass thence through Butler to Chilhowee, in Johnson county; thence northwardly, 4 miles west of Warrensburg, to 4 miles east of Aullville, La Fayette county; thence irregularly meandering through La Fayette county, crossing the Missouri river, passing to ten miles east of Carrollton, Carroll county; thence to the southeast corner of Livingston county, from which point it bears northeast to the center of Linn county, and thence northward. The southern and eastern boundary of the lower Coal Measures is as follows (through Barton, Bates, Vernon, and Saint Clair counties the boundary has not yet been well defined): entering the State in Barton, it passes northeast through the eastern part of Vernon; it enters Saint Clair about midway on its western line; thence meanders eastward to a point a few miles north of Osceola; thence northward to within eight miles of Clinton, Henry county; thence northeast to the east line of Henry county; thence northwardly, with occasional variations of sandstones as much as eight miles east to Brownsville, Saline county; thence northeastward to Marshall, and thence to Miami. On the north side of the river it passes eastward from a point opposite Arrow Rock to the east line of Howard county; and thence in a meandering course via Columbia, Boone county, and New Bloomfield and Fulton, Callaway county, to the northeast corner of Callaway; thence northeastwardly to a point three miles west of the northeast corner of Montgomery county; thence northwest to near the mouth of Lick creek, Ralls county; thence southwest to Mexico, Audrain county; from thence to the northwest corner of Monroe county; thence irregularly trending northward to the northwest corner of Knox county; thence to a point on the north line of Lewis county, about 12 miles west of the Mississippi river; thence northwardly to the Des Moines river, on the north line of the State of Missouri. East of this are small outlying deposits in Montgomery, Warren, Lincoln, and Saint Louis counties, and perhaps others in southwest Missouri.

Bates and Vernon counties are being rapidly developed. At Rich Hill, Bates county, a town not two years old, there were 500,000 tons mined in 1882. This new district is traversed north and south by the Missouri, Kansas, and Texas, the Missouri Pacific, and the Kansas City, Rich Hill, and Memphis railroads, and east and west by the Emporia, Rich Hill, and Saint Louis railroad. Extensive prospecting has developed immense beds of very fine bituminous coal at depths of 20, 40, and 80 feet—three strata. The upper is 5½, the middle is 6, and the lower is 7½ feet thick. What seems to give this locality most importance is the fact that it is the only source of cheap coal supply for the treeless plains of Kansas and Nebraska.

The production of coal has been as follows:

Production of coal in Missouri since 1873.

	Gross tons.
1873	700,000
1874	714,000
1875	750,000
1876	900,000
1877	900,000
1878	900,000
1879	900,000
1880	1,500,000
1881	1,750,000
1882	2,000,000

MONTANA.

In Montana bituminous and brown coal is known to occur over an extremely great extent of territory, some authorities estimating that an area of 60,000 square miles of the surface is underlaid with coal. The lack of satisfactory surveys and the practically unopened condition of the northern portion of the Territory, however, render estimates such as this of but little value. The construction of the Northern Pacific railroad along the Yellowstone valley is proving an important factor in developing the coal resources of the Territory. An extensive vein of true bituminous coal was discovered in 1882 on the line of the Northern Pacific near the new town of Livingston on the Yellowstone river, and the railway company is preparing to develop the mine extensively and use the coal in its locomotives. Coal of good quality is found near Helena, and the bank here has been opened to some considerable extent, and has proved excellent, the product being in general use for blacksmithing and similar purposes throughout the Territory. The great abundance of fine timber in the mountains of Montana has heretofore been the principal cause of the neglect of the coal beds, but as the population increases and the forests are destroyed more attention will be given to them. No statement of the small product of the coal mined near Helena has been obtainable. Near Bozeman coal occurs abundantly in numerous beds. The following are analyses of specimens from two different beds in that locality:

	No. 1.	No. 2.
Water	3.0	7.0
Volatile matter	41.5	34.5
Fixed carbon	43.5	50.5
Ash	12.0	8.0
	100.0	100.0

NEW MEXICO.

In New Mexico coal is found in Colfax, Santa Fé, Rio Arriba, Socorro, Bernalillo, and Doña Aña counties in extensive beds from 1½ to 14 feet in thickness. The coal found in New Mexico ranges through all varieties from brown lignite to anthracite. The most important fields yet opened are those in Colfax county at Raton. The coal fields here embrace an area of 600,000 acres, the product being a good bituminous coking coal which compares favorably with the best soft coals of Pennsylvania. The following analyses were made from specimens taken near the surface:

	Top of vein.	Middle.	Bottom.
Water	2.0	3.1	2.6
Volatile matter	37.1	35.0	33.5
Fixed carbon	51.6	51.5	47.5
Ash	9.3	10.4	15.6
	100.0	100.0	99.2

The mines are from 4 to 6 miles from Raton, and the principal ones are now operated by the Raton Coal and Coking Company for the benefit of the Atchison, Topeka, and Santa Fé railroad. The veins here vary in width from 3½ feet in the Blossburg mine to 9 feet in the Le Conte mine, and the coal strongly resembles anthracite in general appearance. It contains small quantities of sulphur, generally yields a red ash, is adapted to every use to which bituminous coal is applied, and is the chief source of the coke supply of the New Mexican smelters. The mines here came into the possession of the Atchison, Topeka, and Santa Fé Railroad Company in February, 1881, and during the remainder of the year produced 24,000 tons of coal. In 1882 the output was 91,798 tons.

The coal field of Colfax county extends on the west to the base of the

Rocky mountains, and is an extension of the Las Animas coal field of southern Colorado.

The anthracite and bituminous fields of Santa Fé county cover an area of at least 15,000 acres, a considerable proportion of which is underlaid by four distinct veins of anthracite coal varying from 4 to 6 feet in width. The coal beds are found between the Rio Galisteo and the Rio Santa Fé, and are about 25 miles southwest of Santa Fé, and not very far from Cerillos station on the Atchison, Topeka, and Santa Fé railroad. They are known as the Los Cerillos beds. The coal here is hard, dense, and of brilliant luster, and is said, "so far as its application for all practical purposes is concerned, to be fully equal to the best Pennsylvania anthracite." Its composition is shown by the following analysis:

Water	2.90
Volatile matter	3.18
Fixed carbon	88.71
Ash	5.21
	100.00

The vein now being worked is the next to the lowest, is 5 feet in width, and from it about 500 tons of good coal were taken in 1882 and shipped to Santa Fé, Albuquerque, and Las Vegas. About 2 miles west from the anthracite vein now being worked are the bituminous coal mines. Here seventeen veins of coal are exposed, the one on which work is prosecuted being about 4½ feet in width. The coal is remarkably free burning, and about 10,000 tons have been mined to January 1, 1883.

The coal field of Rio Arriba county is opened at Amargo, and is an extension of the La Plata county (Colorado) deposit. The veins here are very wide, and have been developed to some extent since the completion of the Durango branch of the Denver and Rio Grande railroad, furnishing as they do the principal supply of fuel for that branch. The coal is in every respect similar to that from the Peacock mine at Durango, and cokes satisfactorily. In 1882 some 12,000 tons were produced.

In Bernalillo county brown coal is extremely abundant, the known area comprising almost the entire western portion of the county. The principal developments are at Gallup and Defiance, and the mines are owned and operated by the Atlantic and Pacific Railroad Company, the fuel supply for the road coming entirely from this locality. In the Tijeras cañon one vein 9 feet thick is exposed, while along the cañons of the upper Rio Puerco veins of brown coal from 4 to 8 feet in thickness are everywhere exposed. The distance of these beds from a market has prevented their development, but the Atlantic and Pacific Railroad Company is now rapidly opening them up. The product of the mines at Gallup from March 20 to December 31, 1882, was 33,373 tons, of which 30,705 tons were used by the railroad and 2,668 tons were shipped for commercial use. The average number of men employed at Gallup is 220.

Near Silver City, Grant county, there is a bed of moderate extent which produces a massive, compact, very hard, and non-intumescent coal of the semi-anthracite variety. Its composition is:

Water	2.13
Volatile matter	4.86
Fixed carbon	86.56
Ash	6.45
	100.00

It has not yet been developed to any extent.

The coal area in the vicinity of San Antonio, Socorro county, is of considerable extent, but has not as yet been fully explored. The mines here are owned and operated by the Atchison, Topeka, and Santa Fé Railroad Company, the coal output having been entirely consumed by this company. The bed is of considerable thickness. At first the product was of extremely poor quality, great trouble being experienced on locomotives in making steam on account of the large percentage of water and ash, but with depth the coal has become much better and is now giving complete satisfaction for all railroading purposes. In 1882 the output of coal amounted to 16,321 tons.

The coals of New Mexico are in general inferior to those found further north, and only a small proportion of the Territory is known to be coal-bearing. With further and more thorough exploration other and good beds may be found.

The product of the Territory in 1882, so far as reported, was as follows:

Coal product of New Mexico in 1882.

	Net tons.
Raton district	91,798
Gallup district	33,373
Amargo district	12,000
Los Cerillos district	10,500
San Antonio district	16,321
Total	163,992

No returns could be obtained from the Atlantic and Pacific mines at Gallup and Defiance.

From January 1 to June 30, 1883, the production, so far as reported, was:

Output in first six months of 1883.

	Net tons.
Raton district	56,127
Los Cerillos:	
Hard coal	144
Soft coal	360
Gallup—Atlantic and Pacific Railroad mines	32,528
Monero—Denver and Rio Grande Railroad mines	8,631
San Antonio—Atchison, Topeka, and Santa Fé Railroad mines	19,955
Total	117,745

The capacity of the mines at Raton is stated at 500 tons per day, and of those at Amargo 125 tons daily. About 485 men are employed in the mines exclusive of those employed at Defiance. About 93 per cent. of the product of the Territory is consumed by the railways.

The value of these coals may be put at $3 per ton, making a total value of $391,857 for the product of the Territory in 1882.

OHIO.

The coals of Ohio are all of the bituminous variety, and are known by various and general names, as block coal, gas coal, cannel coal, etc., and by many special names, as Mahoning valley coal, Hocking valley coal, Salinesville coal, etc., according to the localities from which they are drawn. The best furnace coal is the block coal of the Mahoning valley; the best coke is made from the coals at Leetonia and Washingtonville, in Columbiana county; the best house coal is found in Jackson county; the best gas coal, so far as recent tests would seem to indicate, is the Barnesville coal of Belmont county.

In the Mahoning valley raw coal, with a little Connellsville coke, is used in the blast furnaces of the district. In the Hocking valley raw coal is also used. In Jackson county raw coal from two seams, the Jackson shaft coal and the Wellston, is used. At Leetonia coke is used, partly made on the spot and partly Connellsville. At Steubenville a mixture of coke and coal is used from the same seam, the shaft coal of the county. The Jefferson county coal is one of the most valuable in the State. Gas is made from the coals of the Mahoning valley, the Hocking valley, the Steubenville coal, the Ohio river coal at Bellaire and Pomeroy, and the Hanging Rock coal of Ironton.

The output is growing to such an extent that Ohio is now second on the list of coal-producing States in the Union. Many of the early mines were crude affairs, and the method of working was reckless and short-sighted. Already many localities, once supposed to possess inexhaustible stores of coal, are being rudely awakened to the fact that the wanton waste in the past, if continued but a short time, will render their coal fields worthless. Mining of coal is a business demanding the best of talent; and the practical miners, costly machinery, and skilled employés of every grade now employed will help this State to maintain its position.

The Ohio coal field, which occupies nearly one-third the area of the State, and which along the Ohio river from Bellaire to Pomeroy attains a thickness of 1,600 feet, has been so recently opened, and so limited have been the excavations, that it is largely a matter of conjecture as to the causes as well as the extent of many of the wants or intervals of barren ground. But that great areas of barren ground extend through many if not every one of the twenty or more different beds of coal of workable thickness known to exist in the State is now generally acknowledged alike by geologists, mining engineers, and practical men. A vast and invaluable amount of information in regard to the existence of wants in coal seams was brought to light by the late State Geological Survey, particularly in the more recent volumes of the survey, for the first published reports were more hopeful than the later ones as to the amount of coal inclosed in the mineral strata of the State.

The steadiest of all the coal beds is No. 8 of the geological nomenclature—the Pittsburgh vein; next to this in steadiness, so far as developments would indicate, is the "great vein" of the Hocking valley, No. 6 of the geological reports. The least reliable coal, though one of the most valuable as regards quality and adaptability to various uses, is the lower coal of the State series, No. 1, or the "block coal" of the Mahoning valley. This coal is mined extensively near Youngstown, Massillon, and Akron, and is also opened and worked to a considerable extent around the village of Jackson, in Jackson county. It is everywhere found disposed on a wavy and uneven floor, being thickest in the low places or swamps of the mine, and growing gradually thinner as it extends up the sides of the swamps or troughs, until it is either suddenly cut away by a fault or it continues the ascent of the trough sides till it thins down to a feather edge.

The growth in production of coal within this State is shown in the following table:

Production of coal in Ohio since 1873.

	Gross tons.
1873	3,944,340
1874	3,810,344
1875	4,346,653
1876	3,500,000
1877	5,250,000
1878	5,000,000
1879	5,000,000
1880	7,000,000
1881	8,250,000
1882	9,450,000

The following deductions are made in Census Bulletin No. 273 from a study of 187 typical Ohio mines, classified on the basis of power used:

Comparison of results in coal mining in Ohio.

CLASS 1. Mines using no power to supplement manual labor.
CLASS 2. Mines using the power of animals only.
CLASS 3. Mines using boiler power not exceeding 100 horse-power.
CLASS 4. Mines using boiler power exceeding 100 horse-power.

	Class 1.	Class 2.	Class 3.	Class 4.	Total.
Number of mines in class	12	88	78	9	187
Aggregate maximum yearly capacity	231,865	3,830,000	3,031,000	682,175	7,775,040
Product census year, net tons	99,875	2,068,000	2,129,421	404,908	4,702,201
Value of census year's product at mines	$157,218	$2,337,000	$2,939,625	$628,415	$6,062,258
Average yearly product, net tons per mine	832	23,500	27,300	44,990	25,145
Average value per ton at mine	$1 57	$1 13	$1 38	$1 55	$1 30
Average cost of labor per ton mined	$0 93	$0 77	$0 96	$1 03	$0 88
Average number of days worked by each man	216.4	267.5	223.6	228.0	229.4
Average earnings per man, census year	$267 00	$339 00	$318 00	$388 00	$330 70
Average per diem wages earned	$1 23	$1 27	$1 42	$1 70	$1 41
Average product per man per day worked, net tons	1.33	1.64	1.49	1.66	1.63
Average horse-power to mine	....	7.2	38.2	146.0	26.4
Tons mined per horse-power yearly	....	3,264	715	3,082	953
Per cent. of value of product paid for labor	59.1	68.42	69.34	66.13	68.45
Per cent. of value of product paid for materials	7.47	16.57	10.86	10.95	12.58
Per cent. of value of product for profits, including interest, repairs, and royalty	33.43	15.01	19.80	22.92	18.97
Average number of hands to mine, all classes of labor, including superintendence	29.0	53.6	82.2	119.0	67.1

PENNSYLVANIA.

Twenty-five counties in Pennsylvania contain no coal whatever, viz.: Philadelphia, Delaware, Chester, Montgomery, Bucks, Northampton, Lehigh, Berks, Lebanon, Lancaster, York, Adams, Franklin, Cumberland, Mifflin, Juniata, Perry, Snyder, Union, Montour, Monroe, Pike, Wayne, Susquehanna, and Erie. They are all situated in the southeastern part of the State, except Erie in the northwestern corner. The anthracite coal of Pennsylvania is principally in the counties of Dauphin, Schuylkill, Carbon, Luzerne, and Lackawanna, with smaller quantities in Northumberland, Columbia, Sullivan. and Wyoming counties. Six counties contain detached fields of semi-bituminous coal: Bradford, Lycoming, Tioga, Huntingdon, Bedford, and Fulton. Twenty-seven counties in the western and northwestern part of the State contain bituminous coal, viz.: Somerset, Fayette, Greene, Washington, Westmoreland, Cambria, Indiana, Armstrong, Allegheny, Beaver, Lawrence, Butler, Clarion, Jefferson, Clearfield, Blair, Centre, Clinton, Cameron, Elk, Forest, Venango, Mercer, Crawford, Warren, McKean, and Potter. The total bituminous coal area is 12,222 square miles, besides 80 miles in Broad Top and 468½ in the anthracite fields, making a total of 12,770½ square miles of coal of all kinds in Pennsylvania.

The anthracite regions and their output are fully described on preceding pages, and therefore facts relating to the bituminous coal only will here be considered. From the best sources of information, the following statement of the production has been prepared:

Output of bituminous coal in Pennsylvania since 1873.

	Gross tons.
1873	11,695,383
1874	11,000,000
1875	10,500,000
1876	11,500,000
1877	12,500,000
1878	13,500,000
1879	14,500,000
1880	19,000,000
1881	20,000,000
1882	22,000,000

In order to systematically attend to the matter of proper ventilation, etc., the bituminous mines in Pennsylvania are divided into four districts, and the inspectors of mines hold office for four years, the present incumbents holding commissions dating from May 15, 1881. Their several districts are as follows:

First district. James Louttit, for the counties of Greene, Washington, Fayette, Somerset, Bedford, and that portion of Allegheny lying south of the Ohio and Monongahela rivers.

Second district. John J. Davis, for the counties of Beaver, Butler, Armstrong, Indiana, Westmoreland, and that portion of Allegheny lying north of the Ohio and Monongahela rivers.

Third district. Thomas K. Adams, for the counties of Lawrence, Mercer, Crawford, Erie, Warren, Forest, Venango, Clarion, Jefferson, Clearfield, Cameron, Elk, and McKean.

Fourth district. Roger Hampson, for the counties of Cambia, Blair, Huntingdon, Centre, Clinton, Lycoming, Sullivan, Potter, Tioga, and Bradford.

The production during 1882 was as follows, in tons of 2,000 pounds:

Production of bituminous coal in 1882, by districts.

	Tons.
First district	10,237,458
Second district	7,307,580
Third district	4,618,245
Fourth district	3,500,000

These figures are largely estimates, as many of the operators do not reply to the circulars asking for information.

By the last census it appears that Allegheny county produced one-tenth of the total bituminous coal produced in the United States. What is known here as "Second Pool" coal has no successful rival as a gas-making coal, and is consumed in all river cities in the Mississippi valley. It reaches Chicago, Milwaukee, Detroit, East Saginaw, Rochester, Toronto, and a host of smaller places, by rail. A few years ago Pittsburgh coal reached inland cities by the way of Cincinnati to a greater extent than is now the case. But still Columbus, Indianapolis, Peoria, and other cities are so supplied. The other cities along the river take gas coal in quantities of the following magnitude annually: Cincinnati, 1,500,000 bushels; Saint Louis, 1,500,000 bushels; Louisville, 600,000 bushels; New Orleans, 500,000 bushels; Memphis, 300,000 bushels; and Vicksburg, Baton Rouge, and other cities in lesser quantities.

In regard to the available quantity of bituminous and semi-bituminous coal in the State of Pennsylvania, the following statement has been made by the present State Geological Survey:

Reserves of bituminous coal in Pennsylvania.

	Tons.	Tons.
Upper barren measures:		
Washington bed, 3 to 3½ feet	787,200,000	
		787,200,000
Upper productive measures:		
Waynesburg bed, 3 to 5 feet	2,126,400,000	
Uniontown bed, 2 to 3 feet	312,000,000	
Sewickley bed, 3 feet	432,000,000	
Redstone bed, 2 to 3 feet	326,400,000	
Pittsburgh bed, 6 to 12 feet	10,438,800,000	
		13,635,600,000
Lower barren measures:		
Brush creek, Coleman, etc., beds	878,400,000	
		878,400,000

	Tons.	Tons.
Lower productive measures:		
In Westmoreland, Fayette, and Allegheny counties	2,064,000,000	
Millerston bed, 3 feet	28,800,000	
Freeport upper bed, 3 to 5 feet	3,764,800,000	
Freeport lower bed, 2 to 6 feet	2,385,600,000	
Kittanning upper bed, 2 to 4 feet	1,596,000,000	
Kittanning middle bed, 2 to 3 feet	829,800,000	
Kittanning lower bed, 2 to 6 feet	4,225,200,000	
Clarion coals, 2 to 3 feet	696,000,000	
Brookville bed, 2 to 4 feet	1,627,200,000	
		17,217,400,000
Conglomerate series:		
Mercer coals, 2 to 3 feet	932,600,000	
Quakertown bed, 2 feet	57,600,000	
Sharon coal horizon, 2 to 3 feet	38,400,000	
		1,028,600,000
Total		33,547,200,000

Statistics of many of the bituminous coal districts of Pennsylvania, with the imports, and also the output of Cumberland coal.

	Blossburg.	Barclay.	Mc Intyre.	Broad Top.	Snow Shoe.	Clearfield.	Monongahela Slackwater.	McKean Co.	Westmoreland.	Imports.	Cumberland.
1840	4, 235	......	......	......	......	......	......	......	......	162, 867	......
1841	25, 966	......	......	......	......	......	......	......	......	155, 394	......
1842	13, 164	......	......	......	......	......	......	......	......	141, 521	1, 708
1843	6, 268	......	......	......	......	......	......	......	......	41, 163	10, 082
1844	14, 234	......	......	......	......	......	......	......	......	87, 073	14, 890
1845	29, 836	......	......	......	......	......	184, 200	......	......	85, 776	24, 653
1846	16, 509	......	......	......	......	......	311, 156	......	......	156, 853	29, 795
1847	29, 087	......	......	......	......	......	385, 805	......	......	148, 021	52, 940
1848	33, 762	......	......	......	......	......	392, 774	......	......	196, 168	79, 571
1849	32, 095	......	......	......	......	......	398, 340	......	......	198, 213	142, 449
1850	23, 161	......	......	......	......	......	491, 918	......	......	180, 439	196, 848
1851	25, 000	......	......	......	......	......	490, 850	......	......	214, 774	257, 679
1852	20, 000	......	......	......	......	......	585, 233	......	......	183, 015	334, 178
1853	45, 507	......	......	......	......	......	628, 654	......	......	231, 508	533, 979
1854	70, 214	......	......	......	......	......	693, 278	......	......	252, 865	659, 681
1855	73, 204	......	......	......	......	......	889, 360	......	......	287, 4[illegible]8	662, 272
1856	70, 669	2, 295	......	42, 000	......	......	353, 364	......	......	293, 507	706, 450
1857	94, 314	6, 265	......	78, 813	......	......	1, 158, 939	......	......	360, 712	582, 486
1858	41, 894	17, 560	......	105, 478	......	......	1, 027, 866	......	......	396, 628	649, 656
1859	48, 592	30, 143	......	130, 595	......	......	1, 131, 467	......	......	403, 928	724, 354
1860	96, 918	27, 718	......	186, 903	......	......	1, 517, 909	......	......	389, 986	788, 909
1861	112, 712	40, 835	......	272, 625	......	......	834, 630	......	......	465, 434	269, 674
1862	179, 334	52, 779	......	333, 606	8, 260	7, 239	743, 358	......	......	541, 099	317, 634
1863	235, 843	54, 535	......	305, 678	12, 039	24, 330	1, 134. 570	......	......	624, 348	748, 345
1864	384, 977	62, 058	......	686, 645	33, 593	65, 380	1, 402, 828	......	......	597, 738	657, 996
1865	394, 642	73, 197	......	315, 996	51, 881	60, 629	1, 580, 791	......	......	696, 193	903, 495
1866	411, 759	99, 453	......	265, 720	70, 890	107, 878	1, 704, 212	......	......	643, 294	1, 079, 331
1867	481, 318	74, 739	......	244, 412	58, 137	169, 219	1, 202, [illegible]08	......	......	521, 305	1, 193, 822
1868	603, 328	73, 675	......	280, 936	60, 149	171, 238	1, 812, 040	......	......	402, 299	1, 330, 433
1869	715, 094	180, 610	......	360, 799	89, 356	259, 994	2, 100, 504	......	......	423, 810	1, 882, 669
1870	733, 035	273, 335	17, 808	313, 425	85, 276	379, 863	2, 303, 856	......	......	420, 683	1, 717, 075
1871	815, 079	378, 335	106, 130	319, 625	79, 984	542, 896	1, 944, 852	......	......	443, 955	2, 345, 153
1872	849, 262	382, 842	171, 427	297, 473	68, 988	431, 915	2, 291, 220	......	......	490, 631	2, 355, 471
1873	991, 057	337, 644	212, 462	350, 245	95, 257	592, 860	2, 094, 312	......	......	456, 015	2, 674, 101
1874	796, 388	337, 062	138, 907	226, 693	63, 540	639, 630	2, 503, 504	......	952, 971	498, 028	2, 410, 895
1875	581, 782	376, 637	164, 507	258, 488	62, 426	928, 297	2, 275, 265	33, 501	796, 963	441, 600	2, 342, 778
1876	616, 984	361, 138	208, 701	225, 803	51, 399	1, 281, 861	2, 495, 800	81, 830	900, 13[illegible]	488, 132	1, 835, 081
1877	602, 245	340, 099	183, 715	194, 881	42, 985	1, 374, 927	2, 677, 460	73, 222	786, 039	498, 275	1, 574, 339
1878	652, 597	314, 320	154, 205	213, 272	29, 168	1, 295, 201	2, 797, 530	72, 098	692, 586	566, 938	1, 679, 322
1879	874, 010	382, 504	127, 632	209, 523	56, 654	1, 631, 120	2, 623, 232	85, 745	816, 392	449, 167	1, 730, 709
1880	921, 555	462, 866	216, 225	247, 186	56, 020	1, 739, 873	3, 361, 634	100, 046	943, 177	577, 458	2, 136, 160
1881	1, 178, 581	433. 836	236, 922	296, 564	128, 263	2, 401, 987	3, 450, 186	110, 099	982, 293	834, 875	2, 261, 918
1882	1, 165, 604	398, 576	209, 858	370, 211	233, 708	2, 838, 970	4, 057, 384	73, 834	1, 278, 121	774, 425	1, 540, 466

The Pennsylvania Bureau of Industrial Statistics reports the force employed in the bituminous coal mines of the State in 1882 as follows:

Labor employed in bituminous coal mining, etc.

Miners	28,372
Inside laborers	1,281
Outside laborers	2,863
Mule drivers	2,412
Blacksmiths and carpenters	616
Overseers and clerks	681
Boys	1,343
Coke oven employés	2,080
All others	385
Total	40,033

An agreement between the Pennsylvania Railroad Company and the Baltimore and Ohio Railroad Company was made in March, 1883, to charge an equal toll on the coal carried to tidewater by the roads. It was not, however, rigidly adhered to. Bituminous coal sold at $4 per ton at Philadelphia, $3 at Georgetown, and $3.25 at Baltimore, in March and April. Subsequently these rates were cut, especially on large contracts, to the extent of 25 cents per ton.

The miners along the railroads centering at Pittsburgh have had a series of combats with the operators on the wages question. Starting at 3½ cents per bushel, an attempt was made to reduce this rate to 3 cents. Arbitration was tried and failed. Then a recourse was had to a labor tribunal, with an umpire under the Wallace act, but this resulted in nothing. It should be remembered that the miners were kept fitfully at work during these efforts to agree on a price; the wages being paid at 3 cents pending a decision. The operators contend that their coal goes to the same markets as coal dug in Ohio, which pays only 75, 80, and 85 cents for digging. Along the Monongahela, work has been steady during the six months from January to July, 1883, at 3½ cents per bushel, or 93 cents per ton. Shippers find that coal from the Kanawha river is competing with Pittsburgh coal in the lower markets, and it may ultimately drive the coal out, as it has already reduced the price.

The Bureau of Industrial Statistics of Pennsylvania reports the rates of wages of the various classes of employés in bituminous coal mining and coke making during the past eight years, as follows:

Wages in bituminous coal mining and coke making in Pennsylvania.

Classes of employés.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Miners	$2 47	$2 59	$1 65	$1 88	$1 74	$2 25	$2 16	$2 16
Laborers, inside	1 90	1 71	1 64	1 47	1 42	1 69	1 81	1 81
Laborers, outside	1 76	1 52	1 34	1 47	1 42	1 46	1 63	1 63
Mule drivers	1 81	1 61	1 57	1 46	1 41	1 63	1 80	1 80
Blacksmiths	2 29	2 15	1 80	1 91	1 75	1 96	2 16	2 16
Carpenters	2 29	2 15	1 80	1 90	1 75	1 84	2 06	2 06
Mining overseers	3 04	2 84	2 40	2 64	2 56	2 63	2 60	2 60
Clerks	......	......	......	2 38	......	1 93	2 11	2 11
Coke oven chargers	......	......	......	1 60	......	1 46	1 76	1 76
Coke oven drawers	......	......	......	1 60	1 55	1 44	1 74	1 74
Boys	97	87	90	77	68	79	84	84

The following table shows the number of collieries, number of persons employed, production, etc., in the several counties of the bituminous coal and coke fields of Pennsylvania, compiled from returns made to the Bureau of Industrial Statistics for the year ended December 31, 1882:

Bituminous coal and coke statistics of the Bureau of Industrial Statistics of Pennsylvania.

Counties.	Collieries.	Days in operation.	Persons employed.	Wages paid.	Coal produced.	Coke ovens.	Coke produced.
					Tons.		*Tons.*
Allegheny	90	190	10, 195	$4, 940, 430 35	4, 033, 548. 10	159	24, 562. 09
Armstrong	7	232	258	128, 957 97	119, 186. 08	66	12, 797. 00
Beaver	6	217	216	121, 782 73	91, 905. 03	4	766. 03
Bedford	7	244	297	119, 082 78	175, 506. 00	88	36, 033. 00
Blair	4	278	330	137, 749 05	143, 690. 15	101	60, 027. 10
Bradford	7	239	688	395, 871 64	390, 957. 00	....	....
Butler	5	227	303	149, 962 19	122, 881. 04	50	9, 000. 00
Cambria	24	264	1, 463	633, 281 92	880, 024. 05	119	39, 438. 00
Cameron	1	250	65	50, 000 00	33, 000. 00	20	5, 000. 00
Centre	5	244	442	203, 300 14	297, 253. 00	66	22, 401. 00
Clarion	13	260	890	368, 108 31	378, 327. 00	42	13, 500. 00
Clearfield	44	225	4, 211	1, 657, 757 54	2, 872, 568. 02	86	20, 281. 00
Elk	6	279	808	363, 380 56	402, 226. 16	....	....
Fayette	54	186	4, 642	2, 263, 950 31	2, 971, 126. 05	5, 522	1, 764, 584. 18
Huntingdon	11	248	556	235, 111 60	288, 399. 00	200	49, 232. 06
Indiana	2	300	18	8, 000 00	15, 900. 00	.....	....
Jefferson	6	229	419	200, 833 80	288, 430. 05	31	11, 891. 00
Lawrence	8	206	420	169, 568 42	112, 077. 15	18	6, 200. 00
Lycoming	4	241	517	220, 368 75	209, 875. 00	....	....
McKean	3	209	164	84, 156 28	79, 924. 00	....	....
Mercer	18	220	1, 134	485, 043 21	416, 839. 12	....	....
Somerset	15	202	625	242, 051 01	423, 697. 02	6	....
Tioga	8	272	2, 517	1, 263, 152 88	1, 157, 106. 00	200	64, 525. 00
Venaugo	4	260	77	28, 416 96	21, 764. 15	....	....
Washington	30	203	2, 125	956, 663 52	864, 536. 10	4	1, 000. 00
Westmoreland	60	232	6, 756	3, 348, 570 13	3, 903, 340. 17	3, 281	1, 075, 304. 11
Total	442	237	40, 136	18, 775, 553 05	20, 694, 110. 02	10, 063	3, 219, 543. 17

TENNESSEE.

The coal area of Tennessee embraces the whole region of the Cumberland plateau, an area of 5,100 square miles. One may form some conception of the enormous amount of coal in this vast region, when it is borne in mind that throughout this wide extent there are from one to seven workable seams of coal.

The principal coal mines now being worked in this State are the Sewanee mines by the Tennessee Coal, Iron, and Railroad Company; the Victoria mines by the same company; the Coal Creek mines, owned by the Coal Creek Mining and Manufacturing Company, upon which five different companies are working under leases, while two other companies work upon lands of their own; the Rockwood mines, worked by the Roane Iron Company; the Soddy mines at Rathburn, worked by the Soddy Company; the Poplar Creek mines, worked by the Oakdale Company; the Etna, by the Etna Mining Company, near Chattanooga; the Campbell County mine, by the Campbell County Coal Company, at Careyville; the Glen Mary mines, by the Crooke Coal Company; the Helenwood mines, by the Helenwood Coal Company; the

Spring City mines, by the Walden's Ridge Coal Company; the Dayton mines, by an English company; the Daisy mines, by Parks & Company; the Chattanooga, by the Chattanooga Coal Company, besides other operations of lesser importance.

The mines of Coal Creek and Careyville, on the Knoxville and Ohio railroad, produce nothing but coal for steam and domestic use. In 1871 these mines shipped a product of 36,000 tons; in 1872 it amounted to 48,000 tons, and in 1880 to 149,000 tons. For the year 1882, the total reached 200,000 tons. In 1872 there were five mines, employing 184 persons. Now there are eight mines, and one of them employs over 200 persons, and ships more coal than all did in 1872, while the total force employed numbers over 500.

In 1872 the Cincinnati Southern road had been barely surveyed, and on its present line there was only one mine shipping coal to market; now there are five shipping coal, and two more preparing to do so, while the Rockwood mines are worked to their full capacity for supplying the furnaces. In 1872 only 25 men were employed outside of Rockwood in mining coal; now the Soddy alone employs four times that number, and fully 400 persons are more or less directly engaged in this industry on the line of that road, and a large part of this increase has been attained in the last two years.

The increase in the coal product over the whole State has been similar to that of these particular localities. In 1880 the total coal product of the State was 494,491 tons. In 1882 the product was 867,879 tons, worth fully $1,000,000 at the mines.

There are at present four companies in Tennessee engaged in manufacturing iron, using coke as fuel. These companies have seven stacks and have an average aggregate produce of about 500 tons of pig iron per day. They are as follows:

Oakdale Iron Company, Jenks, Roane county, one stack.

Roane Iron Company, Rockwood, Roane county, two stacks.

Chattanooga Iron Company, Chattanooga, Hamilton county, one stack.

Tennessee Coal, Iron, and Railroad Company, South Pittsburg, Marion county, two stacks.

Tennessee Coal, Iron, and Railroad Company, Cowan, Franklin county, one stack.

Details of the production are as below:

Production of coal in Tennessee since 1873.

	Gross tons.
1873	350,000
1874	350,000
1875	360,000
1876	550,000
1877	450,000
1878	375,000
1879	450,000
1880	641,042
1881	750,000
1882	850,000

TEXAS.

The coal fields of Texas are coming quite prominently to the front of late years. There are three very large and promising fields in the State, the Red River coal district, the Rio Grande, and the Pecos districts. In the first of these districts are embraced the counties of Montague, Clay, Wise, Jack, Young, Shackleford, Palo Pinto, Parker, Erath, Comanche, Eastland, Callahan, Brown, Coleman, Runnells, McCulloch, San Saba, and Menard. The same coal also crops out at various places in Burnet, Mason, Llano, and Tom Green counties, and they may therefore be considered a part of the same district. To the north of this coal district and bordering it almost everywhere the Permian formation is found, under which the Carboniferous sinks, outcropping occasionally at different points, from which it is reasoned that the Carboniferous underlies the Permian throughout the whole extent in Texas.

As this State has never yet had a geological survey, the extent of her coal strata is not well defined. It is supposed, however, to embrace about 30,000 square miles in the northern and western portions of the State. Over this great area coal has been found, at a great many places, but at no place has it been mined except to a very small extent. It is a bituminous coal, and almost, if not quite, precisely similar to the McAllister coal of the Indian Territory. Some anthracite has also been discovered in this coal field. The railroads are now penetrating the coal formations of Texas, and this great source of wealth will soon doubtless be rapidly developed. In addition to the true coals of Texas, there is an immense bed of lignite, which extends apparently across the entire State, from northeast to southwest. It is said to be at some points 20 feet thick. This lignite much resembles cannel coal. Extensive developments of superior coal have been made at and near Laredo.

It is estimated that the demand for coal at Laredo, to supply at least 1,000 miles of railroad in Texas, is equal to 48,000 tons per annum. Add to this 12,000 tons for Laredo, San Antonio, etc., and there should be an export by rail into Mexico. Railroads to the Gulf and cheap freights might give a trade to Gulf ports.

No coal is found available for this region of country nearer than the Indian Territory mines, about 625 miles distant. It will thus be seen that if the coal holds its quality there is a very fair future before this field. The seam worked is thin, only 26 inches, but test pits show other seams below having 24 and 50 inches of coal, respectively. Miners are paid at the rate of $2 per ton. Coal sells at $6 a ton retail at Laredo, and even at this rate is cheaper than mesquite wood at $3.50 to $3.75 per cord.

UTAH.

In Utah, the first discoveries of coal appear to have been made at Coalville, on the Weber river, when the Allen mine was opened eighteen years ago. This had a vein 11 feet thick, dipping to the west. It was worked year after year until the town of Coalville had a series of levels and chambers under the entire place. The coal mined was for several years hauled to Salt Lake and other places by wagon. A narrow gauge road, styled the Summit County railroad, was built from Echo on the Union Pacific to Coalville, a distance of 7 miles, and operated as a coal road for several years. Five years ago the miners struck a jolt in the vein, and the mine has since been abandoned for the present. The Spriggs mine is located near, was opened about the same time, and worked until about one year ago. On the hill west of Coalville and high up the range the Carleton mine, opened about the same time, supplied Fort Douglas with coal for two years. This vein was 7 feet thick and had a 2-foot deposit of fire clay in the center. This was abandoned about sixteen years ago, when the Gen. Connor mine, 10 miles up Weber river above Coalville, was opened and worked for two years. The Dry Hollow vein, lying west of Coalville, was opened a little about this time, since which it has lain idle. There was no record kept of the workings of these various properties, and it would be mere guesswork to make any estimates of the quantity of coal taken from them. The town of Coalville has now a population of 1,100, many of whom get their living from the coal mines there.

The Crismon mine is located up a gulch near its head, and is reached by the Utah Eastern, which climbs up 2 miles, part of which the grade is 175 feet per mile. The mine is supplied with an engine and hoisting machinery. The shaft runs on an incline on the vein, the dip to the northwest being 13 degrees. The incline is in 700 feet and levels are cut every 100 or 200 feet. These levels run each side, and have been extended 1,200 feet each from the shaft. From these levels chambers are taken out on the upper side, the chambers being 30 feet wide, leaving pillars 16 feet wide between. After all the chambers are worked out on the level, then the pillars are nearly all removed, permitting the earth above to sink and close up the aperture. The vein is 11 feet thick, and was not struck on the incline until a depth of 350 feet had been reached. A short distance down the gulch is the Wahsatch mine, worked in similar manner to the Crismon. The machinery from the old Wahsatch shaft has been placed at the new one, and work of mining lately begun. The coal on being hauled to the surface is dumped from the cars on slanting screens, which permit the "slack" or finer portions going into a car for waste while the good coal goes into another car. The amount of waste or screenings is 30 to 40 per cent. of the whole.

Three miles down the Weber river from Coalville, a branch road runs up Grass creek 3 miles on a heavy grade to the Grass creek mines. The vein is 10 feet thick and dips to the north at an angle of 36°. The incline shaft has reached a depth of 800 feet, from which levels are run every 200 feet. These levels have extended a distance of 200 feet on one side and 1,400 feet on the other. The manner of mining is the same as already described. This coal is of good quality, being compact, and yet the loss in screenings amounts to about 30 per cent. This is dumped along the road and there rescreened by people who pay 75 cents per wagon load for what they haul away, which amounts to 40 or 50 loads daily.

In the San Pete valley is found a coal yielding 50 per cent. fixed carbon, and 34 per cent. volatile matter. These three deposits are nearly in the center of the Territory, just south of Salt Lake City, and near to the line of the Denver and Rio Grande and the Utah Central railroads—the former passing just east and the latter just west of the mines, and with both of which they will all soon be connected by branch railroads. A branch has already been constructed to the Pleasant valley mines.

ANALYSES AND CALORIFIC VALUES OF SOME UTAH COALS.

By Ellsworth Daggett.

In view of the rapidity with which industries of all kinds are being developed in our western States and Territories, the time is rapidly approaching, and must be now near at hand, when the apparently inexhaustible deposits of iron ore in southern Utah will be developed and utilized.

The Cedar City and Kanara coal fields, on account of their nearness to the iron deposits, are unquestionably the sources which will furnish most of the fuel. For this reason some analyses of carefully taken samples may be of interest.

It is perhaps hardly necessary to state that none of these coals are from the true Coal Measures, but are of much later formation, being Upper Cretaceous or Lower Tertiary. In all cases, unless otherwise specially mentioned, the samples were taken entirely across, and fairly represent the average of, the bed or part of bed mentioned.

CEDAR CITY COAL FIELD.

In this field four openings were visited:

The *Walker No.* 1 is situated on the left side of Coal creek, about 3½ miles from, and about 600 feet above, Cedar City. An incline, driven on the coal, is reported to be 150 feet deep, with a level at the bottom, all of which is now filled up with water to within 60 feet of the surface. The bed is 6 feet in thickness, with several streaks of clay or dirt. The sample marked "Walker No. 1" was taken across the entire bed, omitting the layers of dirt mentioned, and is therefore of carefully mined coal.

The *Walker No.* 2 is situated up a small gulch on the left of Coal creek about one-fourth mile from the Walker No. 1 opening. It consists of a cut and tunnel of 40 feet, an incline on the coal of 80 feet, and at the bottom a drift of 340 feet. The bed, doubtless the same as the Walker No. 1, is 6 feet in thickness. Upon the bottom is a layer of clean coal 2 feet in thickness (sample marked Walker No. 2 *a*); above this a layer of 6 to 10 inches of dirt, then 1 foot 6 inches of clear coal (sample marked Walker No. 2 *b*); above this 3 to 8 inches of waste, and at the top 1 foot 8 inches of coal (sample marked Walker No. 2 *c*).

The *Leyson claim* is situated up the main south branch of Coal creek about 5 miles distant from, and about 1,600 feet above the level of, Cedar City. It has more development than any other claim in this field. There are about 600 feet of accessible incline and drift, exposing a bed of coal 6 feet in thickness, which was, wherever closely examined, divided by a layer of clay and dirt into two parts; the upper part 2 feet in thickness (sample marked Leyson claim *a*), and the lower part of 4 feet, the sample from which was marked Leyson claim *b*. The analyses marked Leyson claim *c* and Leyson claim *d* are of picked pieces of coal taken respectively from the upper and lower portions.

The *Woods claim*, situated about a third of a mile up the south branch of Coal creek from the Leyson claim, is opened by a tunnel and incline of a total length of about 200 feet. The bed here is also 6 feet in thickness. Three samples were taken, the upper one of one foot of clean coal next to the roof (marked Woods claim *a*); below this came about 10 inches of clay and dirty coal not sampled, then 2 feet of clean coal (sample marked Woods claim *b*); below this a layer of 10 inches of dirt, not sampled, and on the bottom 1 foot 4 inches of clean coal, of which the sample is marked Woods claim *c*.

In all the openings visited in this field considerable waste will be produced in mining a fair quality of coal—that quality represented by the samples upon which the calorific power is computed in Table B.

KANARA COAL FIELD.

This coal field, which is situated on the top of the Kanara mountain about 5 miles distant from, and 2,600 feet above the level of, the settlement of Kanaraville, is about the same distance as the Cedar City coal field from both of the great iron deposits, viz., about 12 miles from Iron Springs, and about 25 miles from Iron City. Two openings in this field were visited. The first, owned by Messrs. Godbe & Hampton, is known as the Lone Tree claim.

The *Lone Tree claim* consists of an incline on the coal, of about 150 feet in length. As both roof and foot of incline were in coal, the entire bed, which, as shown by the next mentioned opening, is not less than 14 feet thick, could not be sampled. The 8 feet of it exposed in the face of the incline was in layers as follows, beginning at the roof of incline:

1 foot 10 inches coal; sample marked Lone Tree claim *a*.
3 to 6 inches clay and dirt; not sampled.
6 inches coal; sample marked Lone Tree claim *b*.
3 to 4 inches clay and dirt; not sampled.

4 feet 3 inches coal; sample marked Lone Tree claim *c*.
2 inches clay and dirt; not sampled.
10 inches coal; sample marked Lone Tree claim *d*—to bottom of incline.

Pollock claim.—The opening on this claim is about one-third of a mile, in a southwesterly direction, from the Lone Tree opening, and consists of an incline on the coal about 100 feet in length, at the end of which is a raise exposing a bed 14 feet 3 inches thick, with coal still in the roof of the raise. The positions of the layers of coal and dirt exposed in the raise were as follows, beginning at top of raise, above which coal still extended:

1 foot coal, forming part of sample Pollock *b*.
2 to 6 inches dirt and clay.
1 foot 8 inches coal; part of sample marked Pollock *b*.
1 to 3 inches dirt and clay.
6 inches coal; part of sample marked Pollock *b*.
2 to 4 inches dirt.
4 feet 6 inches coal; sample marked Pollock *a*.
3 inches dirt.
10 inches coal; part of sample marked Pollock *b*.
6 inches dirt.
2 feet 6 inches coal; part of sample marked Pollock *b*.
6 inches dirt.
1 foot 3 inches coal; sample marked Pollock *c*.
The streaks of dirt are not included in the samples.

Here also in mining a fair quality of coal considerable waste will be produced.

In the following Table A the above-mentioned samples are collected. All determinations of volatile matter, fixed carbon, and ash were made in duplicate, the result given being the average.

Table A.

Sample.	Specific gravity.	Volatile matter.		Fixed carbon.	Ash.
		Moisture at 112° C.	Other volatile matter.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Walker No. 1	1.31	4.75	39.62	45.99	9.64
Walker No. 2 *a*	1.36	4.38	42.35	46.02	7.25
Walker No. 2 *b*	1.36	4.32	39.73	50.28	5.67
Walker No. 2 *c*	1.38	4.47	38.95	43.82	12.75
Leyson claim *a*	....	3.85	39.75	40.90	15.50
Leyson claim *b*	....	4.75	41.45	46.40	7.40
Leyson claim *c*	1.41	3.88	39.10	46.32	10.70
Leyson claim *d*	1.31	4.03	42.79	49.95	3.23
Woods claim *a*	1.36	3.90	41.62	48.62	5.85
Woods claim *b*	1.34	3.52	43.20	47.15	6.12
Woods claim *c*	1.34	3.65	40.12	44.87	11.35
Lone Tree claim *a*	1.32	9.80	36.67	47.06	6.47
Lone Tree claim *b*	1.30	8.65	38.10	46.75	6.50
Lone Tree claim *c*	1.30	9.12	38.27	46.14	6.47
Lone Tree claim *d*	1.32	8.20	41.32	46.40	4.07
Pollock *a*	1.30	8.47	38.97	46.01	6.55
Pollock *b*	1.36	8.40	37.75	44.95	8.90
Pollock *c*	1.36	7.15	34.75	38.55	19.55

It will be observed that analyses of different parts of the same bed differ considerably; but, so far as observed, there seems to be no regularity in the differences.

In Table B the analyses and values of the coals mentioned in Table A are compared with other Utah and Colorado coals. The units of heat are calculated from the total carbon, as found by determining the amount of lead reduced by a given weight of coal, and assuming the entire reducing power of the coal to be due to the carbon. As all coal contains a small percentage of hydrogen, a portion of which also may reduce lead, and as lead reduced by hydrogen indicates a somewhat higher calorific power than that reduced by carbon, the units of heat given in the table are somewhat too low. On the other hand, no allowance has been made for the heat required to volatilize the moisture and chemically combined water, if there be any, and to raise the products of combustion to the temperature they would possess on leaving an apparatus of combustion. If therefore we regard the "units of heat" as the *available* or *effectual* units of heat, the two causes of error mentioned above in a measure neutralize one another. Again, these and other objections to the method, while they interfere with the *absolute* accuracy of the results, have, when the method is applied to fuels of a class, much less effect on the *relative* or *comparative* values obtained.

In Table B the first five samples are obtained by mixing together the samples representing different parts of a bed in amounts proportionate to the thickness of the parts represented. The analyses of these samples given in the table are not the calculated analyses, but those actually made of the mixtures. The samples fairly represent the coal which, with ordinary care in mining, could be delivered from the various open ings.

Leyson claim.—Coal black. Powder brown. Sinters strongly on heating. Ash gray.

Woods' claim.—Coal black. Powder brown. Sinters on heating. Ash gray.

Walker No. 2.—Coal black. Powder brown. Sinters on heating. Ash gray.

Lone Tree claim.—Coal black. Powder brown. Non-sintering. In contact with water absorbs 4½ per cent. in 12 hours, becoming very fragile. Ash yellowish gray.

Pollock claim.—Coal black. Powder brown. Non-sintering. In contact with water absorbs over 4 per cent. in 12 hours, becoming fragile. Ash yellowish gray.

The samples of coals now in the Salt Lake market were obtained from large piles or loaded cars at the railroad stations, by taking very many small pieces from different parts of the piles, crushing the entire sample to a uniform small size, and quartering down as with an ore sample. The following samples were so taken:

Rock Spring.—From two carloads of coal from the Rock Spring mine on the Union Pacific railroad. Coal black. Powder brown. Absorbs some water when in contact with it, losing some strength. Sinters slightly on heating. Ash gray.

Weber coal.—From six carloads of coal from the Grass Creek mine near the Weber river. Coal black. Powder brown. Non-sintering. Ash white.

Red cañon.—From a large pile of several carloads in sheds at the railroad station, from the Alma mine near Evanston. Non-sintering. Coal black. Powder brown. Ash yellowish gray.

Pleasant valley.—From three carloads from the Winter Quarters mine in Pleasant valley. Coal black. Powder brown. Sinters on heating. Ash yellowish gray.

San Pete.—From about two tons at company's office in Salt Lake City. Coal black. Powder brown. When heated the powder sinters strongly, but does not fuse, and fragments retain their shape, slightly distorted. Ash yellowish red.

Crested Butte coking coal.—From a pile of five carloads at the Salt Lake City gas works, about May 1, 1883. Coal black. Powder brown. Fuses completely on heating. A true coking coal. Ash light yellowish red (inclining to gray).

Crested Butte anthracite.—From a pile of about two carloads, nut size, on platform of Denver and Rio Grande station. Coal hard. Specific gravity high. Luster brilliant. Fixed carbon high; a true anthracite. Ash yellowish red, slightly darker than the last-mentioned sample.

Connellsville coal.—From a piece furnished by Mr. J. F. Beattie. True coking coal. Fuses completely on heating. From Coal Measures of Pennsylvania.

Home Coal Company's coal.—From mine near Coalville. Sample furnished by Mr. E. H. Russell. Coal black. Powder brown. Non-sintering. Ash gray.

The Connellsville coal is of course not on the Salt Lake market. It is introduced in the table merely for comparison. The Home Coal Company's coal is that now used by the Ontario Silver Mining Company for the generation of steam in pumping.

Table B.

Sample.	Sulphur.	Specific gravity.	Volatile matter. Moisture at 112° C.	Volatile matter. Other volatile matter.	Fixed carbon.	Ash.	Lead reduced by one part coal.	Carbon in volatile matter.	Total carbon.	Units of heat.
	Pr. ct.		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	
Leyson claim	1.79	1.34	4.50	39.90	45.47	10.12	23.151	22.62	68.09	5500
Woods claim	(*a*)	1.34	3.33	41.62	47.37	7.67	24.455	24.54	71.91	5810
Walker No. 2	2.36	1.36	4.12	40.15	45.82	9.90	23.658	23.47	69.29	5620
Lone Tree claim	2.45	1.31	8.17	38.55	47.27	6.00	23.252	21.09	68.36	5524
Pollock claim	(*a*)	1.35	7.87	38.15	46.25	7.72	22.582	20.17	66.42	5365
Rock Spring	.322	1.26	7.65	37.27	53.27	1.80	25.287	21.10	74.37	6008
Weber	.33	1.30	8.97	39.10	48.60	3.32	23.272	19.85	68.45	5529
Red cañon	.22	1.37	8.32	37.20	46.70	7.77	22.478	19.41	66.11	5341
Pleasant valley	.27	1.27	4.80	39.75	49.95	5.50	24.836	23.10	73.05	5901
San Pete	2.46	1.46	2.05	31.07	49.85	17.02	23.908	20.47	70.32	5681
Crested Butte coking coal	(*a*)	1.26	.80	28.05	67.37	3.77	29.125	18.19	85.66	6920
Crested Butte anthracite (*b*)	(*a*)	(*a*)	1.47	7.05	84.47	7.00	31.072	6.92	91.39	7383
Connellsville	(*a*)	1.26	1.17	31.43	64.45	2.95	30.052	23.94	88.39	7140
Home Coal Company	(*a*)	(*a*)	10.32	38.90	46.37	4.30	(*a*)	(*a*)	(*a*)	(*a*)

a No determination made.
b Although it does not appear that the analysis of this coal as written can be literally correct, yet epeated determinations do not materially change the figures as given.
r

Table C is an arrangement of the coals in Table B, with the exception of the Connellsville and Home Company's coal, in the order of their calorific power, with the respective market prices on May 26, 1883, per ton of 2,000 pounds, in carload lots, at the Utah Central or Denver and Rio Grande stations in Salt Lake City. In the fourth column is shown the number of heat units in each coal which, at the prices given, can be purchased with $1, or, more properly, the relative calorific value secured for every dollar expended in the purchase, at prices named, of the various coals:

Table C.

Name of coal.	Units of heat.	Price per ton, May 26, 1883.	Calorific value bought by $1.
Crested Buttes anthracite	7383	$10 00	738.3
Crested Buttes coking coal	6920	10 50	659.0
Rock Spring	6008	6 00	1001.3
Pleasant Valley	5901	5 50	1072.9
Woods mine (Cedar City)	5810	(*c*)	(*c*)
San Pete	5681	5 50	1032.9
Walker mine (Cedar City)	5620	(*c*)	(*c*)
Weber Grass Creek mine	5529	4 50	1228.6
Lone Tree mine (Kanara)	5524	(*c*)	(*c*)
Leyson mine (Cedar City)	5500	(*c*)	(*c*)
Pollock mine (Kanara)	5365	(*c*)	(*c*)
Red cañon, Alma mine	5341	3 50	1526.0

c Not in market.

It appears from the foregoing comparisons that though the Red Cañon coal has less calorific effect in a ton than any other coal in the list, it nevertheless contains much more calorific effect in a given number of dollars' worth than any other coal mentioned. (*d*)

d Mr. Daggett's contribution ends here.

VIRGINIA.

The region called southwest Virginia, and which is now by railroad connection tributary to Roanoke, comprises the counties of Botetourt, Roanoke, Montgomery, Floyd, Pulaski, Smyth, Wythe, Washington, Carroll, Grayson, Giles, Craig, Russell, Tazewell, Scott, and Lee. This district is bounded on the east by the Blue ridge. In its topographical features this region is an elevated table-land, intersected by parallel ranges of mountains, running from northwest to southwest, thus dividing the whole country into a series of longitudinal valleys, along one of which the Norfolk and Western railroad runs. Coal is found in workable quantity in Montgomery, Pulaski, and Botetourt counties, but in vast amount in Tazewell and Russell counties. The completion of the branches of the Norfolk and Western railroad into this district opens up a new coal territory, the seaboard outlet and shipping point of which is Norfolk. A sample of coal from the mines at Pocahontas, Tazewell county, yields the following analysis: Water, .932; volatile matter, 20.738; fixed carbon, 73.728; sulphur, .618; ash, 3.984 = 100.000; coke per cent., 76.330; phosphorus, .0013. The result of the analysis shows a coal of excellent quality. Coke produced from it should not contain over 5 per cent. of ash and .6 per cent. sulphur, leaving about 94 per cent. for fixed carbon. The seam is 12 feet in thickness, and above the water level, so that the mines drain themselves and coal can be mined and delivered at the minimum of expense.

In the eastern portion of this State coal mining has been a fluctuating industry for many years.

The following analyses of coal found in the Chesterfield, Powhatan, Goochland, and Henrico basins will prove interesting:

Analyses of Virginia coals.

Locality.	Carbon.	Volatile matter.	Ash.
	Per cent.	*Per cent.*	*Per cent.*
Stonehenge	58.70	36.50	4.80
Maidenhead	63.97	32.83	3.20
Heth's pit	62.35	37.65	2.80
Mill's and Reid's	57.80	38.60	3.60
Will's pit	62.90	32.50	4.60
Will's pit, green-hole shaft	67.83	30.17	2.00
Heth's deep shaft, bottom seam	53.36	35.32	10.82
Heth's deep shaft, middle seam	66.50	28.40	5.10
Heth's deep shaft, top seam	61.68	23.80	9.52
Powhatan pits	59.87	32.33	7.80
Winterpock creek	65.52	29.12	5.36
Cloverhill, Appomattox river slate coal	55.00	38.50	6.50
Cloverhill, mean of four	54.83	33.04	10.13
Richmond coal	59.25	32.00	8.75
Mid Lothian, Woolridge's pit	61.08	28.45	10.47
Mid Lothian, mean result average size coal	53.01	33.25	14.74
Creek Coal Company, mean of six trials	60.30	31.13	8.57
Black Heath pits, mean of four	58.79	32.57	8.64
Tippecanoe pits, mean of four	54.62	36.01	9.37
Randolph's	66.15	30.50	3.35
Coalbrook Dale, second seam	66.48	29.00	4.52
Anderson's pit, first seam	66.78	28.30	4.92
Crouche's lower shaft, upper seam	64.60	30.00	5.40
Scott's pit	60.86	33.70	5.44
Waterloo shaft	56.20	26.80	18.00
Deep Run pits	69.84	25.16	5.00
Will's pit, upper vein	66.60	28.80	4.60
Anderson's pit, bottom seam	64.20	26.00	9.80

WEST VIRGINIA.

The Coal Measures of the great coal basin of the Ohio (ordinarily called the Appalachian coal field), the one in which are the coal fields of Alabama, West Virginia, Maryland, etc., attain their greatest thickness, contain the most workable beds of coal, and aggregate the greatest thickness of coal in the section of this basin drained by the Great Kanawha river in Virginia and West Virginia. In the upper, middle, and lower Coal Measures, Rogers's Nos. XII., XIII., XIV., 156 feet of coal have actually been opened and measured. These are summarized as follows:

In No. XIV., 275 feet of measures, 6 beds, 35 feet 2 inches of coal.

In No. XIII., 1,075 feet of measures, 14 beds, 68 feet 8 inches of coal.

In No. XII., 1,100 feet of measures, 13 beds, 52 feet 4 inches of coal.

Totals, 2,450 feet of measures, 33 beds, 156 feet 4 inches of coal.

Besides these, it is known that there are a number of beds in these measures which have not been opened, and that there are several hundred feet of the upper measures on the Kanawha, below Charleston, that are not included in the above; enough to make, in all, fully 3,000 feet of Coal Measures and about forty coal beds, which aggregate not far from 175 feet of coal.

In regard to the actual working collieries in the Kanawha coal field, the following statement has been published:

1. In New River district, 15 collieries, having a daily capacity for producing 3,125 gross tons of coal.

2. In Kanawha district proper, on Chesapeake and Ohio railway, 27 collieries, having a daily producing capacity of 5,000 gross tons.

3. In Kanawha district, on Kanawha river, shipping by river only, 10 collieries, having a daily capacity of 2,155 gross tons.

So there are in operation at this time, in the Great Kanawha coal basin, in Fayette, Kanawha, and Putnam counties, 52 commercial collieries having a capacity for the production of 10,280 gross tons, or 11,513 net tons, of semi-bituminous and bituminous coal per day, equal to about 3,500,000 net tons per annum. To this list might be added some collieries that produce very considerable quantities for local consumption, salt works, etc.

There are in this region 10 coke works now producing coke, with an aggregate of 731 ovens and a daily capacity of about 800 tons. The largest works is that of the Hawk's Nest Coal Company, 160 ovens, some 5 miles from Hawk's Nest Station, on the Chesapeake and Ohio. The product of these works will be used at the new Victoria furnace of the Iron and Steel Association of Virginia, of which one large stack is completed. The three next largest works are the Low Moor, 122 ovens; the Sewell, 120 ovens; and the Quinnimont, 100 ovens; of which the Low Moor and the Quinnimont supply the furnaces whose names they bear, and the Sewell supplies the furnaces of the Longdale Iron Company.

The gas coal produced on the line of the Chesapeake and Ohio railway is being used at many of the largest cities in the Union for making illuminating gas. The Washington and the Philadelphia, the Manhattan and the Metropolitan of New York, the People's of Brooklyn, the New Haven, the Newport, the Providence; the Boston, the South Boston, the Charlestown, the Dorchester and Chelsea in Boston; the Newton and the Watertown, the Lynn, the Salem, the Waltham, the Haverhill, the Lowell, and the Lawrence, in Massachusetts, and the Portland, Maine, besides those of many other cities and towns, are making use of Kanawha gas coal.

Some recent analyses have been made of the Kanawha coals, and the following are appended. The coals were from the vicinity of Cabin creek, Kanawha county, 15 miles from the Kanawha river:

Analyses of Kanawha coals, West Virginia.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Moisture	1.34	.93	2.28	1.87	1.44	3.25
Volatile matter	38.09	38.92	37.65	36.58	32.73	35.97
Fixed carbon	56.42	57.17	58.19	55.65	59.96	57.31
Ash	4.15	2.98	1.88	5.90	5.87	3.47
	100.00	100.00	100.00	100.00	100.00	100.00
Coke, per cent	60.57	60.10	60.07	61.55	65.83	60.78
Ash in coke	6.85	4.98	3.12	9.58	8.98	5.71
Sulphur (mainly in pyrites)	1.68	.80	.70	.82	.85	.60
Specific gravity	1.2669	1.2219	1.2732	1.3048	1.3230	1.3280

Along the line of the Baltimore and Ohio railroad in Taylor, Marion, Harrison, and Preston counties is found an excellent gas coal, which has been used for many years by the gaslight companies of the Atlantic States. The output is half a million tons per annum, and the coal is mined by the Newburg-Orrel, Despard, Gaston, and Consolidated coal companies. The analyses show 42 per cent. fixed carbon and 57 per cent. volatile combustible matter. About 150 ovens are making coke from the slack of this gas coal.

In the northeastern portion of West Virginia is the large coal territory known as the Potomac-Cheat coal field. By investigations lately made it has been divided in four or five distinct and independent coal basins: The Elk Garden basin, next southwest from the Baltimore and Ohio, extending up the North Branch of the Potomac and Abrams creek, 27 miles; the Stony River basin, southwest of and adjoining the Elk Garden, extending up North Branch Potomac and Stony river and on the headwaters of Cheat river, 28 miles; the Potomac-Cheat basin, extending southwest from the last to the head of North Branch Potomac and on to Cheat river, having a length of 24 miles, about half of it drained by North Branch Potomac and half by Cheat river; and the Cheat River basin, a narrow arm some 45 miles long, mainly drained by Shaver fork of Cheat river, which forms the southwestern end of this Potomac-Cheat coal field, as it should be called.

In recapitulating the coal output of the State, one must include the coal shipped by the Kanawha river; that by the Chesapeake and Ohio railway; the gas coal on the line of Baltimore and Ohio railroad, and the bituminous coal sent out from the Elk Garden basin. The statistics are as follows:

Production of coal in West Virginia since 1873.

	Gross tons.
1873	600,000
1874	1,000,000
1875	1,000,000
1876	800,000
1877	1,000,000
1878	1,000,000
1879	1,250,000
1880	1,400,000
1881	1,500,000
1882	2,000,000

WYOMING.

The coal fields of Wyoming are of great extent and value. They have been known since 1850, but remained undeveloped until the completion of the Union Pacific railroad to Carbon, 100 miles west of Laramie, in 1868. The Coal Measures are estimated to cover at least 20,000 square miles of the surface of Wyoming, and mines are found for nearly 350 miles along the line of the Union Pacific, in every case, where developed, cropping boldly on the surface. In quality the coal is a lignite of superior grade, and suitable for all heating and domestic purposes, but non-coking and useless for gas making.

The vein which is worked at Carbon is 9 feet in width, the coal being the best quality of Tertiary brown coal; compact, pure, and comparatively free from moisture. It is used almost entirely as fuel on the Union Pacific railroad, the supply of coal for domestic purposes coming chiefly from the mines at Rock Spring. The following analyses were made of specimens taken from two veins in Carbon:

	No. 1.	No. 2.
Water	8.10	6.10
Volatile matter	34.70	38.80
Fixed carbon	51.65	49.30
Ash	5.55	5.80
	100.00	100.00

The mines at this point were first opened in 1868, and have been worked steadily since that time. The following table gives the output of the district to January 1, 1883:

Product of the Carbon mines, Wyoming.

	Net tons.
1868	6,560
1869	30,482
1870	54,915
1871	31,748
1872	59,237
1873	61,164
1874	55,880
1875	61,750
1876	69,060
1877	74,343
1878	62,418
1879	75,424
1880	100,433
1881	156,820
1882	200,123
	1,100,357

On the line of the Union Pacific railroad, from Bitter Creek to Rock Spring, coal mines are opened for almost the entire distance. In some cases work has been discontinued, but the output is included in the general summary. The coal at Rock Spring is generally conceded to be one of the best bituminous lignites found in the Far West. Its remarkably low percentage of ash, and freedom from water and sulphur, make it a favorite coal wherever it can be obtained. It is in general use throughout the towns in Wyoming, and large quantities of it are burned in Denver, Salt Lake City, and Ogden. It is a jet-black, semi-bituminous coal, producing no clinkers, and leaving but a small bulk of ash of a reddish color. Its composition and value are shown by the following analysis:

Water	7.00
Volatile matter	36.81
Fixed carbon	54.46
Ash	1.73
	100.00

It is a clean-breaking coal, which does not slack upon exposure to the influence of the atmosphere. The mine was opened in 1868 by Mr. Thomas Wardell, who was in the employ of the Union Pacific Railroad Company, the present owners of the mines. The product of the district to January 1, 1883, has been:

Product of the Rock Spring mines, Wyoming.

	Net tons.
1868	365
1869	16,933
1870	20,945
1871	40,566
1872	34,677
1873	44,700
1874	58,476
1875	104,664

	Net tons.
1876	134,952
1877	146,494
1878	154,282
1879	193,252
1880	244,460
1881	270,425
1882	287,510
	1,752,701

The mines at Almy, on the line of the Union Pacific, are owned by the Union and Central Pacific railway companies. The coal is much inferior to that found at Rock Spring, but is used in large quantities by the railways for their locomotives. The composition of the coal is shown by the following analysis:

Water	15.575
Volatile matter	33.905
Fixed carbon	44.785
Ash	5.928
	100.193

The mines were opened in 1869, and have produced large quantities of coal. In 1872 the Rocky Mountain Coal Company at Almy produced 105,060 tons of coal, and during the same year the Union Pacific mines produced 22,713 net tons. Since 1875 the Rocky Mountain Coal Company has come, by lease and purchase, into the possession of the Central Pacific Railroad Company, which now operates it. The product of the Union Pacific mines was as follows:

Product of the Union Pacific mines at Almy, Wyoming.

	Net tons.
1869	1,967
1870	12,454
1871	21,171
1872	22,713
1873	22,847
1874	23,006
1875	41,805
1876	60,756
1877	54,643
1878	59,096
1879	71,576
1880	100,234
1881	110,157
1882	117,211
	719,636

At Almy the mines owned by the Central Pacific Railroad from 1870 to 1883, inclusive, produced the following amounts:

Product of the Central Pacific mines at Almy, Wyoming.

	Net tons.
1870	16,981
1871	53,843
1872	105,118
1873	130,989
1874	81,699
1875	92,589
1876	69,782
1877	67,373
1878	57,404
1879	60,739
1880	82,684
1881	90,779
1882	94,065
	1,004,045

The only other district in which coal mining is actively pursued is at Twin creek. The coal here is an excellent, soft, non-slacking coal, suitable for many uses. Near the Twin Creek mine a cropping of coal shows 29 beds, which vary in width from 1½ to 48 feet. The mine was opened in 1875 by the Wyoming Coal and Coke Company, but little was done in the way of systematic development and a regular production until its sale to the Union Pacific Railroad Company in 1881. The composition of the coal is shown by the following analysis:

Water	8.58
Volatile matter	35.22
Fixed carbon	49.90
Ash	6.30
	100.00

The product of the mines here in 1882 was 8,855 tons.

Coal has been mined with varying success at many other points along the line of the Union Pacific, and by independent companies, but these companies have in every case finally been absorbed or crowded out by the Union Pacific Railroad Company, and work upon the mines stopped until increasing demand, or the exhaustion of some of the beds at present worked necessitated the development of new fields. The entire coal fields of Wyoming are practically owned by the Union Pacific Railroad. The capacity of these beds is indefinite. They would be able to supply at any time the whole demand of the Far West with a uniformly good coal. Coal has been mined in former years at Separation, Point of Rocks, Black Buttes, Old Rock Spring, Bear river, and other points, but present production is limited to the localities described. Prior to 1871, at Separation, Point of Rocks, Black Buttes, Old Rock Spring, and Bear river, it is estimated that over 100,000 tons of coal were produced, but the annual product is not obtainable. The product of the Territory for the years from 1868 to 1883 has been as follows:

Recapitulation of the coal production of Wyoming since 1868.

Years.	Carbon.	Rock Spring.	Almy. Union Pacific mines.	Almy. Central Pacific mines.	Twin Creek.	Total.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
1868	6,560	365	....	....	....	6,925
1869	30,482	16,933	1,967	....	....	49,382
1870	54,915	20,945	12,454	16,981	....	105,295
1871	31,748	40,566	21,171	53,843	....	147,328
1872	59,237	34,677	22,713	105,118	....	221,745
1873	61,164	44,700	22,847	130,989	....	259,700
1874	55,880	58,476	23,006	81,699	....	219,061
1875	61,750	104,664	41,805	92,589	....	300,808
1876	69,060	134,952	60,756	69,782	....	334,550
1877	74,343	146,494	54,643	67,373	....	342,853
1878	62,418	154,282	59,096	57,404	....	333,200
1879	75,424	193,252	71,576	60,739	....	400,991
1880	100,433	244,460	100,234	82,684	....	527,811
1881	156,820	270,425	110,157	90,779	....	628,181
1882	200,123	287,510	117,211	94,065	8,855	707,764
Total	1,100,357	1,752,701	719,636	1,004,045	8,855	4,585,594

The distribution of the coal mined by the Union Pacific Railroad Company in 1882, and 63,950 tons mined at Grass creek, Utah, in the same year, was as follows:

	Net tons.
Union Pacific Railroad	449,977
Commercial	222,507
Employés at mines	5,166
Total	677,650

The production of the Wyoming mines from January 1 to June 30, 1883, was as follows:

Output in first six months of 1883.

	Net tons.
Almy:	
Union Pacific mines	*a*43,276
Central Pacific mines	*b*41,436
Carbon, Union Pacific mines	*a*105,253
Rock Spring, Union Pacific mines	*a*122,947
Twin creek, Union Pacific mines	*a*15,249
Total	328,161

The number of men employed at the various mines is, on an average, about 920. The wages paid coal miners range from 90 cents to $1.15 per ton of coal mined.

The value of the coal product of Wyoming may be estimated at $2.25 per ton, or a total of $1,592,469 for the year 1882. The ton used throughout is the short ton of 2,000 pounds.

COAL ON THE PACIFIC COAST.

On the west coast of the United States very few coal mines have been opened and worked, and large importations of foreign coal are made to

a Output for May and June estimated. *b* Output for June estimated.

meet the demand for fuel. Within the past few years, however, the coal supply has increased greatly, new mines being opened, old ones more fully developed, and facilities of transportation improved. Yet the mines on American soil which yield the coal are very few in number, considering the area of the region under consideration. On this subject Mr. W. A. Goodyear, an engineer who has paid great attention to this branch of mining, says:

"The coal fields of the western coast of North America are limited in extent, and of comparatively recent geological origin. They are none of them of the Carboniferous age, and, indeed, so far as yet known, none of them date back of the Cretaceous period. They mostly furnish a non-caking bituminous coal, which belongs to the class of lignites or brown coals. Vancouver's Island, however, produces caking coal; and some caking coal of good quality has also been found in Washington Territory. Small quantities of anthracite have been found on Queen Charlotte's Island, and probably also in Washington Territory. But no workable mine of anthracite has ever been discovered on the coast, and the little that has been found has always proved, on investigation, to have been the result of local and special metamorphism.

CALIFORNIA.

"Of the two States and one Territory which border the Pacific Ocean between Mexico and British Columbia, Washington Territory is by far the most liberally supplied with coal. Oregon comes next, and California last. In fact, California is decidedly unfortunate in the extent and character of her coal fields. For, although it is easy to find coal at many localities in the Coast range from one end of the State to the other, as well as at certain points in the western foothills of the Sierra Nevada, yet it generally happens either that its quality is poor, or its quantity is small, or else that it is situated in the heart of the mountains so far from market that the cost of transportation alone would far exceed the value of the coal.

"The extent of the Mount Diablo coal field may be stated in broad terms to be some ten or twelve miles along the line of outcrop of the beds running through the northern part of township 1 north, range 1 east, and the northwestern and central portions of township 1 north, range 2 east, Mount Diablo meridian.

"The details of the line of outcrop are in many places very irregular, and especially so in the western portion of the field, where the hills are high, and the cañons are deep and steep. But its general course may be described as follows: It is curvilinear and convex towards the north. Beginning in the northeast quarter of section 7, township 1 north, range 1 east, it runs at first northeasterly, but curves rapidly to the east till it reaches a point in the northwestern quarter of section 8, from whence it follows for almost three miles nearly true east across the northern portions of sections 8, 9, and 10, and close to the northern edges of these sections. But in going easterly across section 11, it bends to the south, and crossing the south half of section 12, enters the southwest quarter of section 7, in the adjoining township. From thence it follows an irregular southeasterly course through the northwestern and central portions of the township as far as the Brentwood mines, upon the Rancho de Los Meganos, and near the line between sections 22 and 27 of township 1 north, range 2 east. Beyond this locality to the southeast the beds have not been traced with any certainty. The dip throughout is in a northerly direction; but it varies in amount at different localities from 12° or 15° up to 32° or 33°, being generally highest in the western portion of the field.

"A range of high hills, whose culminating points on sections 8 and 9 reach altitudes of 1,500 to 1,700 feet above the sea, runs in a general east and west direction across the northern half of township 1 north, range 1 east, and is separated by a narrow valley on the south from the still higher mountainous region which culminates in the double summit of Mount Diablo itself, 3,856 feet in height.

"In going east, however, from section 9 the hills diminish in height, and following the lines of the coal beds southeasterly across the next township they gradually fall lower and lower, till we reach the level of the valley at the Brentwood mines, which are situated on the edge of the San Joaquin plains, at an altitude of only between 100 and 200 feet above tidewater. In its higher portions this range of hills is deeply scored by cañons.

"The strata have been considerably disturbed at numerous localities by faults of greater or less magnitude, and the coal beds themselves are subject, within short distances, to so great variations in thickness and quality of coal, as well as in the character of the rocks which inclose them, that it is not possible with present knowledge to certainly recognize any single bed in the eastern portion of the field as being the same with any of those which have been so extensively worked in the western portion.

"By the phrase 'Mount Diablo coal field,' as here used, must be understood not merely the actually productive region, but the whole extent of the belt through which there has been found some definite evidences of probability that the beds were once continuous, or nearly so, and within which sufficient discoveries have been made to lead to the expenditure of any considerable sums of money in explorations and attempts to develop new mines. The area within which the mines have hitherto been profitably worked, however, is far more limited in extent. It lies among the higher hills in the western portion of the belt above described, and includes a distance of only about two miles and a half along the strike of the beds, from the west limits of the Black Diamond Company's workings in the northeast quarter of section 7, where the beds either split up, or run out, or become too much crushed and broken to pay for working, to the most eastern limits of the Pittsburgh Company's workings in the southwest quarter of section 3 and the northwest quarter of section 10, where they are stopped by the wall of a great fault which intervenes between them and Stewart's mine on the east.

"The Central (*i. e.*, Stewart's) mine is not here included within the profitably productive limits, for the simple reason that while it has produced considerable coal, its shipments having been sometimes as high as a thousand tons per month, it is more than probable that its production has been at a loss instead of a profit to its owners. Within the productive limits above indicated, the chief openings of the mines, as well as the dwellings of the miners and other buildings, are, owing to the topography of the country, concentrated at two considerable villages, about a mile apart. The first of these villages, known as Nortonville, is located on the southeast quarter of section 5.

"The second one, known as Somersville, is chiefly on the southeast quarter of section 4, township 1 north, range 1 east. Each village is at the bottom of a sort of amphitheater among the hills, and at the head of a deep cañon, which runs northerly some 3 miles to the edge of the San Joaquin plain, from which point the distance north across the plain to the river is also in each case about 3 miles. Down each of these cañons there runs a railroad of the ordinary gauge (4 feet 8½ inches) to points of shipment on the San Joaquin river, just above its junction with the Sacramento. Each railroad is therefore about 6 miles in length, the Black Diamond railroad running to the Black Diamond Landing (otherwise known as New York Landing), and the railroad from Somersville (called the Pittsburgh railroad) running to Pittsburgh Landing, some 2 or 3 miles further up the river. The height of the villages themselves above tidewater ranges from 700 to 850 feet.

"In the northwest corner of the southeast quarter of section 5 a round-topped hill rises to a height of 1,348 feet above low water, and near the middle of the line between the northwest and southwest quarters of section 4 a similar hill rises to a height of about 1,500 feet. Each of these two hills (between which runs the cañon of the Black Diamond railroad) is connected with the hills to the south, in which lie the mines, by a saddle some 300 or 400 feet lower than its own summit—the saddle between Nortonville and Somersville being some 300 or 400 feet higher than the village of Nortonville itself. There are few points in the hills containing the mines which rise to a greater height than the higher of the two hills just described. At Nortonville, as well as at Somersville, the cañon, at the head of which stands the village, forks into numerous branches which spread upwards in all directions to the south, southeast, and southwest among the hills, thus cutting up the surface of the mining ground by rough and precipitous gulches, often 200 to 300 feet in depth, so that the line of outcrop of the beds, as already stated, is at this locality very irregular in detail and deeply indented by the gulches. The rocks which inclose the mines consist of unaltered, grayish and reddish siliceous sandstone, generally not very hard, alternating with occasional strata of rather soft clay-rock, the whole belonging to the latest formations of the Cretaceous period.

"The coal beds which have been profitably worked to a greater or less extent are three in number, and are known, respectively, as the 'Clark vein,' the 'Little vein,' and the 'Black Diamond vein.' Of these the Clark vein is the highest in stratigraphical position; next in order below it comes the Little vein; while the Black Diamond vein is the lowest, and underlies both the others. The beds lie nearly parallel with each other, all dipping to the north, and at the immediate localities of the villages, both of Nortonville and Somersville, the amount of dip is from 30° to 32°.

"In the Clayton tunnel, at Nortonville, as the level distance from the floor of the Clark vein south to the roof of the Black Diamond vein is 696 feet, and the dip here being about 31°, it follows that the total thickness of the strata, including the Little vein, between the Clark and Black Diamond veins, is at this locality about 359 feet. At certain points the level distance between the beds is somewhat less than it is here, while in other places it is considerably greater. This is due mainly to changes in the degree of dip of the beds, though it is more than probable that the actual thickness of the strata between them also varies somewhat at different localities.

"Outside of the Mount Diablo coal fields, there are numerous localities besides Corral Hollow, scattered throughout the Coast range of mountains from San Diego to Crescent City, and a number of localities also in the western foothills of the Sierra Nevada, in California, where more or less coal has been found. None of these localities have yet proved themselves to be of any financial value here, and the great majority of them would be utterly worthless in any country."

The following rates are paid by the Mount Diablo mining companies to the miners: On the Clark vein, 75 cents a yard, the vein varying in width from 2 feet 6 inches to 2 feet 10 inches. On the Black Diamond vein in the same mine, $1 per yard is paid. At the Pittsburgh mine (same region), $1 per yard is paid on a coal vein 2½ to 4 feet thick. The men board themselves and furnish their own powder, oils, etc., the companies furnishing the tools.

The Empire Coal Company, Mount Diablo, took out in 1882, 36,000 tons of coal, and the estimated product for the first six months of 1883 is 19,000 tons. Between 50 and 60 men are employed, all of whom are whites. Average wages are $2.75 per day, the men boarding themselves. Foremen are paid $3.50 per day.

The Mount Diablo coal, which is mainly used for steam coal in San Francisco and on the steamers of the bay, is of poor quality, and, owing to its sulphur, is disliked for domestic purposes.

Mr. Goodyear estimates that the total cost of production at the Mount Diablo mines has varied at times since 1866 from a minimum of about $5, or possibly less, to a maximum of between $6.50 and $7 per ton.

But, for a general estimate of the total average cost of all Mount Diablo coal which has ever been sent to market, $5.75 may be taken as a fair approximation.

The monthly receipts of coal at San Francisco from Mount Diablo mines during recent years were as follows:

Receipts of Mount Diablo coal at San Francisco.

Months.	1878.	1879.	1880.	1881.	1882.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
January	7,974	9,571	12,451	11,795	8,715
February	6,458	8,185	13,225	9,125	9,140
March	8,608	9,400	14,700	8,721	9,975
April	10,678	10,142	13,907	7,699	8,681
May	10,027	10,167	11,546	8,048	10,754
June	10,323	9,994	11,965	8,528	10,721
July	11,133	12,144	12,468	7,668	8,269
August	11,268	12,684	13,331	7,612	10,130
September	11,819	13,159	14,026	8,757	9,483
October	11,169	14,353	14,233	9,287	10,033
November	12,900	12,393	13,138	8,140	9,182
December	9,677	12,243	13,733	7,675	7,972
Totals	122,034	134,435	158,723	103,055	113,255

The following table shows the amount of Mount Diablo coal received from each mine during the year 1882:

Product of the Mount Diablo mines in 1882.

Months.	Pitts-burgh.	Black Diamond.	Empire.
	Tons.	*Tons.*	*Tons.*
January	1,553	4,462	2,700
February	1,600	4,740	2,800
March	1,775	5,000	3,200
April	1,670	4,211	2,800
May	1,717	5,337	3,700
June	1,638	6,083	3,000
July	1,601	4,668	2,000
August	1,512	6,118	2,500
September	....	6,583	2,900
October	....	6,233	3,800
November	507	5,275	3,600
December	1,960	3,012	3,000
Totals	15,533	61,722	36,000
Same time in 1881	30,313	60,742	12,000

OREGON.

The coal mines in Oregon are mainly located at Coos bay, on the western coast of the State, about 100 miles north of the California boundary and 40 miles north of Cape Blanco. The Coos bay coal field covers several hundred square miles of territory, stretching from the Umpqua river, on the north, to points beyond the Coquille river, on the south, and extending back from the coast from 15 to 20 miles. The country is covered with a heavy growth of timber. The coal to be mined at a profit must be of good quality, favorably situated for cheap mining, and very close to navigable waters.

The following analyses of Oregon coals have been published:

	Coos bay.	Astoria.
Water	20.00	2.56
Volatile matter	32.59	46.29
Fixed carbon	41.98	48.49
Ash	5.34	2.74
	99.91	100.08

At Southport, Coos bay, where the coal is 4 feet 6 inches to 5 feet thick, the men are paid 87½ cents a cubic yard, boarding themselves, and being furnished tools only, by the company.

WASHINGTON.

At present the industry is only in its infancy, but the mining of coal in the Puget Sound basin promises to increase even more rapidly in the future than it has done hitherto. One enthusiastic writer says that the time is not far distant when there will be as many men employed in coal mining in the Territory as there are now at work in the mines of Pennsylvania.

The coal deposits of Washington Territory are mainly at Bellingham bay, close to the British Columbia line, and in the vicinity of Seattle, on the eastern shore of Puget sound. The Seattle coal field is one of the most important on the coast, and covers a large area.

Although King county has several mines that are rapidly developing, yet the coal deposits of Puget sound are not confined alone to this county. The *Northwest Enterprise* calls attention to the fact that there is plenty of coal on the Snohomish, Stilaguamish, Samish, and upper Nootsack rivers, in many places positively known to exist, and in others only hinted at and designedly kept quiet. In only a few instances has the quantity or value been investigated by making an opening. Northwest of the Sumas road, running from Bellingham bay to Sumas lake in British Columbia, there are no indications of it on the surface, while east of that line coal has been found in many places. The Nootsack plain is composed of drift and sediment, supposed to have come from Fraser river; yet lying deeper there may be coal in the Nootsack as well as in the Stilaguamish and Skagit river valleys, as it is known to extend under Bellingham bay, where it has been mined. The valley containing this coal extends across the sound, and shows coal again in the Olympic mountains and Vancouver Island sides. Coal has been reported at Langley, Burrard inlet, Pitt river, and other places in the plains on the Fraser, underneath a sediment like that of Bellingham bay. Pieces of coal are also found in the drift of Guemas, Samish, and Fidalgo islands, adjacent to older rocks, the situation of which clearly implies that it is in place somewhere not very far away.

The second great source of wealth of the Puget sound region is the coal field lying back of its eastern shores up against the base of the Cascade mountains. Its width is from 10 to 20 miles, and its length when fully explored will probably be found to be as great as that of the sound itself, reaching from Carbonado northward to and beyond the British Columbia line, a distance of over 100 miles. Mining operations in this field are facilitated by railroad transportation to tidewater.

The Carbon Hill coal mine is about 3 miles from Wilkinson and 32½ miles northeast from Tacoma, near the line of the Northern Pacific railroad. The mine is the largest on the coast, and belongs to the managers of the Central Pacific Railroad Company (Pacific Improvement Company), who have a line of steam colliers carrying the coal to San Francisco bay, for the use of steamers and locomotives of the Central Pacific and Southern Pacific railroads. It is stated that the mine can produce 20,000 tons a month; though the yield for 1882 was but 64,745 tons. The facilities for mining and transportation have been greatly increased, and the product for the first six months of 1883 is estimated at 63,380 tons. At the mine 234 men are employed, of whom 45 are Chinese. The Chinese are paid $1.25 per day, and white men from $2.75 to $3 per day, all boarding themselves. Some work by the piece and earn from $2 to $3 per cubic yard broken out. These average $2.75 per day. Extensive wharves and bunkers have been built, and the mine has been opened up on a large scale. The coal from this region is a true bituminous coal, hard, solid, black, and clean, not equal in heat-producing capacity to the best Pittsburgh coal, but a good fuel for railroad and steamship purposes.

Back of Seattle, and reached by a narrow-gauge railroad, lies the Newcastle lignite field. The coal is of a younger formation than that of the Carbonado district. It comes out in fine, clean, solid blocks, does not slack easily, like the brown coal of Dakota, and has about two-thirds the heat-producing quality of bituminous coal. The Newcastle mine, which shipped about 150,000 tons last year, will increase the shipments to 200,000 tons for 1883. This mine is 20 miles from the sea.

The Renton mine is 13 miles east of Seattle, and is producing regularly. Its coal is sent to the seaboard by the Columbia and Puget Sound railroad.

The Bellingham Bay mine, the oldest source of supply on the American side of Puget sound, was first worked upwards of twenty years ago. Its production reached the highest point in 1869, when it sent upwards of 20,000 tons to San Francisco. The shipments to that point in 1871, 1873, and 1876 were also about 20,000 tons. A few years ago the mine caught fire, and though the fire was subdued, it has been worked with little activity since, the shipments to San Francisco having ceased in 1878. The following is an analysis of Bellingham Bay coal:

Water	8.39
Volatile matter	33.26
Fixed carbon	45.69
Ash	12.66
	100.00

Further analyses of Pacific coast coals may be found in the State Geological Survey Report (Geology of California, Vol. I, p. 30), and in a table by Mr. Archibald R. Marvine in the annual report for 1873 of the United States Geological Survey of the Territories, by F. V. Hayden, pp. 113, 114.

The officers of the leading coal companies in San Francisco furnish the following figures of the output in 1882 of the mines named:

Product of various Pacific Coast mines in 1882.

Mine.	Location.	Net tons.
Black Diamond...	Mount Diablo, California..	61,722
Pittsburgh	......do	15,634
Empire	......do	36,000
Southport	Coos bay, Oregon	12,866
Seattle............	Newcastle, King county, Washington.	150,000
Renton	......do	24,000
Carbon Hill........	Carbon hill, Washington.	64,745

These mines will produce about the same in 1883 as in 1882, except the Pittsburgh, which, having been shut down part of the time in 1882, on account of a fire, did not yield its full quota. The total product will therefore be somewhat greater in 1883 than last year.

Annual receipts of coal at San Francisco.

Years.	Mount Diablo.	Coos Bay.	Bellingham Bay.	British Columbia.	Chili.	Australia.	English-Scotch.	Cumberland.	Anthracite.	Charlotte Island.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1860......	....	3,145	5,490	6,655	1,900	7,850	6,640	5,970	39,985	....
1861.......	6,620	4,630	10,055	6,475	12,495	23,370	23,565	2,975	26,060	....
1862.......	23,400	2,815	10,050	8,870	5,110	12,590	16,055	4,970	36,685	....
1863.......	43,200	1,185	7,750	5,745	1,790	16,890	14,660	5,670	38,660	....
1864.......	50,700	1,200	11,845	12,785	2,323	21,160	18,330	7,275	41,680	....
1865.......	60,530	1,500	14,446	18,181	1,410	17,610	9,655	4,230	22,585	....
1866.......	84,020	2,120	11,380	10,852	1,480	53,700	7,400	9,524	12,124	....
1867.......	109,490	5,415	8,899	14,829	14,949	26,619	7,302	12,177	48,518	....
1868.......	132,537	10,524	13,866	23,348	8,511	31,590	29,561	2,292	29,592	....
1869.......	148,722	14,824	20,552	14,880	1,114	75,115	17,386	11,536	24,844	....
1870.......	129,761	20,567	14,355	12,640	7,350	83,982	31,196	9,322	21,320	....
1871.......	133,485	28,690	20,284	15,621	4,161	38,942	54,191	6,060	7,231	565
1872.......	177,232	32,562	4,100	26,008	3,682	115,332	29,190	10,051	19,618	....
1873.......	171,741	38,066	21,211	31,435	400	96,435	52,616	8,857	18,295	....
1874.......	206,255	44,857	13,685	51,017	....	139,109	37,826	15,475	14,263	....
1875.......	142,808	32,869	10,445	61,072	....	136,869	57,849	10,328	18,810	....
1876.......	108,078	41,286	21,335	100,965	3,150	131,695	121,948	12,520	11,871	....
1877.......	96,172	30,941	10,475	102,421	8,145	100,513	89,362	10,608	21,791	....
1878.......	122,034	35,124	2,820	140,323	....	131,678	44,005	8,069	21,064	....
1879.......	134,435	45,909	....	160,142	....	80,175	36,588	1,777	21,982	....
1880.......	158,723	35,415	....	169,162	....	59,872	66,600	20,916	19,629	....
1881.......	103,055	21,246	....	158,629	230	126,296	281,313	24,982	13,697	....
1882.......	113,255	14,533	....	157,762	580	158,901	188,771	14,860	24,996	....

Annual receipts of coal at San Francisco—Continued.

Years.	Sitka.	Seattle.	Rocky Mountain.	Saghalien.	Fuca Straits.	Japan.	Ione.	Ounalaska.	Buckeye.	Carbondale.	Carmel Bay.	Tacoma.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1860													77,635
1861													116,245
1862													120,545
1863													135,550
1864													167,298
1865													150,141
1866													192,605
1867				218	509								248,925
1868				204									282,023
1869													328,973
1870													320,494
1871	18	4,918	1,025										315,197
1872		14,830	1,862										434,462
1873		13,572	1,904			50							454,587
1874		9,027	433										531,949
1875		67,106	53										538,208
1876		95,314	226										648,380
1877		102,333	133				3,458	190	41	177			576,763
1878		116,008	371				765	450		4,022			626,737
1879		135,012								1,229	425	845	618,519
1880		123,741											654,118
1881		152,893										17,339	899,680
1882		154,611										54,627	882,896

The foreign coal is mainly from British Columbia, Great Britain, and Australia, the receipts from the two last-named countries depending on the demand for grain raised in California, coal being brought at low rates of freight by grain-carrying vessels on the return voyage.

MISCELLANEOUS STATISTICS.

THE COKE INDUSTRY.

Mr. J. D. Weeks, of Pittsburgh, special agent of the United States Census to collect the figures relating to this trade, has made a report of which the following is a synopsis. The figures are for the census year ending May 31, 1880, and as a matter of course they are below what would be the case if a census were taken at the present time.

Census statistics of coke for the year ending May 31, 1880.

States.	Establishments.	Capital.	Hands.	Wages.	Coal used.		Other materials.	Coke produced.	
					Net tons.	Value.		Net tons.	Value.
Alabama	4	$135,500	64	$38,500	67,376	$75,314	$1,304	42,035	$148,026
Colorado	1	150,000	75	13,500	29,500	29,500	600	18,000	90,000
Georgia	1	80,000	107	13,837	117,000	120,000	4,900	70,000	140,000
Illinois	4	205,000	18	9,347	15,000	15,000	420	7,600	24,700
Indiana	2	80,000	4	300	1,500	2,025	200	1,000	3,000
Ohio	15	144,012	152	51,977	193,848	228,432	5,399	109,296	334,546
Pennsylvania	104	4,262,525	2,444	983,431	3,608,095	2.031,305	209,849	2,317,149	4,196,136
Tennessee	4	200,021	114	38,820	179,311	124,137	8,092	91,675	212,493
Virginia	2	30,000				(*a*)			
West Virginia	12	330,000	163	48,942	148,480	135,944	3,020	95,720	216,588
Total	149	5,545,058	3,142	1,198,654	4,360,110	2,761,657	233,784	2,752,475	5,365,489

a Not in operation in 1880.

The price of Connellsville coke has fallen off since the beginning of 1882. This is due partly to the increased number of ovens, but mainly to the competition between large producers for the leadership in the trade. The unsettled condition of the iron trade may temporarily have had something to do with the demand for coke from time to time; but, as there is a constantly increasing sale, it does not materially affect the price. Operators and dealers working for increased trade force prices down. In January, 1882, prices ranged from $1.70 to $1.75 at the ovens. In June the rate was $1.40 to $1.50; in September, $1.15 to $1.25. Rallying a little after this date, there were sales at $1.30 to $1.35. At the opening of the year 1883 sales were recorded at $1.20 to $1.25. In February, sales were made at $1.15, and even $1 per ton is said to have been the rate paid by close buyers. During March and April, sales were made at $1 to $1.10. During May, 85 to 90 cents per ton at the ovens was the rate. In June, rates kept at about 90 cents per ton for blast-furnace coke, and $1.10 for foundry coke at the ovens. A restriction of the output was accomplished in the latter part of June, and at one time 2,400 ovens were idle in order to keep the price from still further declining.

By the returns for 1882—and there has been no reduction in wages this year—the cost of producing a ton of coke was something over $1.10 per ton for wages alone. As an example:

Days worked	303
Persons employed	391
Paid in wages	$209,482 81
Coal produced, net tons	277,890
Coke ovens	500
Coke produced, net tons	190,482

Every operator in coal which has coking qualities endeavors to show by analysis that it equals Connellsville coal from Fayette county. It is not so long ago that the business of coking coal began, and yet to-day land within the charmed circles of ovens is valued at from $750 to $3,000 per acre. At one cent per bushel royalty it is worth the larger sum. In a few years at the present rate of production—three million tons of coke, or nearly five millions of coal—there may be even greater revenue realized from this land. The Connellsville district is situated in the southwestern part of the State, lying mainly in the counties of Westmoreland and Fayette, and distant some 50 to 60 miles from Pittsburgh. The coal basin is 50 miles in length, by about 3 miles in width; and the coal seam is from 8 to 9½ feet in thickness. From this little strip of territory is drawn the solid carbon which feeds blast and smelting furnaces from Lake Champlain on the east to Omaha and Salt Lake on the west, and from Canada to Texas.

The coal is bituminous, with generally a dull resinous luster, alternating with seams of bright, shining, crystalline coal, coated with a yellowish silt. It contains numerous particles of slate, and some crystals of pyrites. It is compact, with a tendency to break into cubes. One of the latest analyses of this coal showed: fixed carbon, 64.12; volatile matter, 28.50; ash, 6.12; sulphur, 0.6; moisture, 1.20. It yields a coke which is nearly 90 per cent. fixed carbon, and less than one-half of one per cent. sulphur.

The coke from this region is of silvery luster, cellular, with a metallic ring, tenacious, comparatively free from impurities, and capable of bearing a heavy burden in the furnace. Its porosity and ability to "stand up" in the furnace are what have given it such a reputation for a blast furnace fuel, and created such a demand for it for mixing with anthracite and bituminous coal in the East and West, especially where an open iron, such as is used in the Bessemer process, is needed.

In 1876 there were perhaps 3,260 ovens in various stages of completion in the district. At present there are about 8,000 in use, and there are 3,000 more under construction by the various corporations. In the event of all being at work, there would then be a daily yield of 15,000 tons. There are some difficulties in the way of accomplishing this total, and the greatest obstacle is the lack of transportation facilities.

In coking the coal, the beehive oven is in universal use in the Connellsville region. These ovens vary at the different works from 11 to 12 feet in diameter, and from 5 to 6 feet in height. The working is very simple. The coal is dumped through an opening in the crown of the furnace, and spread evenly on the floor, to the average depth of 2 feet for 48-hour coke, and 2½ feet for 72-hour. The front opening through which the coke is discharged is at first nearly closed with brick, luted with loam. The heat of the oven from the previous coking fires the charge, and as the coking progresses the air is more and more shut off by luting the openings, and finally closing the roof openings. The average charge is 100 bushels of coal at 76 pounds, and the yield in coke, 120 bushels at 40 pounds, making the percentage yield 63, or 1.6 tons of coal to 1 ton of coke. The average time of coking is 48 hours, with 72 hours for that burned over Sunday; 24-hour coke is sometimes made; 72-hour coke is firmer coke than either of the others, but it is questionable whether it is a better furnace coke. When the coke is thoroughly burned the door is removed, and the coke is cooled by water thrown in from a hose and then drawn.

Within the past year what is called crushed coke has been made. In order to adapt it for general use without rendering it necessary to change stoves, grates, or furnaces, the Frick Coke Company conceived the idea of crushing into sizes to correspond with the sizes of anthracite coal, viz., egg, stove, small stove, and nut, so that persons ordering would have no difficulty in knowing just what size they required. It is used domestically for cooking in base burning stoves, furnaces, and in open grates. Large quantities are used at hotels for broiling purposes, it making a very clear and hot fire. Manufacturers of safes, chains, axles, shovels, files, bolts, agricultural implements, brass founders, maltsters, blacksmiths, etc., use the small stove or nut sizes. Steel manufacturers, as a rule, prefer the stove size for their crucible furnaces.

IMPORTS AND EXPORTS OF COAL.

The tariff from 1824 to 1843 was 6 cents per bushel, or $1.68 per ton; from 1843 to 1846, $1.75 per ton; 1846, 30 per cent. ad valorem; 1847 to 1861, 24 per cent. ad valorem; 1862–'63–'64, $1 per ton; 1865, $1.10; 1866 to 1872, $1.25 per ton; since August, 1872, 75 cents per ton. During the period from June, 1854, to March, 1866, the reciprocity treaty was in force, and coal from the British possessions in North America was admitted into the United States duty free. The imports are from Australia and British Columbia to San Francisco; from Great Britain to the Atlantic and Pacific coasts; from Nova Scotia to Atlantic coast ports. Exports are mainly from the lake and Atlantic shipping ports to the Canadian provinces and to the West Indies.

The imports and exports for the calendar years named have been as follows (gross tons of 2,240 pounds):

Imports and exports of coal.

	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Imports:							
Bituminous	488, 132	498, 275	566, 938	449, 167	577, 458	834, 875	774, 425
Exports:							
Anthracite	362, 044	377, 979	312, 273	421, 992	411, 706	538, 090	531, 836
Bituminous	253, 387	324, 829	345, 347	221, 371	198, 413	232, 073	413, 171

The following details of the importations and the exports for the fiscal year ending June 30, 1882, are of interest:

Details of importations in 1882.

	Tons.
Imports:	
From Great Britain	390, 863
From Canadian provinces	117, 831
From British Columbia	172, 625
From Australia	166, 425
All other ports (mainly ship stores, sold here)	3, 950
Received at—	
San Diego and San Francisco	660, 136
Other Pacific coast ports	17, 480
Boston, Massachusetts	40, 058
Portland, Maine	40, 667
All other New England ports	32, 147
New York	37, 776
All other ports on the Atlantic	23, 074

Of the coal imported north and east of New York on the Atlantic seaboard 60,769 tons was culm.

Details of exports in 1882.

	Bituminous.	Anthracite.
Exports:	*Tons.*	*Tons.*
To Quebec, Ontario, etc	199,671	501,497
To Cuba	75,385	24,934
To Mexico	7,028	9,545
Other ports and places (41 in number)	32,236	17,766
	314,320	553,742
Shipped from—		
Baltimore, Maryland	45,430	....
Champlain, New York	....	95,783
Cleveland, Ohio	87,525	31
Detroit, Michigan	53,015	94
Genesee, New York	226	56,755
New York (includes Perth Amboy, etc.)	3,481	73,554
Oswego, New York	....	294,675
Philadelphia, Pennsylvania	61,885	21,515
Other ports and places (20 in number)	62,758	11,335
	314,320	553,742

LOSS ENTAILED BY STRIKES.

In regard to the loss caused by strikes, the long strike in 1882 of the miners at the railroad pits along the Panhandle road leading into Pittsburgh is a noteworthy example.

Work ceased in the Panhandle pits March 31, when the operators notified the men that it was impossible to pay 4 cents and compete successfully in western and northwestern markets with coal from other localities mined at much lower rates. The protracted struggle was a severe loss to both operators and miners. In wages the latter lost in four and a half months $250,000; the operators lost all their summer contracts, and the railroads lost in freights at least $200,000. The money loss to a given coal mining locality is not always the most disastrous, for trade is taken by other districts, and once having been diverted it frequently does not return when the strike is adjusted; thus Pittsburgh coal, which formerly supplied western and central New York, the Canadas, etc., no longer goes to these markets, which now draw their supply from Reynoldsville and the Low-Grade division of the Allegheny Valley railroad, where digging is and has been cheaper. This change has been made in the face of the acknowledged superiority of the Pittsburgh fuel.

COAL TRADE OF PRINCIPAL CITIES.

The coal business done at some of the most important cities in the Union in the year 1882 is given below:

Gross tons of 2,240 pounds:	
Buffalo, New York	3,031,791
San Francisco, California	882,896
Providence, Rhode Island	821,837
Boston, Massachusetts	2,106,870
New York City	6,000,000
Brooklyn, New York	1,600,000
Jersey City, New Jersey	500,000

Net tons of 2,000 pounds:

New Orleans, Louisiana	300,000
Baltimore, Maryland	2,200,000
Erie, Pennsylvania	700,000
Toledo, Ohio	1,782,810
Cincinnati, Ohio	2,197,407
Saint Louis, Missouri	1,910,015
Louisville, Kentucky	750,000
Mobile, Alabama	25,000
Richmond, Virginia	215,903
Chicago, Illinois	3,852,070
Milwaukee, Wisconsin	400,000
Duluth, Minnesota	264,688
Cleveland, Ohio	1,922,595
Kansas City, Missouri	420,731

It is not to be supposed that the coal noted above was in every case used or consumed in the several cities, for many of them are distributing centers. It is safe to say that the average consumption of coal for domestic uses in the large cities of the Union is two tons per capita per annum. This average, of course, does not hold for the country at large.

WAGES PAID FOR DIGGING COAL.

The following is a statement of the rates paid in various districts for mining coal in March, 1883, from the best sources obtainable:

Miners' wages, per measure, at different points.

Alabama, 55 to 60 cents per ton.
Along the Monongahela, 3½ to 4 cents per bushel.
Angus, Iowa, $1.12½ per ton.
Anthracite regions, 85 cents per 2-ton car.
Belleville district, Illinois, 1½ cents per bushel.
Brazil, Indiana, 4 cents per bushel.
Bridgeport, Ohio, 75 cents per ton.
Boulder, Colorado, 90 cents per ton.
Clearfield region, Pennsylvania, 50 cents per ton.
Connellsville coke region, 1 cent per bushel.
Coalton, Kentucky, 70 cents per ton, screened coal.
Coal creek, Indiana, 90 cents per ton.
Elk Garden, West Virginia, 50 cents per ton.
Glen Mary, Tennessee, 4½ cents per bushel.
George's creek, Maryland, 50 cents per ton.
Hocking valley, Ohio, 80 cents per ton.
Kanawha river, West Virginia, 3 cents per bushel.
Myersdale, Pennsylvania, 40 cents per ton.
Missouri (Ray county), 6 to 7 cents per bushel.
Mahoning valley, Ohio, 65 to 75 cents per ton.
Murphysborough, Illinois, 75 cents to $1 per ton.
Nova Scotia mines, 34 cents per ton.
Reynoldsville, Pennsylvania, 50 cents per ton for run-of-mine coal.

THE PROPERTIES OF GAS COAL.

The most important requisites of gas coal are, first, that it contain a large amount of volatile combustible matter, or gas; second, that the volatile matter be of a good illuminating power; third, that the coal be as free as possible from sulphur; and fourth, that the coke furnished from the carbonization of the coal be bulky, and at the same time firm, that is, not inclined to be granular.

1. The precentage of the volatile matter in the coals usually employed in gas-making is from 25 to 40, and in cannel coal it rises to 60 or 70 per cent., a portion being nitrogen and oxygen. A ton of coal should produce from 8,000 to 9,000 feet of carbureted hydrogen or illuminating gas, or from 4 to 4½ feet per pound, the latter, as is well known, being the product of fair average samples of Youghiogheny coal. Gas works practically obtain more gas per pound than the chemists in analyzing the coal, doubtless through the redistillation of the tarry matter and its conversion into permanent gas. Besides this, at gas works, the measurement is taken at a high temperature, a difference of 5° changing the volume of gas about 1 per cent. By using the steam-jet exhaust (a recent improvement), an increased quality of gas is obtained, which would otherwise pass off in little bubbles in the tar.

2. That the gas produced from the coal be of good illuminating power is also very important. The standard of gas in our large cities ranges from 14 to 16 candle power. The standard candle in testing gas is of spermaceti, burning at the rate of 120 grains per hour, compared with a standard gas-burner consuming 5 cubic feet per hour. When it is supposed to give fifteen times the amount of light furnished by such standard candle, the gas is said to have 15-candle power, or be 15-candle gas. But the standard of illuminating power can easily be raised by the addition of a few per cent. of some rich cannel or oil shale, or some substance of the character of albertite or grahamite; for example, for a coal that produces by itself 15-candle gas, by the addition of 10 per cent. of cannel the gas was raised to the standard of 18 candles. Many coals which produce gas of a low illuminating standard, but in large quantities, and which coke well, are used as gas coals.

3. It is important that the coal should contain but a small proportion of sulphur compounds, as it is then easily purified, requiring less lime, producing a better quality of gas, and the coal may be safely stored without danger from spontaneous combustion. Good gas coal should not require more than one bushel of lime to purify 5,000 or 6,000 feet of gas. The sulphur in coal is sometimes in combination with iron; in other cases it passes off in a volatile state, leaving but little in the coke. For gas-making, this latter is a disadvantage, as the less sulphur entering the gases the better, since it must be removed by purification. For the blast furnace, on the contrary, the less sulphur remaining in the coke the better, since it is the sulphur in the coke which is injurious, and not that in the hydrocarbons, which pass off at the top of the furnace stack. In some cases, however, when the gas carries with it most of the sulphur, the gas may be so superior in illuminating power as to warrant its use, notwithstanding its increased cost of purification.

4. A ton of good coal, used in the manufacture of gas, should produce 35 to 40 bushels of coke, weighing 35 pounds to the bushel. The coke is used for heating the retorts, and should burn up clean, with but little clinker. There should be a surplus of coke when a large amount of gas is manufactured, besides that used in the gas-house, and this is valuable to the gas manufacturer as a merchantable product, especially in localities where coal of a good quality for domestic and other purposes is expensive.

PRICES OF COAL.

It is extremely difficult to give a tabular statement of the price of coal that will be understood by the general reader; there are so many collateral circumstances which need explanation to those not in trade. It has been the endeavor in the following tables to quote only such figures as will be clear. New York being the principal market, the fluctuations in the price of anthracite by the cargo at that point will be of interest. Prices usually open low in the spring and rise gradually until December, and remain at the closing rate until the following spring.

Fluctuations in anthracite at New York.

Years.	Lowest.	Highest.	Years.	Lowest.	Highest.	Years.	Lowest.	Highest.
1860	$5 50	$6 00	1868	$6 50	$11 50	1876	$3 75	$5 55
1861	4 20	6 00	1869	6 50	10 50	1877	3 25	3 75
1862	4 25	8 50	1870	4 50	8 50	1878	2 75	4 50
1863	7 00	11 00	1871	5 00	13 00	1879	2 15	3 25
1864	9 00	15 00	1872	3 75	6 25	1880	3 50	4 45
1865	8 50	13 50	1873	5 00	6 50	1881	4 00	4 65
1866	8 50	13 00	1874	4 55	5 55	1882	4 50	4 85
1867	6 50	8 50	1875	4 40	5 55			

Bituminous coals at New York.

	Per 2,240 pounds.
George's Creek, from Maryland	$4 25 to $5 25
Clearfield, from Pennsylvania	4 65 to 5 00
Gas coal, from Pennsylvania	4 75
Gas cannel, from West Virginia	9 00

George's Creek coal at Baltimore.

Below is a schedule of average rates obtained for this coal in a series of years, per ton of 2,240 pounds, at Baltimore, Maryland:

	Prices.
1871	$4 54
1872	4 52
1873	4 83
1874	4 70
1875	4 35
1876	3 87
1877	3 15
1878	2 86
1879	2 75
1880	3 75
1881	3 75
1882	3 50

Prices at Pittsburgh.

	Price.
Pittsburgh coal, per ton of 2,000 pounds:	
Wholesale, on board	$1 86
Retail, delivered	2 64

Prices at Cincinnati.

Pittsburgh coal, per ton of 2,000 pounds:	
Wholesale, on board	$2 38
Retail, delivered	3 31

Prices at Louisville.

Pittsburgh coal, per ton of 2,000 pounds:	
Wholesale, on board	$2 38
Retail, delivered	3 31

Prices at Saint Louis.

Per ton of 2,000 pounds:	
Illinois coal at wholesale	$2 25
Illinois Bessemer at wholesale	2 75
Indiana block at wholesale	3 37

Prices at New Orleans.

Per ton of 2,000 pounds:	
Pittsburgh coal, at wholesale	$3 15
Alabama coal, at wholesale	2 65
Anthracite, at wholesale	7 50

Prices at Toledo, Ohio.

Per ton of 2,000 pounds:	
Ohio coal, at wholesale, lump	$3 40
Pennsylvania coal (Blossburg)	4 40
Maryland coal (Cumberland)	4 35
Per ton of 2,240 pounds:	
Anthracite	6 50

Prices at Buffalo, New York.

Per ton of 2,000 pounds:	
Pennsylvania run of mines coal, at wholesale	$2 90
Ohio coal, run of mines, at wholesale	3 40
Anthracite coal, at wholesale	5 50

Prices at Chicago, Illinois.

Per ton of 2,000 pounds:	
Hocking Valley, at wholesale	$4 00
Minonk, &c., Illinois, at wholesale	3 00
Blossburg, Pennsylvania, at wholesale	4 40
Cumberland, Maryland, at wholesale	4 40
Indiana block coal, at wholesale	3 40
Pittsburgh steam coal, at wholesale	4 25
Per ton of 2,240 pounds:	
Anthracite, average of size, at wholesale	7 50

Prices at San Francisco, California.

Per ton of 2,240 pounds:	
Australian, at wholesale	$6 75
Liverpool coal, at wholesale	6 00
Welsh coal, at wholesale	6 25
Coos Bay, Oregon, at wholesale	7 00
Lehigh lump from Atlantic ports	18 00
Cumberland, from Maryland, at wholesale	13 00

ACCIDENTS IN COAL MINING.

The opinion appears to be general that miners, especially those employed in the extraction of coal, are engaged in the most unhealthful of employments, and that their death rate is particularly high as compared with other workers. But this is a fallacy easily discovered when put to the test of actual fact. So far, indeed, from this being the case, the miners as a body are as long-lived as the men engaged in most occupations above ground, and live considerably longer than those employed in many surface pursuits. The working places of American coal mines are usually far more healthy than many workshops and factories, for the temperature in the former is moderate and very uniform; and of late years one great evil, that of inhaling the fine particles of coal dust, has been greatly diminished and can be still more so without much trouble or expense.

The following statistics relative to the death rate in anthracite coal mines of Pennsylvania, gathered from the official reports for 1882, are of value:

Accidents in the anthracite mines of Pennsylvania in 1882.

	Killed.	Injured.	Tons mined in 1882.
Wilkes-Barre district.	73	185	7, 066, 356
Hazleton district......	40	130	4, 939, 780
Pottsville district.....	20	94	1, 709, 280
Shenandoah district ..	40	167	4, 661, 024
Scranton district.......	77	288	7, 439, 485
Shamokin district.....	50	150	4, 588, 799

There were 76,307 persons employed in and about the anthracite mines.

The accidents in the bituminous mines of Pennsylvania were as follows:

Accidents in the bituminous coal mines of Pennsylvania in 1882.

	Killed.	Injured.	Tons mined in 1882.
First district..........	31	26	10, 237, 458
Second district.........	34	56	7, 307, 580
Third district.........	17	44	4, 618, 245
Fourth district........	12	32	3, 500, 000

In all, 44,793 persons were employed in and about the mines.

The fatal accidents included in the foregoing tables were 394 out of 121,100 persons employed, showing a death-rate from accidents of 3.25 per 1,000.

IRON.

IRON ORE AND ITS PRODUCTS.

BY JAMES M. SWANK.

The world's production of iron and steel.—The remarkable industrial activity of the present age is most strikingly exemplified in the progress that has been made in the world's production and consumption of iron and steel. This progress has, again, been most marked in very recent years. The world's production of pig iron in 1876 was about 14,000,000 tons, but in 1882 it was over 20,000,000 tons, an increase of 43 per cent. in six years. The world's production of steel in 1877 was about 2,400,000 tons, but in 1882 it was over 6,000,000 tons, an increase of 150 per cent. in five years. As most of the iron and steel that is now produced is made with coal which is dug out of the earth, instead of the charcoal which the forests produce, the production of this mineral product in late years has also very greatly increased. In 1876 the world's production of coal was about 280,000,000 tons, but in 1882 it was about 375,000,000 tons, an increase of 34 per cent. in six years. The figures above given for 1876 and 1877 were published in my annual reports for those years, accompanied by sufficient details to establish their claim to general acceptance. The figures given for 1882 have been obtained by an examination of all the iron and steel and coal statistics that are accessible for that year or for the next most recent year. Such remarkable progress as is here shown has never before been equaled or approximated in any sphere of industrial activity. Rapid as has been the extension of the American railroad system, about which all the world wonders, the iron and steel industries of both Europe and America have made even more rapid strides. What a vast amount of human energy, undreamed of when men who are not yet middle-aged were schoolboys, is represented in the production in one year of 374,860,501 tons of coal, 46,777,299 tons of iron ore, 20,656,184 tons of pig iron, and 6,307,756 tons of steel! The countries which have contributed to this marvelous development, and the proportion which each has contributed, are given in the following table, English tons of 2,240 pounds being used for Great Britain, the United States, and "other countries," and metric tons of 2,204 pounds being used for all the continental countries of Europe.

The world's production of iron ore, pig iron, steel, and coal.

Country.	Iron ore.		Pig iron.		Steel.		Coal. (a)	
	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
Great Britain	1882	16, 627, 000	1882	8, 493, 287	1882	2, 259, 649	1882	156, 499, 977
United States	1882	9, 000, 000	1882	4, 623, 323	1882	1, 736, 692	1882	86, 862, 614
Germany	1882	8, 150, 162	1882	3, 170, 957	1882	1, 050, 000	1882	65, 332, 925
France	1882	3, 500, 000	1882	2, 033, 104	1882	453, 783	1882	20, 803, 332
Belgium	1882	250, 000	1882	717, 000	1882	200, 000	1882	17, 485, 000
Austria and Hungary	1881	1, 050, 000	1881	523, 571	1882	225, 000	1881	15, 304, 813
Russia	1880	1, 023, 883	1880	448, 514	1880	307, 382	1880	3, 292, 212
Sweden	1881	826, 254	1881	435, 489	1881	52, 234	1882	250, 000
Spain	1882	5, 000, 000	1880	85, 939	1873	216	1880	847, 128
Italy	1882	350, 000	1882	25, 000	1876	2, 800	1874	182, 500
Other countries	1882	1, 000, 000	1882	100, 000	1882	20, 000	1882	8, 000, 000
Total	......	46, 777, 299	......	20, 656, 184	......	6, 307, 756	......	374, 860, 501
Percentage of total production contributed by the United States	......	19	......	22	......	28	......	23

a Some slight discrepancies between Mr. Swank's coal statistics and those given in the foregoing discussion will be noticed. Mr. Swank's figures, however, command attention, and their presentation in this connection is in every way desirable.—A. W., jr.

Relative increase in Great Britain and in the United States.—The relative as well as the absolute prominence of Great Britain and the United States as producers of the finished and raw materials mentioned in the table will be observed at a glance, but the relative growth of the two countries in the production of these materials, except iron ore, is also worthy of notice. Great Britain doubled its production of pig iron in the twenty years from 1863 to 1882; the United States doubled its production in the five years from 1878 to 1882. Great Britain doubled its production of steel in the five years from 1878 to 1882, and so also did the United States. Great Britain added only 50 per cent. to its production of coal in the sixteen years from 1867 to 1882, but the United States more than doubled its production of coal in the ten years from 1870 to 1880, and since 1880 has added 25 per cent. to the production of that year, increasing its production in the two subsequent years at least 20,000,000 tons, while Great Britain increased its production in these two years only about 10,000,000 tons. These comparative facts are given simply to show that the rate of progress in the manufacture of pig iron and in the production of coal has recently been much greater in the United States than in Great Britain, and that the rate of progress in the production of steel by both countries has been the same in late years. Iron ore has recently been so largely imported by Great Britain that the statistics of its production by that country cannot fairly be used for comparison.

The progress of two decades.—The rapid progress of the United States in the production of the raw and finished materials under consideration is more fully shown by a comparison of the census statistics of 1860 with the census statistics of 1880. These statistics are as follows, in census tons of 2,000 pounds:

Materials.	1860.	1880.
	Tons.	*Tons.*
Coal	14, 333, 922	71, 067, 576
Iron ore	3, 218, 275	7, 974, 705
Pig iron	987, 559	3, 781, 021
Steel	11, 838	1, 150, 667

Consumption of iron and steel.—Our national pride may well be gratified with the foregoing statistical statements. To be second only to Great Britain in the production of iron ore, coal, pig iron, and steel is itself a great fact; to have made the vast strides of the last few years in the production of these materials is another great fact; but to contribute 23 per cent. of all the coal produced in the world, 19 per cent. of all the iron ore, 22 per cent. of all the pig iron, and 28 per cent. of all the steel is a still greater fact. But the most remarkable fact of all in connection with this vast material development remains to be stated. Large as our production of iron ore, pig iron, and steel is shown to be, it is not large enough to meet our wants, and we are consequently importers in a large degree of the iron and steel products of other countries, and indirectly of the iron ore and coal which are required in their manufacture; we are also large direct importers of iron ore itself. Were it necessary to do so, statistics could readily be cited which would fully establish the fact that our country is a larger consumer of iron and steel than any other country. It is natural that we should be, as our population is greater than that of any other civilized country, Russia alone excepted, and as our railroad system, which absorbs fully one-half of all the iron and steel we produce and import, embraces a greater number of miles of track than that of all Europe.

The status of various foreign countries.—In the table of the world's production the reader will observe that Spain is a large producer of iron ore but a small producer of pig iron, although it is not wanting in coal nor in forests for the production of charcoal. Its iron industry, if such it may be called, is chiefly devoted to the exportation of iron ore to Great Britain, France, Germany, Belgium, and the United States. It will also be observed that Belgium, although a large producer of pig iron, is a very small producer of iron ore, while it is a large producer of coal. The neighboring grand duchy of Luxemburg (which for statistical purposes is included in Germany), upon the other hand, is a large producer of iron ore but is deficient in coal, and from it Belgium draws its main supplies of iron ore. Italy produces iron ore of remarkable richness on the island of Elba, which is chiefly exported. There are also mines of good iron ore on the mainland of Italy, particularly in Lombardy, but this country lacks both coal and charcoal, and mainly for this reason manufactures but little pig iron. Of the "other countries" named in the table, China, New South Wales, Nova Scotia, India, Japan, Vancouver's Island, and Asia Minor are in the order named the principal producers of coal; Algeria is the principal producer of iron ore, nearly all of which is exported; Nova Scotia and Turkey-in-Europe are the principal producers of pig iron, and China is the principal producer of steel.

Domestic sources.—We now come to consider the details of the production of iron and steel in the United States in 1882, beginning with the production of iron ore. The statistics of the production of iron ore in the United States are not collected annually, owing to the difficulties which would surround the undertaking. The mines are not in one locality, nor are the miners always large companies—conditions which, if they existed, would restrict the work of collecting statistics within reasonable dimensions.

Iron ore is now mined in twenty-five States and two Territories, as follows: Maine, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, Georgia, Alabama, West Virginia, Kentucky, Tennessee, Ohio, Michigan, Wisconsin, Minnesota, Missouri, Texas, Colorado, California, Oregon, Utah Territory, and Washington Territory. Very large deposits are found near Lake Superior, in Michigan and Wisconsin; near Lake Champlain, in New York; in southeastern Missouri; in northern New Jersey; and at Cornwall, in Lebanon county, Pennsylvania. These are the principal sources of the iron-ore supply of the United States. Smaller deposits are innumerable, and are usually in the hands of individuals, who often lease them to furnace owners for a royalty of from 25 to 50 cents on every ton of iron ore mined. It is a work of extraordinary difficulty to reach every miner of iron ore in the country under such conditions, in order to ascertain the quantity mined in any year, and, therefore, this work is only done by the United States Government, and only once in every ten years.

In the absence of direct reports from all the iron-ore mines of the country, it is necessary to carefully estimate from ascertained figures of iron and steel production in 1882 the quantity of iron ore consumed in that year. The elaborate census figures for 1880, which I had the honor to compile, furnish the data from which to ascertain the proportions of raw material used in the finished product, and the figures contained in my annual report for 1882 furnish the requisite iron and steel statistics for the basis of calculation.

Census statistics of iron ore.—The only authoritative information concerning all the iron ore mined in the United States in any recent year is contained in Prof. Raphael Pumpelly's special report for the census of 1880. He states that in the census year, which began June 1, 1879, and closed May 31, 1880, the total quantity of iron ore mined was 7,974,706 tons of 2,000 pounds, or 7,120,273 tons of 2,240 pounds. The value per net ton is stated at $2.90, which is equal to $3.25 per gross ton. This is, it is presumed, the value at the mine.

Professor Pumpelly reports that iron ore was mined in twenty-three States in 1880. Among these was Indiana, which, we believe, mined no ore in 1882, as a charcoal blast furnace in that State which used some native ore in 1880 was idle in 1882. No Territory appears in the list for 1880, whereas in 1882 both Utah and Washington mined some iron ore. Minnesota, Colorado, and California did not mine ore in 1880, but did in 1882.

Two States which made pig iron in 1882 did not procure within their own borders any of the iron ore they used. These were Illinois and Indiana. The iron ore used in the blast furnaces of these States was taken from Michigan and Missouri. On the other hand, one State, Delaware, mined iron ore in that year, but made no pig iron, having no blast furnaces; the iron ore mined was taken to Maryland to be smelted.

In the fiscal year ending June 30, 1880, which ended only a month later than the census year, the importation of iron ore was 425,012 gross tons. The total supply for the census year 1880 was therefore about as follows:

Supply of iron ore in the census year.

	Gross tons.
Production	7,120,273
Importation	425,012
Total	7,545,285

The collection of iron and steel statistics for the census of 1880 was placed in my hands, and it was ascertained that the quantity of iron ore actually used in the manufacture of iron and steel in the United States in the census year 1880 was as follows:

Consumption of iron ore in the census year.

	Net tons.
Blast furnaces	7,256,684
Iron rolling mills	363,959
Steel works	9,455
Forges and bloomaries	79,610
Total	7,709,708

This total is equivalent to 6,883,668 gross tons. It would therefore seem that in the month of June, 1880, the iron and steel works of the United States were carrying a large stock of iron ore, as will appear from the following table.

Surplus stock of iron ore in the census year.

	Gross tons.
Total supply	7,545,285
Actual consumption	6,883,668
Remainder	661,617

At the rate of consumption of iron ore in the United States in the year referred to this remainder was equivalent to 35 days' supply. As

1880 was a year of brisk demand and good prices for manufactured products, it is natural to suppose that every iron-ore consumer would be provided with abundant supplies of raw material. Recently, however, prices have fallen in consequence of the diminished demand, and the stock of iron ore carried by manufacturers has not been so large. In some cases, notably among the Lake Superior iron-ore producers, the ore mining companies have recently been accumulating large stocks.

Census statistics of iron and steel.—The production of iron and steel in the census year 1880 was as follows:

	Net tons.
Pig iron	3,781,021
Rolled iron	2,353,248
Rolled Bessemer steel	889,896
Rolled open-hearth steel	93,143
Finished crucible steel	70,319
Blister and other steel	4,956
Iron blooms	72,557

The pig iron above referred to was divided as follows, according to the fuel used in its manufacture:

Kind of fuel.	Net tons.
Bituminous coal and coke	1,515,107
Anthracite	1,112,735
Mixed anthracite and coke	713,932
Charcoal	435,018
Furnace castings	4,229
Total	3,781,021

The steel above referred to was nearly all manufactured from ingots, classed as follows:

Ingots.	Net tons.
Bessemer	985,208
Open-hearth	84,302
Crucible	76,201
Total	1,145,711

Consumption of ore, fuel, and flux.—The following table shows the quantities of iron ore, fuel, and flux used by the iron and steel works of the country in 1880:

Works.	Iron ore.	Limestone.	Anthracite coal.	Bituminous coal.	Coke.	Charcoal.	Mill cinder.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Bushels.*	*Net tons.*
Blast furnaces	7,256,684	3,169,149	2,615,182	1,051,753	2,128,255	53,909,828	354,048
Rolling mills	363,959	....	526,126	3,915,377	14,834	2,569,756	....
Bessemer and open-hearth steel works	7,327	....	140,458	465,655	104,980	37,552	....
Crucible steel works	2,128	....	40,392	224,657	22,791	60,594	....
Forges and bloomaries	79,610	....	340	1,613	6,695	13,014,361	....
Total	7,709,708	3,169,149	3,322,498	5,659,055	2,277,555	69,592,091	354,048

Other materials.—The iron rolling mills, steel works, and forges and bloomaries used the following materials in addition to what are given above:

Works.	Pig iron.	Old iron rails.	Scrap iron.	Ore blooms.	Pig or scrap blooms.	Muck bar purchased.	Spiegeleisen.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
Iron rolling mills	1, 574, 693	708, 534	422, 282	14, 147	46, 861	53, 754	....
Bessemer and open-hearth steel works	966, 603	....	13, 911	16, 053	250	....	86, 138
Crucible steel works	17, 226	....	1, 952	13, 211	2, 400	....	....
Forges and bloomaries	38, 113	....	8, 933	....	....	....	....
Total	2, 596, 635	708, 534	447, 078	43, 411	49, 511	53, 754	86, 138

Works.	Old steel rails and crop ends.	Bessemer steel ingots and blooms purchased.	Open-hearth ingots and blooms purchased.	Scrap steel.	Swedish billets and bars.	Other billets and bars.	Oil used as fuel.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Barrels.*
Iron rolling mills	....	....	....	....	....	....	....
Bessemer and open-hearth steel works	85, 653	42, 939	17, 713	90, 645	....	....	....
Crucible steel works	....	....	....	19, 726	10, 410	16, 496	....
Forges and bloomaries	....	....	....	....	....	....	853
Total	85, 653	42, 939	17, 713	110, 371	10, 410	16, 496	853

Proportion of raw material to product.—It will be seen that these tables from the census of 1880 furnish proportions of raw material to finished product which can be used in our calculations of raw materials required to produce the iron and steel made in 1882. Calculations made upon this basis will therefore not be mere guesses nor wild estimates, and will not vary materially from true results.

Summary of the production of iron and steel in 1882.—The exact statistics of the total production of iron and steel in 1882 are summarized as follows:

Products.	Net tons.
Pig iron	5, 178, 122
Rolled iron	2, 493, 831
Bessemer steel ingots	1, 696, 450
Open-hearth steel ingots	160, 542
Crucible steel ingots	85, 089
Miscellaneous steel	3, 014
Iron blooms	91, 293

Classification of pig iron.—The total production of pig iron may be divided as follows according to the ordinary classification of the fuel used in its manufacture:

	Net tons.
Bituminous coal and coke	2, 438, 078
Anthracite	2, 042, 138
Charcoal	697, 906
Total	5, 178, 122

Of the pig iron classified under the head of bituminous coal and coke, also of that under the head of anthracite, a considerable quantity was made with mixed anthracite and coke, namely, 282,705 net tons of the former and 1,022,574 tons of the latter, or a total of 1,305,279 tons. The division of pig iron strictly according to the fuel used will be as follows:

Kind of fuel.	Net tons.
Bituminous coal and coke	2,155,373
Mixed anthracite and coke	1,305,279
Anthracite	1,019,564
Charcoal	697,906
Total	5,178,122

Raw materials and product in 1882 *and first six months of* 1883.—With the foregoing data it is possible to ascertain very closely the quantity of raw materials which were consumed in 1882, and which are incorporated in the table hereto appended. The value of the pig iron is averaged from trustworthy prices current. The value of the iron ore and limestone is averaged from special reports received from miners and consumers of iron ore and limestone in almost every section of the country. The "spot value of all iron and steel in the first stage of manufacture" covers all the pig iron produced, that part of the rolled iron which it is estimated is produced from old or scrap iron, and that part of the iron blooms which it is estimated is produced from old or scrap iron and iron ore, and excludes that part of the rolled iron and iron blooms which it is estimated is made from pig iron, and also excludes all steel, so as to avoid any duplication of values.

Summary of principal statistics of iron production in 1882 *and in the first six months of* 1883.

Details.	Calendar year 1882.	First six months 1883.
Pig iron made, tons of 2,240 pounds	4,623,323	2,352,019
Average spot value per ton at furnace	$23.00	$20.00
Total spot value pig iron at furnace	$106,336,429	$47,040,380
Iron ore mined in United States, tons of 2,240 pounds	9,000,000	4,500,000
Iron ore (American) consumed, tons of 2,240 pounds	8,700,000	4,500,000
Average spot value per ton at mine	$3.60	$2.75
Total spot value American ore mined, at mine	$32,400,000	$12,375,000
Total spot value American ore consumed, at mine	$31,320,000	$12,375,000
Imported iron ore consumed, tons of 2,240 pounds	589,655	185,000
Total iron ore consumed, tons of 2,240 pounds	9,289,655	4,685,000
Limestone consumed as flux, tons of 2,240 pounds	3,850,000	1,950,000
Average spot value limestone per ton at quarry	$0.60	$0.55
Total spot value limestone at quarry	$2,310,000	$1,072,500
Anthracite consumed in iron smelting, tons of 2,240 pounds	3,000,000	1,450,000
Anthracite consumed in all iron and steel works, including furnaces, tons of 2,240 pounds.	3,800,000	1,810,000
Bituminous coal consumed in iron smelting, tons of 2,240 pounds	1,500,000	840,000
Bituminous coal consumed in all iron and steel works, including furnaces, tons of 2,240 pounds.	6,600,000	3,140,000
Coke consumed in iron smelting, tons of 2,240 pounds	3,100,000	1,680,000
Coke consumed in all iron and steel works, including furnaces, tons of 2,240 pounds.	3,350,000	1,780,000
Charcoal consumed in iron smelting, bushels of 20 pounds	86,500,000	29,250,000
Charcoal consumed in all iron and steel works, including furnaces, bushels of 20 pounds.	107,000,000	38,750,000
Total spot value of all iron and steel in first stage of manufacture, excluding all duplications.	$171,336,429	$71,000,000

Some details of the production of iron ore in the United States in 1882.—From A. P. Swineford, esq., the editor of the Marquette *Mining Journal*, we learn that the production of iron ore by the Lake Superior mines in 1882 was 2,948,307 gross tons, or a little more than double the production of 1879, and more than 600,000 tons larger than the production of 1881. The production of the last six years has been as follows:

	Gross tons.
1877	1,025,129
1878	1,125,093
1879	1,414,182
1880	1,987,598
1881	2,321,315
1882	2,948,307

The aggregate production of all the Lake Superior iron ore mines since the commencement of their development is 20,590,750 tons, more than the half of which is credited to the six years above mentioned.

Of the product of 1882 the Marquette range contributed 1,812,289 gross tons, and the Menominee range 1,136,018 tons. Of this latter amount 276,017 tons came from the two mines in Florence county, Wisconsin, and 97,560 tons from mines located in Marquette county. Apportioning the product among the several counties, Marquette county is credited with a product of 1,885,830 tons; Menominee county with 762,441 tons; Florence, Wisconsin county, with 276,017 tons, and Baraga, Michigan county, with 24,019 tons.

The total production of iron ore in the Lake Superior district since the beginning of its development is given by Mr. Swineford in the following table:

Production of iron ore in the Lake Superior district.

	Gross tons.
1856 and previous	86,319
1857	25,646
1858	22,876
1859	68,832
1860	114,401
1861	114,258
1862	124,169
1863	203,055
1864	247,059
1865	193,758
1866	296,713
1867	465,504
1868	510,522
1869	639,097
1870	859,507
1871	813,984
1872	948,553
1873	1,195,234
1874	935,488
1875	910,840
1876	993,311
1877	1,025,129

	Gross tons.
1878	1,125,093
1879	1,414,182
1880	1,987,598
1881	2,321,315
1882	2,948,307
Total	20,590,750

Professor George H. Cook, State geologist of New Jersey, in his annual report for 1882, places the production of iron ore in that State in the year mentioned at 900,000 gross tons. The production of 1880 was 737,052 tons. Professor Cook has compiled the following table, giving the statistics of the production of iron ore in New Jersey during the past decade, and the estimated production at various intervals in preceding years:

Production of iron ore in New Jersey.

	Gross tons.
1790	10,000
1830	20,000
1855	100,000
1860	164,900
1864	226,000
1867	275,067
1870	362,636
1871	450,000
1872	600,000
1873	665,000
1874	525,000
1875	390,000
1878	409,674
1879	488,028
1880	745,000
1881	737,052
1882	900,000

The production in 1882 of the Lake Champlain district of New York is estimated by a very well informed correspondent at 675,000 gross tons, against 637,000 tons in 1881. Included in this district are the Chateaugay mines, from which 224,158 tons were shipped in 1882, according to information received from Mr. A. L. Inman, general manager of the Chateaugay Ore and Iron Company.

Mr. J. Taylor Boyd, general superintendent of the mines of the Cornwall Ore Bank Company, in Lebanon county, Pennsylvania, writes that the shipments of iron ore from these mines in 1882 amounted to 309,680 gross tons, against 249,050 tons in 1881.

Imports of iron ore in the last four years.—The following statement shows the quantities and values of iron ore imported into the United States during the calendar years 1879, 1880, 1881, and 1882, by customs districts:

Imports of iron ore.

Districts.	1879.		1880.		1881.		1882.	
	Gross tons.	Values.	Gross tons.	Values.	Gross tons.	Values.	Gross tons.	Values.
Baltimore	27, 090	$60, 869	170, 308	$506, 560	375, 798	$1, 005, 496	243, 182	$654, 629
Boston	701	2, 438	2, 155	13, 359	716	2, 867	1, 664	3, 322
Buffalo Creek	5, 969	14, 251	13, 554	36, 426	2, 492	7, 320	273	755
Champlain	12	31					2	7
Cuyahoga	550	1, 128	13, 858	48, 463	10, 500	37, 675	9, 420	33, 181
Detroit	1, 287	3, 508	456	1, 169	617	1, 646	48	98
Genesee	2, 125	4, 101	5, 390	16, 274	8, 716	25, 961	6, 851	21, 651
Huron			72	258	264	770	264	677
Newark			269	798				
New York	109, 230	282, 060	148, 987	432, 678	196, 419	641, 344	145, 909	421, 776
Oswegatchie			7, 553	21, 052	3, 418	10, 650	905	2, 783
Oswego	884	2, 130	4, 185	7, 860	13, 612	44, 026	37, 635	120, 008
Perth Amboy	9, 634	29, 010	5, 444	15, 968	13, 671	48, 323	31, 558	101, 859
Philadelphia	126, 659	281, 941	120, 619	335, 119	155, 564	394, 952	111, 944	279, 818
Puget Sound			400	412	1, 100	1, 622		
Cape Vincent			158	413				
Total	284, 141	681, 467	493, 408	1, 436, 809	782, 887	2, 222, 652	589, 655	1, 640, 564

Previous to 1879 the importations of iron ore into this country did not exceed 100,000 tons annually. In that year they amounted to 284,141 tons, valued at $681,467. In 1880 there was a large increase, and in 1881 a still larger increase; but in 1882 there was a decrease of nearly 200,000 tons. We anticipate in 1883 a continued decrease, owing partly to an increase in the duty after July 1 from 20 per cent. to 75 cents a ton, and partly to the lowering of the prices for domestic ores and to the opening of new sources of domestic supply. It will doubtless happen, however, that we will hereafter annually import from Spain and other countries a considerable quantity of foreign ore, for use in connection with our Bessemer steel works, not specially because of its cheapness, but because of its richness and purity, in these respects surpassing the product of many American mines. A peculiarity of the trade in foreign ores is that it would probably not have attained its recent proportions if it had not been profitable for European vessels which come to this country for grain to bring with them cargoes of iron ore in default of other freight.

A company of capitalists in this country has recently acquired possession of extensive deposits of iron ore of great richness and purity in the province of Santiago, in the southeastern part of Cuba, within four miles of the coast, and fifteen miles distant from the port of Santiago, where there is a good harbor. The company is known as the Juragua Iron Company, Limited, and its chairman is Dr. G. B. Linderman, of the Bethlehem Iron Company. Its acquisitions embrace several low mountains of slightly polarized hematite iron ore, which will average about 66 per cent. of metallic iron and about .025 of phosphorus. The ore is exposed in every direction, and can be mined, or rather moved, at slight cost. A railroad will be built from the mountains to the nearest point on the coast, or possibly to Santiago, and docks for the accommodation of vessels will also be constructed. The development of this important enterprise has already been actively commenced, but shipments of ore will probably not take place during the present year. The company will invest about a million dollars.

Details of the production of iron and steel in 1882.—In the following table are presented, in tons of 2,000 pounds, the statistics of the production of pig iron, rolled iron, iron rails, steel rails, steel, and blooms, in the United States in 1882. These statistics are given by States, so that the reader will see at a glance which sections of the country are most interested in the production of the articles mentioned. Pennsylvania leads all the States in the production of all forms of iron and steel, except blooms, as it has done for a hundred years, but Ohio, New York, and Illinois are also large producers of pig iron; Massachusetts, New York, and Ohio are large producers of rolled iron; and Illinois is a large producer of steel. The remarkable fact is, however, established by this table that our iron and steel industries are not confined to any particular section of the country, but are well distributed. It is true that Pennsylvania has most extensively of all the States developed its resources for the manufacture of iron and steel, but in recent years other States that had previously developed no iron or steel industry worthy of notice, if any at all, have suddenly become prominent as rivals of Pennsylvania. This is true especially of Illinois, which in 1870 was excelled by fourteen States in the production of iron and steel, but in 1880 was excelled by only three. It is especially true of some of our Southern States, which are awakening to a knowledge of their great resources for the production of these articles. Virginia, Tennessee, and Alabama now produce very encouraging aggregates of both pig iron and rolled iron, while Tennessee has also commenced the manufacture of steel. Even in the shadows of the Rocky mountains and on the Pacific coast iron and steel are now made, and there is every indication that their production will be largely increased in this part of our country in the near future. We have not mentioned such old rivals of Pennsylvania as Massachusetts, New York, New Jersey, Ohio, West Virginia, Michigan, Wisconsin, and Missouri, but it is a significant fact that in none of these States is the iron industry declining, while in some of them it is growing rapidly, as well as the manufacture of steel. Other States not above mentioned, such as Kentucky and Georgia, possess all the resources necessary to enable them to increase their production of iron and to add to it the manufacture of steel, and with the improved railroad facilities which they are now securing, and the new industrial spirit which they are now manifesting, the hope may confidently be indulged that they will accomplish both of these results.

Production of iron and steel in the United States in 1882, by States and Territories.

States and Territories.	Pig iron.	Rolled iron, including iron rails and nail plates.	Iron rails.	All kinds of steel rails.	Steel ingots and other crude steel.	Blooms from pig and scrap iron and iron ore.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
Maine	4, 100	10, 862	325			
New Hampshire		3, 508			3, 753	
Vermont	1, 210			26, 100	4, 300	820
Massachusetts	10, 335	111, 388		15, 707	18, 023	360
Rhode Island		11, 877				
Connecticut	24, 342	20, 676			460	2, 666
New York	416, 156	138, 541	4, 284	100, 737	129, 353	43, 911
New Jersey	176, 805	96, 441			17, 800	5, 948
Pennsylvania	2, 449, 256	1, 123, 886	82, 764	768, 144	1, 068, 706	29, 408
Delaware		38, 261				
Maryland	54, 524	33, 657				4, 655
District of Columbia		150				
Virginia	87, 731	40, 044				875
North Carolina	1, 150					150
Georgia	42, 440					600
Alabama	112, 765	9, 188	728			
Texas	1, 321					
West Virginia	73, 220	66, 107	1, 436			
Kentucky	66, 522	61, 096	2, 000			
Tennessee	137, 602	38, 770	19, 610	5, 780	4, 000	700
Ohio	698, 900	361, 608	18, 650	95, 156	163, 280	
Indiana	10, 000	71, 626	28, 173			
Illinois	360, 407	93, 943	21, 863	340, 387	404, 697	
Michigan	210, 195	11, 824				
Wisconsin	85, 859	64, 296	24, 685			
Minnesota	8, 126					
Missouri	113, 644	18, 145		85, 528	107, 210	1, 200
Kansas		17, 867	7, 067			
Nebraska		3, 000				
Colorado	23, 718	4, 739		18, 217	23, 513	
Wyoming Territory		16, 488	13, 253			
Utah Territory	57					
California	987	25, 843	3, 036	5, 164		
Oregon	6, 750					
Total	5, 178, 122	2, 493, 831	227, 874	1, 460, 920	1, 945, 095	91, 293

There are several interesting facts relating to the distribution and development of our iron and steel industries, some of which are shown in the foregoing table, which may here be mentioned. Massachusetts is a large producer of rolled iron, but the raw materials for its manufacture are almost wholly procured in other States or from foreign countries. Michigan is a large producer of pig iron, every ton of which is made with charcoal, although more than five-sixths of all the pig iron made in the country is made with coal. Delaware makes nothing but rolled iron, and Georgia makes nothing but pig iron. Tennessee is the most progressive of all the Southern States in the manufacture of iron and steel. After Pennsylvania the largest producer of iron rails is Indiana. The United States Government is a manufacturer of rolled iron at the Washington navy-yard. California rolls more iron than Connecticut, and Wyoming Territory more than Maine and New Hampshire united. Wheeling makes more nails than Pittsburgh, but Pittsburgh makes nearly three-fourths of all the crucible steel made in the United States. Blooms and billets made directly from iron ore in forges, which is the most primitive of all methods for the manufacture of iron, are produced chiefly in the Champlain district of New York, and blooms made from pig and scrap iron in bloomaries, according to the old Walloon method, are made chiefly in Pennsylvania. Down to 1855 charcoal was the principal fuel used in the production of pig iron in this country, but in that year we made more pig iron with anthracite coal than with charcoal. Anthracite remained the leading fuel for use in blast furnaces down to 1875, in which year bituminous coal and coke became the principal fuel for this purpose, and this position they have since maintained. Bessemer-steel rails were first manufactured in this country as a commercial product in 1867, but ten years elapsed before their production equaled that of iron rails. This occurred in 1877. In 1882 the production of steel rails was more than six times as large as that of iron rails.

Statistics of blast furnaces in 1882.—The following table gives the number of completed blast furnaces in the United States at the close of each of the eleven years from 1872 to 1882, allowance being made in each year for furnaces abandoned or torn down to make room for more modern structures:

Blast furnaces in the United States.

1872	612
1873	657
1874	693
1875	713
1876	712
1877	716
1878	692
1879	697
1880	701
1881	716
1882	687

At the close of 1882 there were 27 furnaces in course of erection in the United States, as follows: Pennsylvania, 4 anthracite and 3 bituminous; Virginia, 5 bituminous; Alabama, 4 bituminous and 2 charcoal; Ohio, 3 bituminous; West Virginia, 1 bituminous; Texas, 1 charcoal; Colorado, 1 bituminous; Utah, 1 charcoal; Oregon, 1 charcoal; Washington, 1 charcoal.

The number of furnaces in blast at the close of 1882 was 417, and the number out of blast was 270. Those out of blast were, as a rule, the smallest and least advantageously located; others were undergoing repairs or were idle from various local causes; but there were also among the idle furnaces many which could have been operated with profit if there had been a demand for their product. The importation of 604,978 net tons of pig iron in 1882 seriously interfered with this demand. The capacity of all the furnaces in the country is fully one-third more than the product of 1882.

The following table shows the number of furnaces in the United

States in and out of blast at the close of 1882, as compared with the close of 1881, separated according to the fuel used:

Condition of blast furnaces at the close of 1881 *and* 1882, *respectively.*

Kind of fuel.	December 31, 1881.			December 31, 1882.		
	In blast.	Out of blast.	Total.	In blast.	Out of blast.	Total.
Bituminous	144	75	219	127	83	210
Anthracite	160	63	223	161	64	225
Charcoal	151	123	274	129	123	252
Total	455	261	716	417	270	687

The production of pig iron in 1882 was the largest in our history. The production in the last four years, which includes the "boom" year 1879, was as follows, in net and gross tons:

Production of pig iron in the past four years.

Years.	Net tons.	Gross tons.
1879	3, 070, 875	2, 741, 853
1880	4, 295, 414	3, 835, 191
1881	4, 641, 564	4, 144, 254
1882	5, 178, 122	4, 623, 323

In these four years we increased our production of pig iron 1,881,470 gross tons, or 68 per cent. This increase has been obtained mainly through improved furnace management, and only slightly through an increase in the number of furnaces in blast, as will appear from the following statement of furnaces in blast at the close of 1879 and 1882—the only figures we have for comparison, but sufficient to enable us to reach approximately accurate conclusions:

Furnaces in blast, 1879:	
Anthracite	162
Bituminous	123
Charcoal	103
Total	388
Furnaces in blast, 1882:	
Anthracite	161
Bituminous	127
Charcoal	129
Total	417

Only 29 more furnaces were in blast in 1882 than in 1879, of which 26 were charcoal furnaces, the capacity of which is well known to average very much less than that of either anthracite or bituminous furnaces.

Production of pig iron since 1854.—The following table gives the production of anthracite, charcoal, and bituminous pig iron in the United States from 1854 to 1882, inclusive:

Production of pig iron since 1854.

[Net tons of 2,000 pounds.]

Years.	Anthracite.	Charcoal.	Bituminous.	Total.
1854	339, 435	342, 298	54, 485	736, 218
1855	381, 866	339, 922	62, 390	784, 178
1856	443, 113	370, 470	69, 554	883, 137
1857	390, 385	330, 321	77, 451	798, 157
1858	361, 430	285, 313	58, 351	705, 094
1859	471, 745	284, 041	84, 841	840, 627
1860	519, 211	278, 331	122, 228	919, 770
1861	409, 229	195, 278	127, 037	731, 544
1862	470, 315	186, 660	130, 687	787, 662
1863	577, 638	212, 005	157, 961	947, 604
1864	684, 018	241, 853	210, 125	1, 135, 996
1865	479, 558	262, 342	189, 682	931, 582
1866	749, 367	332, 580	268, 396	1, 350, 343
1867	798, 638	344, 341	318, 647	1, 461, 626
1868	893, 000	370, 000	340, 000	1, 603, 000
1869	971, 150	392, 150	553, 341	1, 916, 641
1870	930, 000	365, 000	570, 000	1, 865, 000
1871	956, 608	385, 000	570, 000	1, 911, 608
1872	1, 369, 812	500, 587	984, 159	2, 854, 558
1873	1, 312, 754	577, 620	977, 904	2, 868, 278
1874	1, 202, 144	576, 557	910, 712	2, 689, 413
1875	908, 046	410, 990	947, 545	2, 266, 581
1876	794, 578	308, 649	990, 009	2, 093, 236
1877	934, 797	317, 843	1, 061, 945	2, 314, 585
1878	1, 092, 870	293, 399	1, 191, 092	2, 577, 361
1879	1, 273, 024	358, 873	1, 438, 978	3, 070, 875
1880	1, 807, 651	537, 558	1, 950, 205	4, 295, 414
1881	1, 734, 462	638, 838	2, 268, 264	4, 641, 564
1882	2, 042, 138	697, 906	2, 438, 078	5, 178, 122

There was an increase in 1882 in each of the above branches of production, but this increase was much the largest proportionately in the anthracite branch. In the last four years the percentage of increase in each branch was as follows: Bituminous, 69.43 per cent.; anthracite, 60.42 per cent.; charcoal, 94.47 per cent.

Spiegeleisen.—The following table shows the production of spiegeleisen in the United States since 1875. The figures given are included in our statistics of pig-iron production:

Production of spiegeleisen since 1875.

	Net tons.
1875	7,832
1876	6,616
1877	8,845
1878	10,674
1879	13,931
1880	19,603
1881	21,086
1882	21,963

The product of 1882 was made by the New Jersey Zinc and Iron Company, the Cambria Iron Company, Carnegie Brothers & Co. Lim.

ited, the Brier Hill Iron and Coal Company, and the Lehigh Zinc and Iron Company.

Stocks.—The following table shows the quantity of each kind of pig iron held in stock by the furnace-owners or their agents at the close of the last three years:

Stocks of pig iron at the furnaces.

Kind of fuel.	December 31, 1880.	December 31, 1881.	December 31, 1882.
	Net tons.	*Net tons.*	*Net tons.*
Bituminous	184,626	36,495	157,196
Anthracite	175,862	90,351	107,259
Charcoal	96,170	84,050	165,239
Total	456,658	210,896	429,694

Consumption of pig iron.—The consumption of pig iron in the United States in 1882 was approximately as follows, in gross tons: Production, 4,623,323 tons; importation, 540,159 tons; stocks of domestic pig iron on hand and unsold at the beginning of the year, 188,300 tons; stocks of foreign pig iron in warehouse at the same time, 9,953 tons; total supply, 5,361,735 tons. From which we deduct 383,655 tons of domestic pig iron in stock at the close of the year, and 14,802 tons of foreign pig iron in warehouse at the same time, or a total of 398,457 tons, leaving 4,963,278 tons as the probable consumption of the year. In my last annual report as Secretary of the Iron and Steel Association I similarly estimated the consumption of 1881 at 4,982,565 gross tons. It would appear that our consumption in these years did not greatly vary.

The production of rolled iron in 1882 *in detail.*—In the term rolled iron are included (1) bar, shaped, bolt, rod, skelp, and hoop iron, and rolled axles; (2) plate and sheet iron; (3) cut nails and spikes; and (4) all sizes of iron rails.

The production of all kinds of rolled iron in the United States in 1882, including iron rails, was 2,493,831 net tons, against 2,643,927 tons in 1881, showing a decrease of 150,096 tons, all of which decrease is, however, accounted for by the great shrinkage in the production of iron rails in 1882. Omitting iron rails, the production of which decreased from 488,581 net tons in 1881 to 227,874 tons in 1882, our production of rolled iron in 1882 was 2,265,957 tons, against 2,155,346 tons in 1881, an increase of 110,611 tons.

The following table gives detailed statistics of the production of the different forms of rolled iron in each of the States in 1882 in net tons:

Production of rolled iron in 1882.

States.	Bar, rod, bolt, hoop, skelp, and shaped iron, and rolled axles.	Plate and sheet iron, except nail plate.	Cut nails.		Iron rails.	Total.
	Net tons.	*Net tons.*	*Kegs.*	*Net tons.*	*Net tons.*	*Net tons.*
Maine	10,537				325	10,862
New Hampshire	3,508					3,508
Massachusetts	46,086	35,688	592,276	29,614		111,388
Rhode Island	11,877					11,877
Connecticut	20,676					20,676
New York	131,226	3,023	166	8	4,284	138,541
New Jersey	76,408	2,016	360,340	18,017		96,441
Pennsylvania	685,049	258,603	1,949,405	97,470	82,764	1,123,886
Delaware	25,366	12,895				38,261
Maryland	17,067	16,590				33,657
District of Columbia	121	29				150
Virginia	31,554		169,806	8,490		40,044
Alabama	8,460				728	9,188
West Virginia	5,494	7,991	1,023,711	51,186	1,436	66,107
Kentucky	35,247	16,380	149,382	7,469	2,000	61,096
Tennessee	10,589		171,413	8,571	19,610	38,770
Indiana	23,177	542	394,682	19,734	28,173	71,626
Illinois	48,932		462,956	23,148	21,863	93,943
Ohio	253,933	49,182	796,857	39,843	18,650	361,608
Missouri	12,090	6,055				18,145
Michigan	8,004	3,820				11,824
Wisconsin	39,611				24,685	64,296
Kansas	10,800				7,067	17,867
Nebraska			60,000	3,000		3,000
Colorado	3,934		16,103	805		4,739
Wyoming Territory	3,235				13,253	16,488
California	22,807				3,036	25,843
Total	1,545,788	412,814	6,147,097	307,355	227,874	2,493,831

The production of steel in 1882 *in detail—Bessemer steel.*—The production of Bessemer steel ingots in the United States in 1882 was 1,696,450 net tons, or 1,514,687 gross tons, an increase over 1881 of 157,293 net tons, or 140,440 gross tons. The increased production in 1881 over 1880 was 335,984 net tons, or 299,985 gross tons. A decided check to the progress of this great branch of our steel industry is discoverable in the figures of 1882. The production of Bessemer steel ingots in this country in the eleven years from 1872 to 1882 has been as follows, in net tons:

Production of Bessemer steel since 1872.

	Net tons.
1872	120,108
1873	170,652
1874	191,933
1875	375,517
1876	525,996
1877	560,587
1878	732,226
1879	928,972
1880	1,203,173
1881	1,539,157
1882	1,696,450

Six States are engaged in the manufacture of Bessemer steel. A comprehensive exhibit of the fifteen Bessemer steel works of the country which were completed on the 1st of April, 1883, is as follows:

Number of Bessemer converters completed, April 1, 1883.

Names of companies.	Converters.
Albany and Rensselaer Iron and Steel Company, Troy, New York	two 7-ton
Bethlehem Iron Company, Bethlehem, Pennsylvania	four 7-ton
Pennsylvania Steel Company, Steelton, Pennsylvania	two 7-ton three 8-ton
Lackawanna Iron and Coal Company, Scranton, Pennsylvania	two 5-ton
Scranton Steel Company, Scranton, Pennsylvania	two 4-ton
Cambria Iron Company, Johnstown, Pennsylvania	two 6½-ton
Carnegie Bros. & Co. Limited, Bessemer, Pennsylvania	three 10-ton
Pittsburgh Bessemer Steel Company Limited, Homestead, Pennsylvania	two 4-ton
Pittsburgh Steel Casting Company, Pittsburgh, Pennsylvania	one 5-ton
Cleveland Rolling Mill Company, Cleveland, Ohio	two 10-ton
North Chicago Rolling Mill Company, Chicago, Illinois (two plants)	two 6-ton three 10-ton
Union Iron and Steel Company, Chicago, Illinois	two 6-ton
Joliet Steel Company, Joliet, Illinois	two 5-ton
Saint Louis Ore and Steel Company, Saint Louis, Missouri	two 7-ton
Colorado Coal and Iron Company, South Pueblo, Colorado	two 5-ton
Total number of converters	38

Crucible steel.—The production of crucible steel ingots in the United States in 1882 was 85,089 net tons, a decrease of 4,673 tons upon the production of 89,762 tons in 1881. Here, again, we discover a check in 1882 to the progress of our steel industry. Seven States made crucible steel in 1882, namely, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, and Illinois.

The following table gives the production of crucible steel ingots in various sections of the country from 1874 to 1882, in net tons:

Production of crucible steel since 1874.

States.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
New England	1,509	1,620	1,098	1,974	1,602	1,608	660	2,780	1,000
New York	2,696	2,300	2,300	2,032	2,800	2,300	3,500	4,961	4,693
New Jersey	8,164	7,098	6,806	6,749	7,377	8,651	10,387	14,500	12,400
Pennsylvania	23,289	26,615	28,217	27,983	30,585	43,614	57,077	66,290	65,139
Western States	570	1,500	700	1,400	480	605	800	1,231	1,857
Southern States	100	268	261	292	62	2	....	....	....
Total	36,328	39,401	39,382	40,430	42,906	56,780	72,424	89,762	85,089

Open-hearth steel.—The production of open-hearth steel ingots in the United States in 1882 was 160,542 net tons, an increase of 13,596 tons upon the production of 146,946 tons in 1881. This was a much smaller proportionate increase than had taken place in any year since we first began to make open-hearth steel. The product of 1882 was made in eight States, namely, New Hampshire, Vermont, Massachusetts, New Jersey, Pennsylvania, Ohio, Tennessee, and Illinois.

The following table gives the production of open-hearth steel ingots in the United States by districts from 1874 to 1882, in net tons:

Production of open-hearth steel since 1874.

States.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
New England	5, 300	3, 010	6, 085	6, 652	8, 228	14, 660	20, 560	24, 600	25, 536
New Jersey and Pennsylvania	1, 700	4, 240	7, 547	7, 771	12, 231	19, 575	50, 736	68, 363	73, 222
Western and Southern	....	1, 800	7, 858	10, 608	15, 667	22, 055	41, 657	53, 983	61, 784
Total	7, 000	9, 050	21, 490	25, 031	36, 126	56, 290	112, 953	146, 946	160, 542

Other steels.—The production of blister, puddled, and "patented" steel in this country is very small; in 1882 only Pennsylvania and Ohio made these kinds of steel, and their united product in that year was only 3,014 net tons.

The production of all kinds of rails in 1882 *in detail.*—For the first time since 1877 our production of rails declined in 1882. The total rail production of 1882 was as follows, in net tons, compared with the production of 1879, 1880, and 1881:

Production of rails since 1879.

Kind of rails.	1879.	1880.	1881.	1882.
Iron rails	420, 160	493, 762	488, 581	227, 874
Bessemer steel rails	683, 964	954, 460	1, 330, 302	1, 438, 155
Open-hearth steel rails	9, 149	13, 615	25, 217	22, 765
Total	1, 113, 273	1, 461, 837	1, 844, 100	1, 688, 794

It will be seen that in 1882 we produced less than half as many tons of iron rails as in 1881, and that our production of open-hearth steel rails in 1882 was somewhat less than in 1881. Our production of Bessemer steel rails increased in 1882 only 107,853 net tons over 1881, whereas in 1881 it increasd 375,842 tons over 1880. The production of rails of all kinds in 1882 was 155,306 tons less than in 1881—a decrease of 8 per cent. No steel-headed rails are now made in this country.

Consumption of rails.—The following table will show approximately the consumption of all kinds of rails in this country from 1867 to 1882, in net tons:

Consumption of rails since 1867.

Years.	Made in the United States.	Imported.		Approximate consumption.
		Iron.	Steel.	
1867	462, 108	163, 049		625, 157
1868	506, 714	250, 081		756, 795
1869	593, 586	313, 163		906, 749
1870	620, 000	399, 153		1, 019, 153
1871	775, 733	566, 202		1, 341, 935
1872	1, 000, 000	381, 064	149, 786	1, 530, 850
1873	890, 077	99, 201	159, 571	1, 148, 849
1874	729, 413	7, 796	100, 515	837, 724
1875	792, 512	1, 174	18, 274	811, 960
1876	879, 629	287	None.	879, 916
1877	764, 709	None.	35	764, 744
1878	882, 685	None.	10	882, 695
1879	1, 113, 273	19, 090	25, 057	1, 157, 420
1880	1, 461, 837	132, 459	158, 230	1, 752, 526
1881	1, 844, 100	137, 013	249, 308	2, 230, 421
1882	1, 688, 794	41, 992	182, 135	1, 912, 921

It may be objected to the figures of approximate consumption for 1882 that they are lower than similar figures for 1881, although the mileage of new railroad constructed in 1882 was larger than in 1881, and that, consequently, they cannot be correct. The apparent discrepancy may be accounted for by reflecting that so urgent in 1881 were the wants of owners of established roads and the projectors of new roads that they bought many tons of rails which were not laid until 1882. In the latter part of 1882 a similar urgency did not exist. Our figures of approximate consumption do not necessarily imply that all the rails made at home or imported from year to year are actually laid down as promptly as they are provided, but they mean simply that the rails in the table have been manufactured and sold in the years specified, and hence have gone into consumption.

Production of all kinds of pig iron in the eleven years from 1872 to 1882, by States.

[Net tons.]

States.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	...	780	1,661	2,046	3,002	1,960	1,190	1,240	3,578	4,400	4,100
Vermont	2,000	3,100	3,450	2,400	550	210	585	625	1,800	2,796	1,210
Massachusetts	17,070	21,136	27,991	21,255	5,040	2,904	1,426	5,404	19,017	18,318	10,335
Connecticut	22,700	26,977	14,518	10,880	10,160	14,443	15,880	16,759	22,583	28,483	24,342
New York	291,155	296,818	326,721	266,431	181,620	230,442	247,698	239,056	395,361	359,519	416,156
New Jersey	103,858	102,341	90,150	64,069	25,349	52,909	70,958	96,908	170,049	171,672	176,805
Pennsylvania	1,401,497	1,389,573	1,213,133	960,884	1,009,613	1,153,356	1,342,633	1,607,763	2,083,121	2,190,786	2,449,256
Maryland	63,031	55,986	54,556	38,741	19,876	26,959	24,027	37,237	61,437	48,756	54,524
Virginia	21,445	26,475	29,451	29,985	13,046	12,434	16,928	18,873	29,934	83,711	87,731
North Carolina	1,073	1,432	1,340	800	400	325	...	...	...	800	1,150
Georgia	2,945	7,501	9,786	16,508	10,518	13,223	16,363	20,373	27,321	37,404	42,440
Alabama	12,512	22,283	32,863	25,108	24,732	41,241	41,482	49,841	77,190	98,081	112,765
Texas	619	280	1,012	...	426	525	...	400	2,500	3,000	1,321
West Virginia	20,796	23,056	30,134	25,277	41,165	34,905	50,667	70,801	70,338	66,409	73,220
Kentucky	67,396	69,889	61,227	48,339	34,686	47,607	50,182	48,725	57,708	45,973	66,522
Tennessee	42,454	43,134	48,770	28,311	24,585	25,940	28,347	41,475	70,873	87,406	137,602
Ohio	399,743	406,029	425,001	415,893	403,277	400,398	420,991	447,751	674,207	710,546	698,900
Indiana	39,221	32,486	13,732	22,081	14,547	15,460	...	11,303	12,500	7,300	10,000
Illinois	78,627	55,796	37,946	49,762	54,168	61,358	78,455	78,143	150,556	251,781	360,407
Michigan	100,222	123,506	136,662	114,805	95,177	82,216	70,853	101,539	154,424	187,043	210,195
Wisconsin	65,036	74,148	50,792	62,139	51,261	22,205	49,887	89,522	96,842	102,029	85,359
Missouri	101,158	85,552	75,817	59,717	68,223	73,565	47,499	84,637	105,555	109,799	113,644
Minnesota	...	...	...	...	...	...	...	...	3,520	7,442	8,126
Utah	...	...	200	150	65	...	...	...	...	...	57
Colorado	...	...	...	...	...	...	...	...	...	6,396	23,718
Oregon	...	...	2,500	1,000	1,750	...	1,310	2,500	5,000	6,100	6,750
California	...	...	...	...	...	...	...	...	...	4,414	987
Washington Territory	...	...	...	...	...	...	...	...	...	1,200	...
Total	2,854,558	2,868,278	2,689,413	2,266,581	2,093,236	2,314,585	2,577,361	3,070,875	4,295,414	4,641,564	5,178,122

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Production of anthracite and bituminous pig-iron in the eleven years from 1872 *to* 1882, *by States.*

[Net tons.]

ANTHRACITE.

States.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Massachusetts	4, 250	5, 432	10, 214	11, 140	....	....	....	394	9, 155	5, 958	....
New York	271, 343	267, 489	298, 428	254, 935	173, 535	213, 879	231, 936	220, 927	367, 517	322, 349	385, 440
New Jersey	103, 858	102, 341	90, 150	64, 069	25, 349	52, 909	70, 958	96, 908	170, 049	171, 672	176, 805
Pennsylvania	968, 453	913, 085	775, 008	554, 992	588, 829	658, 521	783, 731	939, 569	1, 237, 930	1, 213, 353	1, 453, 646
Maryland	21, 908	20, 407	22, 344	15, 840	6, 013	9, 488	6, 245	15, 226	23, 000	21, 130	26, 247
Virginia	....	4, 000	6, 000	7, 070	852	....	....	....	....	....	....
Total	1, 369, 812	1, 312, 754	1, 202, 144	908, 046	794, 578	934, 797	1, 092, 870	1, 273, 024	1, 807, 651	1, 734, 462	2, 042, 138

BITUMINOUS COAL AND COKE.

States.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
New York	....	....	....	....	....	....	....	....	....	6, 703	....
Pennsylvania	388, 011	430, 634	397, 147	371, 401	397, 685	465, 199	529, 542	632, 299	801, 817	925, 525	945, 635
Maryland	12, 079	5, 264	7, 209	1, 751	....	77	....	2, 277	5, 387	....	....
Virginia	....	....	....	7, 519	4, 844	6, 241	10, 595	11, 170	15, 891	64, 673	61, 598
Georgia	....	....	5, 516	12, 685	10, 018	9, 194	13, 860	16, 240	20, 044	24, 000	26, 875
Alabama	....	....	....	....	1, 415	16, 400	17, 489	17, 850	39, 453	53, 860	57, 224
West Virginia	19, 846	21, 106	26, 734	24, 177	40, 865	33, 655	50, 261	70, 601	67, 093	65, 209	73, 220
Kentucky	27, 697	27, 670	24, 583	26, 060	17, 472	30, 603	33, 254	35, 989	36, 534	29, 195	49, 357
Tennessee	8, 360	8, 602	11, 543	10, 300	14, 517	14, 732	17, 120	33, 908	54, 198	68, 360	99, 991
Ohio	304, 121	305, 531	332, 166	353, 922	354, 346	358, 281	387, 478	404, 306	605, 017	644, 377	640, 246
Indiana	39, 221	32, 486	11, 632	20, 381	12, 869	14, 200	....	11, 303	10, 500	7, 300	10, 000
Illinois	78, 627	55, 796	37, 946	49, 762	54, 168	61, 358	78, 455	78, 143	150, 556	251, 781	360, 407
Michigan	13, 382	9, 531	7, 693	13, 000	12, 700	7, 000	....	....	....	....	....
Wisconsin	37, 246	35, 268	21, 819	36, 656	25, 000	....	22, 400	58, 092	53, 929	54, 327	30, 490
Missouri	55, 569	46, 016	26, 724	19, 931	44, 110	45, 005	30, 638	66, 800	89, 786	66, 558	59, 317
Colorado	....	....	....	....	....	....	....	....	....	6, 396	23, 718
Total	984, 159	977, 904	910, 712	947, 545	990, 009	1, 061, 945	1, 191, 092	1, 438, 978	1, 950, 205	2, 268, 264	2, 438, 078

Production of charcoal pig iron in the eleven years from 1872 *to* 1882, *by States.*

[Net tons.]

States.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	....	780	1, 661	2, 046	3, 002	1, 960	1, 190	1, 240	3, 578	4, 400	4, 100
Vermont	2, 000	3, 100	3, 450	2, 400	550	210	585	625	1, 800	2, 796	1, 210
Massachusetts	12, 820	15, 704	17, 777	10, 115	5, 040	2, 904	1, 426	5, 010	9, 862	12, 360	10, 335
Connecticut	22, 700	26, 977	14, 518	10, 880	10, 160	14, 443	15, 880	16, 759	22, 583	28, 483	24, 342
New York	19, 812	29, 329	28, 293	11, 496	8, 085	16, 563	15, 762	18, 129	27, 844	30, 467	30, 716
Pennsylvania	45, 033	45, 854	40, 978	34, 491	23, 099	29, 636	29, 360	35, 895	43, 374	51, 908	49, 975
Maryland	29, 044	30, 315	25, 003	21, 150	13, 863	17, 394	17, 782	19, 734	33, 050	27, 626	28, 277
Virginia	21, 445	22, 475	23, 451	15, 396	7, 350	6, 193	6, 333	7, 703	14, 043	19, 038	26, 133
North Carolina	1, 073	1, 432	1, 340	800	400	325	....	....	....	800	1, 150
Georgia	2, 945	7, 501	4, 270	3, 823	500	4, 029	2, 503	4, 133	7, 277	13, 404	15, 565
Alabama	12, 512	22, 283	32, 863	25, 108	23, 317	24, 841	23, 993	31, 991	37, 737	44, 221	55, 541
Texas	619	280	1, 012	....	426	525	....	400	2, 500	3, 000	1, 321
West Virginia	950	1, 950	3, 400	1, 100	300	1, 250	406	200	3, 245	1, 200	....
Kentucky	39, 699	42, 219	36, 644	22, 279	17, 214	17, 004	16, 928	12, 736	21, 174	16, 778	17, 165
Tennessee	34, 094	34, 532	37, 227	18, 011	10, 068	11, 208	11, 227	7, 567	16, 675	19, 046	37, 611
Ohio	95, 622	100, 498	92, 835	61, 971	48, 931	42, 117	33, 513	43, 445	69, 190	66, 169	58, 654
Indiana	....	....	2, 100	1, 700	1, 678	1, 260	....	....	2, 000	....	....
Michigan	86, 840	113, 975	128, 969	101, 805	82, 477	75, 216	70, 853	101, 539	154, 424	187, 043	210, 195
Wisconsin	27, 790	38, 880	28, 973	25, 483	26, 261	22, 205	27, 487	31, 430	42, 913	47, 702	55, 369
Missouri	45, 589	39, 536	49, 093	39, 786	24, 113	28, 560	16, 861	17, 837	15, 769	43, 241	54, 327
Minnesota	....	....	....	....	....	....	....	....	3, 520	7, 442	8, 126
Utah	....	....	200	150	65	....	....	....	....	....	57
Oregon	....	....	2, 500	1, 000	1, 750	....	1, 310	2, 500	5, 000	6, 100	6, 750
California	....	....	....	....	....	....	....	....	....	4, 414	987
Washington Territory	....	....	....	....	....	....	....	....	....	1, 200	....
Total	500, 587	577, 620	576, 557	410, 990	308, 649	317, 843	293, 399	358, 873	537, 558	638, 838	697, 906

Production of pig iron in Pennsylvania and Ohio in the eleven years from 1872 *to* 1882, *by districts.*

[Net tons.]

Districts.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Pennsylvania:											
Lehigh valley	449, 663	389, 969	316, 789	280, 360	261, 274	335, 059	416, 907	456, 350	544, 987	560, 190	609, 338
Schuylkill valley	232, 225	236, 409	232, 420	123, 184	144, 969	155, 434	144, 558	191, 748	306, 926	309, 049	342, 701
Upper Susquehanna	127, 260	129, 304	88, 243	71, 731	79, 217	56, 776	84, 547	125, 971	168, 128	125, 785	201, 367
Lower Susquehanna	159, 305	157, 403	137, 556	79, 717	103, 369	111, 252	137, 719	165, 500	217, 889	218, 329	300, 240
Shenango valley	160, 188	160, 831	156, 419	137, 025	138, 495	145, 179	122, 958	150, 861	215, 313	198, 968	264, 078
Allegheny county	110, 599	158, 789	143, 660	131, 856	128, 555	141, 749	217, 299	267, 315	300, 497	385, 453	358, 840
Miscellaneous coke	117, 224	111, 014	97, 068	102, 520	130, 635	178, 271	189, 285	214, 123	286, 007	341, 104	322, 717
Charcoal	45, 033	45, 854	40, 978	34, 491	23, 099	29, 636	29, 360	35, 895	43, 374	51, 908	49, 975
Ohio:											
Hanging Rock coke	23, 169	28, 601	26, 015	36, 899	44, 260	44, 544	31, 137	43, 097	60, 316	77, 500	77, 364
Mahoning valley	152, 756	136, 972	121, 403	115, 993	137, 546	136, 526	134, 400	147, 844	226, 877	245, 737	258, 478
Hocking valley	....	....	....	1, 250	7, 483	23, 895	65, 690	51, 908	85, 719	88, 146	78, 770
Miscellaneous coke	128, 196	139, 958	184, 748	199, 780	165, 057	153, 316	156, 251	161, 457	232, 105	232, 994	225, 634
Hanging Rock charcoal	87, 440	92, 365	85, 873	57, 413	42, 822	40, 212	33, 513	43, 445	64, 854	61, 487	55, 546
Miscellaneous charcoal	8, 182	8, 133	6, 962	4, 558	6, 109	1, 905	....	....	4, 336	4, 682	3, 108

Production of all kinds of rolled iron (including iron rails and nail plate) in the United States from 1873 *to* 1882, *by States.*

[Net tons.]

States.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	21,210	18,644	8,100	10,814	6,299	6,642	6,483	7,639	7,616	10,862
New Hampshire	300	300	1,000	1,900	1,900	550	3,000	3,100	3,000	3,508
Vermont	6,088	10,400	6,204	9,183	3,899	700	3,300	1,650	....	....
Massachusetts	118,669	100,500	99,712	78,576	97,293	85,660	105,085	114,250	116,846	111,388
Rhode Island	11,662	10,616	9,584	7,394	7,500	8,000	9,800	7,632	10,769	11,877
Connecticut	11,409	11,921	9,618	10,114	7,298	10,138	13,486	16,046	17,589	20,676
New York	135,406	121,029	142,746	104,596	67,013	84,536	115,201	147,601	123,366	138,541
New Jersey	77,688	58,081	55,249	52,411	49,228	51,632	62,831	64,622	71,286	96,441
Pennsylvania	788,051	731,267	625,987	620,510	625,465	677,774	917,038	1,032,602	1,254,866	1,123,886
Delaware	11,617	11,818	15,252	17,598	18,249	14,427	26,923	29,806	34,275	38,261
Maryland	58,025	68,891	46,687	31,181	21,233	10,575	25,318	40,932	32,732	33,657
District of Columbia	....	....	....	....	....	82	230	276	302	150
Virginia	12,808	16,688	18,843	17,306	17,592	22,424	31,675	37,734	41,002	40,044
Georgia	10,624	9,467	10,325	12,001	13,101	10,122	13,692	1,507	7,000	....
Alabama	500	1,000	1,000	1,000	700	500	1,000	6,604	11,072	9,188
West Virginia	51,796	56,332	54,299	49,636	57,150	53,483	67,290	63,601	75,547	66,107
Kentucky	37,955	34,548	33,961	30,874	45,788	37,000	64,096	51,406	29,915	61,096
Tennessee	16,561	15,926	13,745	23,274	17,902	20,280	23,969	25,402	33,793	38,770
Ohio	247,834	203,097	209,620	209,178	208,109	203,222	238,925	308,566	345,727	361,608
Indiana	36,006	35,507	44,073	55,262	69,520	64,115	66,678	80,428	82,430	71,626
Illinois	105,143	85,813	89,487	57,708	46,535	85,797	112,714	109,429	148,818	93,943
Michigan	8,542	8,208	3,450	5,325	3,200	4,855	12,276	19,804	20,605	11,824
Wisconsin	39,495	29,955	42,840	29,980	33,259	45,300	61,333	64,890	88,643	64,296
Missouri	22,621	36,387	31,540	30,956	20,776	18,001	22,096	26,558	16,641	18,145
Wyoming Territory	....	....	7,000	12,320	10,007	10,425	9,656	9,821	15,172	16,488
Kansas	....	2,000	5,000	14,707	16,201	14,485	14,437	37,985	29,544	17,867
California	7,420	16,221	14,194	15,465	11,542	13,251	15,952	15,277	19,839	25,843
Colorado	....	....	....	....	....	1,600	2,500	4,500	3,949	4,739
Nebraska	....	....	....	....	....	....	500	3,000	1,583	3,000
Total	1,837,430	1,694,616	1,599,516	1,509,269	1,476,759	1,555,576	2,047,484	2,332,668	2,643,927	2,493,831

Production of plate and sheet iron and cut nails in the United States from 1873 *to* 1882, *by States.*

PLATE AND SHEET IRON, EXCLUDING NAIL PLATE.

[Net tons.]

States.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
New Hampshire	......	......	......	400	100	50	......	100	......	......
Massachusetts	8, 822	6, 592	13, 395	11, 326	13, 105	11, 803	20, 730	29, 640	29, 446	35, 688
New York	4, 888	4, 000	4, 000	3, 498	1, 522	500	......	2, 062	4, 945	3, 023
New Jersey	5, 158	2, 256	3, 614	2, 743	900	900	1, 600	921	1, 823	2, 016
Pennsylvania	113, 726	120, 098	116, 997	100, 576	112, 034	120, 908	178, 477	223, 940	251, 225	258, 603
Delaware	3, 343	4, 958	5, 936	6, 430	6, 999	5, 779	9, 496	10, 506	10, 355	12, 895
Maryland	13, 709	12, 428	9, 789	9, 170	10, 317	7, 295	13, 335	14, 645	14, 215	16, 590
District of Columbia	......	......	......	......	......	4	24	11	82	29
West Virginia	1, 000	......	300	1, 947	2, 800	4, 000	5, 300	5, 550	6, 234	7, 991
Kentucky	894	5, 120	7, 000	7, 733	8, 925	6, 300	8, 480	10, 348	6, 035	16, 380
Ohio	14, 811	16, 143	22, 288	15, 345	19, 190	18, 955	24, 280	33, 826	37, 327	49, 182
Indiana	......	......	......	2, 500	2, 050	1, 800	1, 325	6, 500	975	542
Illinois	......	2, 240	2, 000	......	......	......	......	......		......
Michigan	1, 825	1, 553	3, 450	1, 825	1, 650	1, 400	3, 750	7, 265	5, 920	3, 820
Missouri	993	1, 500	4, 000	1, 762	2, 650	2, 348	2, 971	4, 343	4, 500	6, 055
Total	169, 169	176, 888	192, 769	165, 255	182, 242	182, 042	269, 768	349, 657	373, 082	412, 814

CUT NAILS.

[Kegs of 100 pounds each.]

States.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	......	......	7, 000	......	......	......	......	......	......	......
Massachusetts	626, 465	576, 376	551, 798	446, 638	556. 344	476, 863	430, 240	532, 299	525, 089	592, 276
Rhode Island	73, 249	68, 920	58, 730	9, 966	......	......	......	......	......	......
New York	84, 438	118, 985	81, 263	71, 591	76, 147	46, 470	10, 100	7, 482	2, 256	166
New Jersey	456, 537	552, 867	522, 198	342, 391	303, 852	254, 453	294, 182	294, 122	248, 521	360, 340
Pennsylvania	1, 195, 609	1, 503, 019	1, 318, 259	1, 368, 163	1, 591, 924	1, 349, 714	1, 386, 925	1, 737, 560	1, 914, 706	1, 949, 405
Virginia	106, 922	112, 034	121, 976	119, 426	118, 091	127, 970	139, 076	123, 728	127, 566	169, 806
Georgia	10, 183	......	9, 300	15, 000	24, 000	......	......	......	......	......
West Virginia	878, 653	1, 084, 027	1, 035, 772	908, 934	989, 414	890, 140	1, 083, 807	1, 025, 155	1, 241, 102	1, 023, 711
Kentucky	......	102, 411	143, 473	99, 161	135, 000	80, 000	161, 800	120, 900	69, 000	149, 382
Tennessee	......	13, 210	9, 795	8, 609	40, 047	64, 191	104, 039	64, 503	94, 495	171, 413
Ohio	460, 618	545, 052	592, 768	573, 439	594, 336	610, 245	794, 230	824, 683	860, 665	796, 857
Indiana	98, 530	150, 279	185, 988	194, 296	272, 748	277, 860	294, 695	289, 948	326, 496	394, 682
Illinois	33, 500	85, 000	88, 561	200	127, 015	218, 224	301, 837	290, 132	352, 643	462, 956
Nebraska	......	......	......	......	......	......	10, 000	60, 000	31, 667	60, 000
Colorado	......	......	......	......	......	......	......	......	......	16, 103
Total	4, 024, 704	4, 912, 180	4, 726, 881	4, 157, 814	4, 828, 918	4, 396, 130	5, 011, 021	5, 370, 512	5, 794, 206	6. 147. 097

Production of rolled iron (excluding rails and plate and sheet iron) in the United States from 1873 *to* 1882, *by States.*

BAR, BOLT, ROD, SKELP, HOOP, AND SHAPED IRON, AND ROLLED AXLES.

[Net tons.]

States.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	4,710	3,994	3,700	3,314	3,773	3,620	6,162	7,639	5,433	10,537
New Hampshire	300	300	1,000	1,500	1,800	500	3,000	3,000	3,000	3,508
Massachusetts	44,490	40,324	40,336	35,857	46,731	42,019	55,118	48,323	58,524	46,086
Rhode Island	8,000	7,170	6,648	6,900	7,500	8,000	9,800	7,632	10,769	11,877
Connecticut	11,409	11,921	9,618	10,114	7,298	10,138	13,486	16,046	17,589	20,676
New York	85,908	76,590	90,583	66,323	53,831	72,422	87,478	106,274	106,372	131,226
New Jersey	35,954	24,645	24,584	32,305	32,755	38,001	46,522	48,995	56,793	76,408
Pennsylvania	333,556	343,632	300,784	301,350	336,398	399,047	543,566	551,302	714,113	685,049
Delaware	8,274	6,860	9,316	11,168	11,250	8,648	17,427	19,300	23,920	25,366
Maryland	1,960	8,455	6,279	3,167	2,385	80	9,590	19,400	18,517	17,067
District of Columbia	....	....	....	....	....	78	206	265	220	121
Virginia	7,462	11,086	12,744	11,334	11,687	16,025	24,721	31,441	33,984	31,554
Georgia	1,840	1,406	3,360	2,251	1,870	1,777	2,433	1,022	3,000	....
Alabama	500	1,000	1,000	1,000	700	500	1,000	6,304	8,772	8,460
West Virginia	2,863	1,609	1,805	1,704	3,123	3,746	4,518	4,638	4,106	5,494
Kentucky	25,675	18,239	13,936	16,658	18,013	13,700	22,112	20,677	15,425	35,247
Tennessee	2,588	1,573	1,005	1,450	4,527	7,648	6,557	6,215	5,158	10,589
Ohio	103,898	94,413	93,890	104,512	113,071	119,575	132,028	182,677	229,247	253,933
Indiana	4,500	7,376	11,465	13,664	18,957	19,762	19,739	17,908	20,485	23,177
Illinois	5,240	2,500	6,000	9,921	8,941	22,133	30,203	33,647	52,500	48,932
Michigan	2,284	4,207	....	1,900	1,550	3,455	8,526	12,539	14,685	8,004
Wisconsin	....	275	14,437	8,700	11,820	16,400	30,443	34,683	47,478	39,611
Missouri	7,608	10,870	10,144	17,028	16,576	15,291	19,125	20,942	12,141	12,090
California	6,945	9,205	6,121	6,836	5,792	6,472	9,016	10,555	14,204	22,807
Kansas	....	....	....	....	183	1,800	4,229	8,900	10,528	10,800
Wyoming Territory	....	....	....	....	....	....	....	400	3,286	3,235
Colorado	....	....	....	....	....	....	....	....	2,306	3,934
Total	705,964	687,650	668,755	668,956	720,531	830,837	1,107,005	1,220,724	1,492,555	1,545,788

Production of all sizes of iron rails in the United States in the twelve years from 1871 to 1882, by States.

[Net tons.]

States.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Maine	13, 383	14, 058	16, 500	14, 650	4, 050	7, 500	2, 526	3, 022	321	....	2, 183	325
Vermont	....	....	6, 088	10, 400	6, 204	9, 183	3, 899	700	3, 300	1, 650	....	....
Massachusetts	28, 864	29, 242	34, 034	24, 765	18, 391	9, 061	9, 640	7, 995	7, 725	9, 672	2, 622	....
New York	77, 022	68, 841	40, 388	34, 490	44, 100	31, 195	7, 853	9, 291	27, 218	38, 891	11, 936	4, 284
New Jersey	6, 700	9, 185	13, 749	3, 537	941	243	380	8	....	....	244	....
Pennsylvania	320, 354	410, 650	280, 989	192, 386	142, 293	150, 175	97, 437	90, 333	125, 649	170, 482	193, 793	82, 764
Maryland	44, 941	30, 533	42, 356	48, 008	30, 619	18, 844	8, 531	3, 200	2, 393	6, 887	....	....
Virginia	....	....	....	....	....	....	....	....	....	107	640	....
Georgia	7, 840	6, 930	8, 275	8, 061	6, 500	9, 000	10, 031	8, 345	11, 259	485	4, 000	....
Alabama	....	....	....	....	....	....	....	....	....	300	2, 300	728
West Virginia	5, 000	20, 100	4, 000	522	406	538	1, 756	1, 230	3, 277	2, 155	3, 152	1, 436
Kentucky	6, 000	7, 480	11, 386	6, 068	5, 851	1, 524	12, 100	13, 000	25, 414	14, 336	5, 005	2, 000
Tennessee	9, 667	14, 620	13, 973	13, 693	12, 250	21, 394	11, 373	9, 422	12, 210	15, 962	23, 010	19, 610
Ohio	67, 782	116, 165	106, 094	65, 288	63, 804	60, 649	46, 131	34, 180	42, 906	50, 829	36, 120	18, 650
Indiana	12, 778	23, 893	26, 579	20, 617	23, 309	29, 383	34, 876	28, 660	30, 879	41, 523	44, 645	28, 173
Illinois	86, 178	91, 566	98, 228	76, 823	77, 059	47, 777	31, 243	52, 753	67, 419	61, 275	78, 686	21, 863
Michigan	14, 000	9, 883	4, 433	2, 448	....	1, 600	....	....	....	....	....	....
Wisconsin	28, 774	37, 284	39, 495	29, 680	28, 403	21, 280	21, 439	28, 900	30, 890	30, 207	41, 165	24, 685
Missouri	8, 200	15, 500	14, 020	24, 017	17, 396	12, 166	1, 550	362	....	1, 273	....	....
Wyoming Territory	....	....	....	....	7, 000	12, 320	10, 007	10, 425	9, 656	9, 421	11, 886	13, 253
Kansas	....	....	....	2, 000	5, 000	14, 707	16, 018	12, 685	10, 208	29, 085	19, 016	7, 067
California	....	....	475	7, 016	8, 073	8, 629	5, 750	6, 779	6, 936	4, 722	5, 635	3, 036
Colorado	....	....	....	....	....	....	....	1, 600	2, 500	4, 500	1, 643	....
Total	737, 483	905, 930	761, 062	584, 469	501, 649	467, 168	332, 540	322, 890	420, 160	493, 762	488, 581	227, 874

Production of iron and steel rails in the United States in the twelve years from 1871 *to* 1882, *by States, arranged in the order of their production in* 1882.

[Net tons.]

States.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	Per cent. of total production in 1882.
Pennsylvania	335, 604	449, 113	328, 522	259, 288	255, 136	353, 925	347, 968	406, 266	498, 336	670, 198	891, 179	850, 908	50
Illinois	91, 178	107, 496	136, 102	125, 103	188, 248	181, 490	120, 762	196, 538	265, 300	322, 883	433, 420	362, 250	21
Ohio	75, 782	138, 165	130, 326	82, 561	91, 775	100, 799	82, 270	87, 520	109, 386	133, 487	153, 596	113, 806	7
New York	87, 022	86, 518	59, 764	46, 979	82, 960	57, 306	34, 094	54, 471	78, 634	109, 921	109, 283	105, 021	6
Missouri	8, 200	15, 500	14, 020	24, 017	17, 396	20, 903	31, 289	362	....	35, 746	64, 226	85, 528	5
Indiana	12, 778	23, 893	26, 579	20, 617	23, 309	29, 383	34, 876	28, 660	30, 879	41, 523	44, 645	28, 173	2
Vermont	....	....	6, 088	10, 400	6, 204	9, 183	3, 899	2, 200	4, 974	17, 650	15, 200	26, 100	2
Tennessee	9, 667	14, 620	13, 973	13, 693	12, 250	21, 394	11, 373	9, 479	15, 185	18, 552	32, 660	25, 390	2
Wisconsin	28, 774	37, 284	39, 495	29, 680	28, 403	21, 280	21, 439	28, 900	30, 890	30, 207	41, 165	24, 685	1
Colorado	....	....	....	....	....	....	....	1, 600	2, 500	4, 500	1, 643	18, 217	1
Massachusetts	28, 864	29, 242	34, 034	24, 765	18, 391	9, 061	9, 640	7, 995	7, 725	9, 672	2, 622	15, 707	Less than 1 per cent. each.
Wyoming Territory	....	....	....	....	7, 000	12, 320	10, 007	10, 425	9, 656	9, 421	11, 886	13, 253	
California	....	....	475	7, 016	8, 073	8, 629	5, 750	6, 779	6, 936	4, 722	6, 035	8, 200	
Kansas	....	....	....	2, 000	5, 000	14, 707	16, 018	12, 685	10, 208	29, 085	19, 016	7, 067	
Kentucky	6, 000	7, 480	11, 386	6, 068	5, 851	1, 524	12, 100	13, 000	25, 414	14, 336	5, 005	2, 000	
Georgia	7, 840	6, 930	8, 275	8, 061	6, 500	9, 000	10, 031	8, 345	11, 259	485	4, 000	....	
West Virginia	5, 000	20, 100	4, 000	522	406	538	1, 756	1, 230	3, 277	2, 155	3, 152	1, 436	
Alabama	....	....	....	....	....	....	....	....	....	300	2, 300	728	
Maine	13, 383	14, 058	16, 500	14, 650	4, 050	7, 500	2, 526	3, 022	321	....	2, 183	325	
Virginia	....	....	....	....	....	....	....	....	....	107	640	....	
New Jersey	6, 700	9, 185	13, 749	3, 537	941	243	380	8	....	....	244	....	
Maryland	44, 941	30, 533	42, 356	48, 008	30, 619	18, 844	8, 531	3, 200	2, 393	6, 887	....	....	
Michigan	14, 000	9, 883	4, 433	2, 448	....	1, 600	....	....	....	....	....	....	
Total	775, 733	1, 000, 000	890, 077	729, 413	792, 512	879, 629	764, 709	882, 685	1, 113, 273	1, 461, 837	1, 844, 100	1, 688, 794	....

The production of iron and steel in the United States for a long series of years.—The following table has been compiled from the statistics of the American Iron and Steel Association, and is the most comprehensive contribution to the statistical literature of our iron and steel industries that has ever been published. The figures have been carefully verified and may be confidently accepted as absolutely correct. It may be remarked in explanation of the variations in the time at which the statistics of the different branches of these industries begin, that the Association was unable for some years after its organization in 1855 to procure complete statistics of all the branches, owing to the extent of the country, the isolated situation of many establishments, and a lack of interest in statistical inquiries. These difficulties were all happily surmounted many years ago. They did not, however, apply to the collection of the statistics of steel-rail production, which have easily been obtained since steel rails were first made in this country. This table most forcibly and eloquently tells the story of the marvelous growth of our iron and steel industries in the life-time of the present generation.

Production of iron and steel since 1849.

Years.	Pig iron.	Rolled iron, including iron rails and nail plates.	Iron rails.	All kinds of steel rails.	Steel ingots and other crude steel.	Blooms from pig and scrap iron and iron ore.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
1849	....	....	24, 318	....	....	....
1850	....	....	44, 083	....	....	....
1851	....	....	50, 603	....	....	....
1852	....	....	62, 478	....	....	....
1853	....	....	87, 864	....	....	....
1854	736, 218	....	108, 016	....	....	....
1855	784, 178	....	138, 674	....	....	....
1856	883, 137	....	180, 018	....	....	....
1857	798, 157	....	161, 918	....	....	....
1858	705, 094	....	163, 712	....	....	....
1859	840, 627	....	195, 454	....	....	....
1860	919, 770	....	205, 038	....	....	....
1861	731, 544	....	189, 818	....	....	....
1862	787, 662	....	213, 912	....	....	....
1863	947, 604	....	275, 768	....	9, 044	....
1864	1, 135, 996	872, 327	335, 369	....	10,369	....
1865	931, 582	856, 340	356, 292	....	15, 262	63, 977
1866	1, 350, 343	1, 026, 089	430, 778	....	18, 973	73, 555
1867	1, 461, 626	1, 039, 396	459, 558	2, 550	22, 000	73, 073
1868	1, 603, 000	1, 097, 775	499, 489	7, 225	30, 000	75, 200
1869	1, 916, 641	1, 226, 356	583, 936	9, 650	35, 000	69, 500
1870	1, 865, 000	1, 291, 000	586, 000	34, 000	75, 000	62, 259
1871	1, 911, 608	1, 447, 483	737, 483	38, 250	82, 000	63, 000
1872	2, 854, 558	1, 847, 922	905, 930	94, 070	160, 108	58, 000
1873	2, 868, 278	1, 837, 430	761, 062	129, 015	222, 652	62, 564
1874	2, 689, 413	1, 694, 616	584, 469	144, 944	241, 614	61, 670
1875	2, 266, 581	1, 599, 516	501, 649	290, 863	436, 575	49, 243
1876	2, 093, 236	1, 509, 269	467, 168	412, 461	597, 174	44, 628
1877	2, 314,585	1, 476, 759	332, 540	432, 169	637, 972	47, 300
1878	2, 577, 361	1, 555, 576	322, 890	559, 795	819, 814	50, 045
1879	3, 070, 875	2, 047, 484	420, 160	693, 113	1, 047, 506	62, 353
1880	4, 295, 414	2, 332, 668	493, 762	968, 075	1, 397, 015	74, 589
1881	4, 641, 564	2, 643, 927	488, 581	1, 355, 519	1, 778, 912	84, 606
1882	5, 178, 122	2, 493, 831	227, 874	1, 460, 920	1, 945, 095	91, 293

Pig-iron statistics by periods of years.—The following table shows the growth of the pig-iron industry of the United States from 1810, in gross tons. The figures for the early periods have been carefully compiled from authentic sources of information.

Production of pig iron, by periods of years.

	Gross tons.
1810	54,000
1820	20,000
1830	165,000
1840	315,000
1850	564,755
1860	821,223
1870	1,665,179
1880	3,835,191
1882	4,623,323

Desirable as it might be to supplement this table of pig-iron production, and the large table above given, with the statistics of production of rolled iron, steel, and blooms for earlier years than have been noted, it is impossible to do so, except in the most fragmentary and imperfect manner. The early census reports are imperfect, and, besides, give values mainly and not quantities—strangely preserving that which has no historical value and rejecting that which would have had great value.

Imports of iron and steel from 1871 *to* 1882.—The foreign value of the imports into the United States from all countries of iron and steel and manufactures thereof, including tin plates, has been as follows in the twelve calendar years from 1871 to 1882. An increase in 1882 over 1881 will be noted in contrast with the marked decline in 1881 over 1880. A considerable decrease in the imports for the present year is, however, clearly foreshadowed, owing mainly to the decline in the prices of domestic iron and steel products consequent upon a decreased demand and the unfavorable influence of the tariff agitation of the past year.

Value of imports of iron and steel since 1871.

	Values.
1871	$57,866,299
1872	75,617,677
1873	60,005,538
1874	37,652,192
1875	27,363,101
1876	20,016,603
1877	19,874,399
1878	18,013,010
1879	33,331,569
1880	80,443,362
1881	61,555,077
1882	67,075,125

It is not possible to give the quantities of all the iron and steel products imported from other countries in the twelve years above noted, but in the following table we give the quantities of all the products whose statistics are obtainable, the Treasury statisticians not being able in all cases to secure returns of tonnage, although they do of values.

Partial table of quantities of iron and steel imports since 1871.

[Net tons.]

Commodities imported.	1871.	1872.	1873.	1874.	1875.	1876.
Pig iron	245, 535	295, 967	154, 708	61, 165	83, 932	83, 072
Castings	492	407	262	74	26	35
Bar iron	122, 565	89, 576	62, 253	26, 876	27, 542	26, 653
Boiler iron	322	684	464	53	51	15
Band, hoop, and scroll iron	13, 103	12, 365	8, 245	1, 422	255	144
Railroad bars of iron	566, 202	381, 064	99, 201	7, 796	1, 174	287
Railroad bars of steel (*a*)	....	149, 786	159, 571	100, 515	18, 274	....
Sheet iron	12, 047	15, 149	10, 713	6, 741	4, 050	1, 758
Old and scrap iron	220, 340	278, 257	108, 838	40, 633	28, 947	14, 149
Anchors, cables, chains, etc	5, 434	5, 875	4, 668	3, 219	2, 245	1, 863
Tin plates	92, 925	95, 904	108, 838	89, 351	101, 981	100, 740
Total	1, 278, 965	1, 325, 034	717, 761	337, 845	268, 477	228, 716

Commodities imported.	1877.	1878.	1879.	1880.	1881.	1882.
Pig iron	66, 861	74, 484	340, 672	784, 968	520, 835	604, 978
Castings	53	69	61	114	632	2, 079
Bar iron	30, 531	33, 346	48, 840	126, 987	47, 820	79, 220
Boiler iron	2	1	91	168	290	175
Band, hoop, and scroll iron	159	7	1, 031	25, 322	827	6, 021
Railroad bars of iron	....	....	19, 090	132, 459	137, 013	41, 992
Railroad bars of steel	35	10	25, 057	158, 230	249, 308	182, 135
Sheet iron	1, 184	838	5, 459	11, 412	8, 121	12, 985
Old and scrap iron	10, 903	6, 225	248, 429	694, 273	151, 107	164, 591
Anchors, cables, chains, etc	1, 073	646	892	1, 393	1, 520	1, 530
Tin plates	125, 976	120, 808	172, 760	177, 015	204, 966	239, 665
Total	236, 777	236, 434	862, 382	2, 112, 341	1, 322, 439	1, 335, 371

a Previous to July 1, 1871, reported under head of iron rails.

Domestic exports of iron and steel from 1871 *to* 1882.—The value of the exports from the United States to all countries of domestic iron and steel and manufactures thereof in the twelve calendar years from 1871 to 1882 was as follows:

Value of exports of iron and steel, and manufactures thereof, since 1871.

	Values.
1871	$11, 836, 137
1872	10, 030, 125
1873	12, 129, 939
1874	15, 389, 807
1875	16, 092, 906
1876	11, 798, 459
1877	16, 659, 675
1878	13, 260, 369
1879	12, 470, 448
1880	12, 960, 995
1881	15, 782, 202
1882	19, 029, 759

Prices of iron and steel in the United States during the last ninety years.—The foregoing statistics of production and of imports and exports only tell the story of the growth of our iron and steel industries and of our consumption of iron and steel; the thoughtful reader will look for them to be accompanied by a record of the prices paid for leading products. This record is here presented. It goes back to the closing years of the last century, and comes down to the month of May in the present year. It is as complete as it has been possible to make it, and no pains have been spared to make it accurate.

The first table contains the average prices of charcoal pig iron at Philadelphia from 1799 to 1849, when anthracite pig iron became the standard of comparison. Until 1827 the prices are for best pig iron; from 1827 to 1833 they are for an average of all grades; from 1833 to 1840 they are for gray iron; and from 1840 to the close of the table they are for No. 1 foundry. In the second table the average prices of No. 1 anthracite foundry pig iron at Philadelphia are given from 1842, in which year quotations first appear, to 1883. The first table also embraces the average prices of hammered bar iron at Philadelphia from 1793 to 1844, although its manufacture and sale, which had been declining prior to 1844, continued for several years afterwards. In the second table the average prices of best refined rolled bar iron at Philadelphia are given from 1844 to 1883.

In the second table the average prices of iron rails are given at Philadelphia from 1847 to 1883. In the last four months of 1882 no sales of iron rails were made at Philadelphia, and the price we give for that year is consequently an average for the first eight months only. In 1883 the manufacture of iron rails of standard sections at the mills near Philadelphia may be said to have come to an end, although the manufacture of light iron rails continues. A few standard iron rails, as well as light rails, are still made in other sections of the country, the former at about the prices we give for steel rails in 1883. The column in the second table devoted to steel rails gives the average prices at Philadelphia from 1867, when they were first made in commercial quantities, to 1883. The same table also gives the average prices at which anthracite coal has been sold by the cargo at Philadelphia from 1834 to 1883. The quotations are for hard white-ash lump coal. The tons used in the tables are tons of 2,240 pounds.

Prices of charcoal pig iron and hammered bar iron from 1793 *to* 1849, *per gross ton.*

Years.	Charcoal pig iron.	Hammered bar iron.
1793	....	$80 00
1794	....	77 50
1795	....	82 50
1796	....	106 50
1797	....	101 50
1798	....	97 50
1799	$36 25	98 50
1800	35 75	100 50
1801	32 75	117 50
1802	30 75	99 00
1803	29 25	97 50
1804	29 75	98 50
1805	30 75	101 00
1806	35 75	108 50
1807	38 75	110 50
1808	40 00	104 00
1809	40 00	107 50
1810	38 00	108 00
1811	44 00	105 00
1812	47 50	106 00
1813	47 25	106 00
1814	46 00	133 00
1815	53 75	144 50
1816	50 25	127 00
1817	47 00	114 00
1818	42 25	110 00
1819	36 50	110 00
1820	35 00	103 50
1821	35 00	90 50
1822	35 00	94 50
1823	35 25	90 00
1824	40 00	82 50
1825	46 75	97 50
1826	46 50	101 50
1827	39 25	100 00
1828	35 00	100 00
1829	35 00	97 00
1830	35 00	87 50
1831	35 00	85 00
1832	35 00	85 00
1833	38 25	82 50
1834	30 25	82 50
1835	30 25	81 50
1836	41 50	100 00
1837	41 25	111 00
1838	32 25	93 50
1839	30 00	96 50
1840	32 75	90 00
1841	28 50	85 00
1842	28 00	83 50
1843	26 75	77 50
1844	28 25	75 00
1845	32 25	....
1846	31 25	....
1847	31 50	....
1848	28 50	....
1849	24 50	....

Prices of No. 1 anthracite foundry pig iron, iron and steel rails, bar iron, and Schuylkill anthracite coal, from 1834 to 1883, per gross ton.

Years.	No. 1 anthracite foundry pig iron.	Iron rails.	Steel rails.	Best refined rolled bar iron.	Schuylkill anthracite coal.
1834	....	....	....	....	$4 84
1835	....	....	....	....	4 84
1836	....	....	....	....	6 64
1837	....	....	....	....	6 72
1838	....	....	....	....	5 27
1839	....	....	....	....	5 00
1840	....	....	....	....	4 91
1841	....	....	....	....	5 79
1842	$25 62	....	....	....	4 18
1843	....	....	....	....	3 27
1844	25 75	....	....	$85 62	3 20
1845	29 25	....	....	93 75	3 46
1846	27 87	....	....	91 66	3 90
1847	30 25	$69 00	....	86 04	3 80
1848	26 50	62 25	....	79 33	3 50
1849	22 75	53 87	....	67 50	3 62
1850	20 87	47 87	....	59 54	3 64
1851	21 37	45 62	....	54 66	3 34
1852	22 62	48 37	....	58 79	3 46
1853	36 12	77 25	....	83 50	3 70
1854	36 87	80 12	....	91 33	5 19
1855	27 75	62 87	....	74 58	4 49
1856	27 12	64 37	....	73 75	4 11
1857	26 37	64 25	....	71 04	3 87
1858	22 25	50 00	....	62 29	3 43
1859	23 37	49 37	....	60 00	3 25
1860	22 75	48 00	....	58 75	3 40
1861	20 25	42 37	....	60 83	3 39
1862	23 87	41 75	....	70 42	4 14
1863	35 25	76 87	....	91 04	6 06
1864	59 25	126 00	....	146 46	8 39
1865	46 12	98 62	....	106 38	7 86
1866	46 87	86 75	....	98 13	5 80
1867	44 12	83 12	$170 00	87 08	4 37
1868	39 25	78 87	158 50	85 63	3 86
1869	40 62	77 25	132 25	81 66	5 31
1870	33 25	72 25	106 75	78 96	4 39
1871	35 12	70 37	102 50	78 54	4 46
1872	48 87	85 12	112 00	97 63	3 74
1873	42 75	76 66	120 50	86 43	4 27
1874	30 25	58 75	94 25	67 95	4 55
1875	25 50	47 75	68 75	60 85	4 39
1876	22 25	41 25	59 25	52 08	3 87
1877	18 87	35 25	45 50	45 55	2 59
1878	17 62	33 75	42 25	44 24	3 22
1879	21 50	41 25	48 25	51 85	2 70
1880	28 50	49 25	67 50	60 38	4 53
1881	25 12	47 12	61 12	58 05	4 53
1882	25 75	46 37	48 50	61 41	4 61
1883 (May)	22 00	....	38 50	51 52	4 20

Fluctuations in prices.—A study of the foregoing tables reveals many and wide fluctuations in prices. The greatest uniformity will be found during the charcoal era, ending about 1842, allowance being made for the disturbing influence of the second war with Great Britain. The greatest fluctuations will be found since the close of that era, not counting the great enhancement in values during the civil war. In other words, before we began to produce iron largely, and especially while we held to the old ways of manufacturing it, the market for its sale was least excited and least depressed. The new methods reduced prices to lower figures than they had ever touched during the charcoal era, and the rebound has frequently been proportionately greater than at any time during that era. Until we began to manufacture pig iron with anthracite coal its yearly price after 1799 never fell below $29 per ton, but in 1878 the average price for the year of No. 1 anthracite foundry pig iron was $17.62. Until we began to roll the most of our bar iron instead of hammer it, its yearly price after 1793 did not fall below $77.50 per ton, but in 1878 the average price for the year was $44.24, or a little less than two cents per pound. The greatest fall in prices has been in steel rails, which are now sold at less than one-fourth the price charged for them when we began their manufacture in 1867.

When anthracite coal first became a marketable commodity in large quantities, the price of the quality quoted in the table was much higher than was afterwards obtained for it. In 1826 it sold at from $7 to $7.80 per ton; in 1827, at $7; in 1829, at from $7.25 to $7.50; in 1830, at from $5.75 to $7.25; in 1833, at from $4.87½ to $6. These prices do not appear in the table. The lowest yearly price at which anthracite coal has been sold in this country was in 1877, when it cost only $2.59 per ton by the cargo.(*a*)

IRON IN THE ROCKY MOUNTAIN DIVISION.

Colorado.—The following account of the iron interest in Colorado is taken from the State geologist's report for 1882:

"Accompanying and contiguous to the coal mines, as well as independently at many other points, both in the mountains, parks, and on the plains, in nearly every section of the State vast deposits of iron ore of good quality have been discovered, comprising nearly all the known varieties. But until the past two years very little attention has been given to this branch of industry. As an indication of what has been accomplished in this short period, I cannot do better than to insert the statement of the operations of the Colorado Coal and Iron Company, which was organized January 23, 1880.

"This corporation owns and controls the following properties: 99,376 acres of selected lands along the line of the Denver and Rio Grande railway. Of these 13,971 acres are coal lands; 83,788 acres are in town sites, colony and agricultural subdivisions, including South Pueblo, the site of the steel works, part of Cañon City, and the town sites of El Moro, Cucharas, and Labran; 1,057 acres are iron ore lands, embracing what is known as Iron mountain, a large deposit of magnetic iron ore lying between Cañon City and Silver Cliff; also the Calumet & Hecla and Smithville iron mines, near Salida, including about 300 acres of fine magnetic ore; also, at Hot Springs, over 100 acres containing large deposits of superior hematite. They have, in addition, a lease of the Placer iron mines, near Placer station, with a lease to work other mines

a Mr. Swank's contribution ends here.

in the Trinchera estate. Of coal lands, the company own 8,121 acres at El Moro; 2,390 acres on the Cucharas; in the Cañon fields 3,300 acres, and controlling by lease 160 acres more. At Crested Butte they own 160 acres, and lease 1,120 adjoining. At Irwin they hold by lease 240 acres. On the San Carlos, seven miles from their works, they own extensive lime quarries and beds of clay.

Value of products in 1883.

[December estimated.]

Coal	$2,000,000
Coke	500,000
Steel, iron, and nails	2,400,000
Iron ore	250,000
Total	5,150,000

Production in 1882.

[Fourth week of December estimated.]

COAL.	Tons.	COKE.	Tons.
Coal Creek mines	91,072	El Moro	83,642
Oak Creek No. 1.	5,455	Crested Butte	9,128
Oak Creek No. 2.	44,977		
Walsenburg mines	95,377		
El Moro mines	235,449		
Crested Butte mines	38,909		
Total	511,239	Total	92,770

IRON ORE.		IRON AND STEEL.	
South Arkansas mine	14,202	Merchant bar, mine rail, etc	3,883
Hot Springs mine	29,190	Pig iron	24,303
Placer mine	8,378	Castings	2,752
Silver Cliff mine	854	Muck bar (four months only)	1,253
Grape Creek mine	801	Nails (four months only)	807
		Spikes (six months only)	251
		Steel ingots (eight months only)	20,919
		Steel blooms (eight months only)	18,068
		Rails (eight months only)	16,139
Total	53,425	Total	88,375

"The first rail was rolled by this company on April 12, 1882, and the nail mill was started September 15 following. It is confidently expected that their operations will be at least doubled within the next year. The following table shows the comparative productions of 1881 and 1882:

	Tons.
Coal:	
1881	350,944
1882	511,239
Increase	160,295

Coke:	Tons.
1881	47,670
1882	92,770
Increase	45,100

"Besides the mines owned and controlled by this company, many might be mentioned as of special importance, but I shall only name a few. One on the Cebolla creek, a short distance above its junction with the Powder Horn, where there is an immense and apparently inexhaustible body of valuable magnetic ore. The following analysis of a sample of this ore by Mr. Otto Wuth, an able analytical chemist of Pittsburgh, Pennsylvania, tells its own story:

Water	.94
Silicic acid	1.87
Alumina	.48
Magnetic oxide of iron	56.63
Peroxide of iron	38.66
Lime	1.02
Magnesia	.37
Phosphoric acid	.018
Sulphuric acid	.012
	100.00
Metallic iron	68.06
Phosphorus	.0084"

Large deposits of iron ore exist also at Morrison, Langford, Como, and other parts of the State. The first iron smelting effected in Colorado was done by Mr. W. S. Marshall, owner of the Marshall coal mine in Boulder county. Before 1873 he erected a small furnace at Langford and produced in a run of two months 250 tons of pig iron. It was found that it required 5,000 pounds of ore to make one ton of iron. The ore used was mined in the immediate neighborhood of the coal bank, but after a fair trial the supply of ore proved insufficient and the furnace was abandoned.

The ores from Cebolla creek, Gunnison county, have recently attracted much attention, and a strong company of experienced iron men are now putting up works for the treatment of this ore, and for the manufacture of rails, nails, etc., at Gunnison City.

The red hematite ore at Morrison is now manufactured into paint, which is used in Denver.

From January 1, 1883, to June 30, 1883, the Colorado mines named produced the following amounts of iron ore:

	Net tons.
South Arkansas	9,587$\frac{1800}{2000}$
Hot Springs	14,987$\frac{1300}{2000}$
Placer	1,512$\frac{1300}{2000}$

No ore was produced by the Grape Creek and Silver Cliff mines.

The Colorado Coal and Iron Company, at South Pueblo, made during the same period:

	Net tons.
Merchant bar, mine rail, etc	1,959$\frac{1020}{2000}$
Pig iron	12,656$\frac{1870}{2000}$
Castings	881$\frac{1773}{2000}$
Muck bar	1,930$\frac{1578}{2000}$
Nails (30,800 kegs)	1,540$\frac{350}{2000}$
Spikes (3,905 kegs)	386$\frac{466}{2000}$
Steel rails	9,100$\frac{528}{2000}$

Wyoming.—In Wyoming large beds of iron ore of excellent quality exist in the Seminole mountains, in Carbon county. Large quantities of this ore have been shipped to smelting works at Salt Lake City and other Western points, but no record of the output is obtainable. The red color of the oxide here renders it suitable for paint, and considerable quantities are used for that purpose.

In Laramie county, about 25 miles northeast of Laramie City, occurs an enormous mass of ore, which is called the Iron mountain. This locality is capable of furnishing indefinite quantities of iron ore. The following is an analysis of the mineral:

Sesquioxide of iron	45.03
Protoxide of iron	17.96
Silica	0.76
Titanic acid	23.49
Alumina	3.98
Sesquioxide of chromium	2.45
Sesquioxide of manganese	1.53
Lime	1.11
Oxide of zinc	0.47
Magnesia	1.56
Sulphur	1.44
Phosphorus	trace.
	99.78
Metallic iron	45.49

Montana and Dakota.—In Montana iron in some form occurs in almost every county, but as yet none has been manufactured. Some very fine beds exist in the Yellowstone valley. Iron is also found in Dakota, but not in sufficient quantity or purity to render its extraction profitable.

New Mexico.—In New Mexico the deposits of iron ore are numerous, extending from the Raton mountains to the Placer and Sandia mountains, overlooking the Rio Grande. It is found of excellent quality near Las Vegas; while south of Santa Fé, in the Placer mountains, there are three veins (from 3 to 8 feet in width) of good ore.

At the Hanover copper mine there is an apparently inexhaustible supply of iron ore, partly magnetic, partly a red hematite, forming a continuous ridge some miles in length. On the Rio Puerco, associated with the coal, occur frequent bands of iron ore of similar quality to that mined formerly at Marshall's mine in Colorado, and in far greater quantity. East of the Gallinas range and about 30 miles west of Socorro, in Socorro county, there is a large tract of land covered with nodules of iron ore varying from 100 to 500 pounds in weight, the ore being unusually pure and good. It has been shipped in large quantities to the Cerillos smelter, the La Joya smelter at Socorro, and the Magdalena smelter at South Camp, in the Magdalena mountains. Good iron ore occurs also in the Santa Rita, Burro, and other ranges in the southern section of the Territory.

IRON ON THE PACIFIC COAST.

Very little iron mining is done on the west coast of the United States; in fact at present there are only three or four mines working. This is owing rather to the absence of suitable fuel in proximity to the ore than to any lack of ore, as that has been found at a number of localities where it is not utilized, although of good quality.

The only iron mine being worked in California is at Hotaling, near Clipper Gap, Placer county. In 1881 this mine produced 4,500 tons of first-class iron, which sold in San Francisco at the best prices. In 1882 990 tons had been made, when a disastrous fire destroyed the works and stopped progress. The works were rebuilt and operations resumed in 1883, and up to July 750 tons were made. The production will be largely increased, however, arrangements having been made to that end. All the iron from this mine is consumed in San Francisco and Oakland, California.

The Puget Sound mine in Washington Territory has one furnace. Very little work was done in 1882. The furnace was blown in in March, 1883, and during the first six months of this year the production was about 3,000 tons. The force employed in the mine and at the furnace, and as wood-choppers, etc., is 225 men. The average wages are $2 per day and found.

The Oswego Iron Company employs 400 men, and will soon increase the force to 700 men. This company is controlled by the Northern Pacific Railroad Company. Its works shipped to San Francisco in 1882 about 3,200 tons of iron, which sold at an average of $31 per ton. In the future it is expected that all the iron produced by the company will be held for the requirements of the railroad.

Iron is brought to San Francisco from England in returning grain vessels at comparatively low rates of freight, considering the distance; and while the consumption is very heavy, the prices paid for the crude metal are by no means exorbitant.

Iron ore is used as a flux in some of the silver-lead smelting districts of this region.

THE IRON ORES OF ALABAMA, IN THEIR GEOLOGICAL RELATIONS.

By Eugene A. Smith.

METAMORPHIC ORES.

The question of the geological age of the metamorphic rocks of Alabama is still an open one, but since these rocks are sufficiently distinct in their physical characters from other non-crystalline rocks, the ores of the metamorphic region may very conveniently be considered separately.

The iron ores of this region are magnetite, titaniferous magnetite, hematite, menaccanite, limonite, and pyrite.

Magnetite.—In Coosa county and elsewhere, magnetite occurs in limited quantity in masses showing crystalline faces of considerable size. Fragments of large size, of granular texture, have been found in Clay county, but the vein itself has not yet been discovered. An analysis of this ore shows comparatively little phosphorus. In Randolph, Cleburne, and other counties, a magnetite of slaty texture is not uncommon.

Titaniferous magnetite.—Ores of this kind have been found at a good many localities in Chambers county. One specimen from near Oak Bowery was analyzed by Dr. Mallet. Near Fredonia, very fine specimens of this ore have been lately brought to notice, but I am unable to say whether the quantity is large.

Hematite disseminated in scales in rocks has been found in Coosa, Clay, Tallapoosa, and other counties.

Menaccanite, or titanic iron, like the hematite, is known only as an accessory ingredient of some of the rocks of this region. In Coosa and Clay counties it is seen in flattened scales in a laminated sandstone or arenaceous schist, and in Coosa county it has been found in rounded, apparently water-worn, fragments of considerable size. None of the ores above mentioned have yet been found in quantity, but there seems to be good reason for thinking that the magnetite of Clay county and the titaniferous magnetite of Chambers county come from beds of considerable size.

The *limonites*, which are much more abundant than any of the ores above mentioned, appear in most cases to be "gossans," *i. e.*, the result of decomposition of beds of pyrites. Such is the case in Coosa, Clay, Tallapoosa, Randolph, and Cleburne counties, where beds of this character, of great superficial extent but of unknown depth, have been examined. Some of these ores appear to be mixtures of turgite and limonite, as may be seen from the analyses. In the red clayey loams derived from the disintegration of hornblendic rocks, compact concretionary masses of limonite are of very common occurrence, but not often in quantity sufficient to form an ore bank. In one locality in Clay county ore of this character was largely used some time ago in a Catalan forge.

Pyrite, though hardly to be classed with the ores from which iron is produced, deserves notice here because of its occurrence in large quantities in Clay, Coosa, and other counties of this region. Some of the pyrite is nearly pure, some cupriferous, containing 10 to 12 per cent. of copper. If more accessible, these pyritous deposits might be valuable as material for the manufacture of sulphuric acid.

Analyses of Alabama metamorphic ores.

	A.—Magnetites.		B.—Limonites.			
	1.	2.	3.	4.	5.	6.
Specific gravity	3.85	4.83	3.03	3.14	3.67	3.40
Combined water	0.91	....	7.16	7.51	10.90	9.79
Siliceous matter	3.75	0.54	1.61	40.62	9.26	1.78
Ferrous oxide	25.88	28.80	......	....	....	....
Ferric oxide	57.52	61.37	88.12	46.12	78.27	83.13
Alumina	6.00	Traces.	1.35	1.85	1.65	3.67
Oxide of manganese	6.24	....	0.02	0.29	0.50	0.19
Lime	Trace.	....	0.40	0.39	0.44	0.50
Magnesia	0.00	0.08	0.02	0.75	0.22	0.04
Phosphorus	Trace.	....	.58	.38	0.09	.33
Sulphur	0.00	....	0.20	0.07	0.03	.61
Titanium dioxide	0.00	10.21	....	....	....	....
Metallic iron	60.40	65.36	61.71	32.30	54.81	58.21

1. Granular magnetite, near J. M. Kennedy's, Clay county. Prof. W. C. Stubbs, analyst.
2. Granular magnetite, William Andrews, near Oak Bowery, Chambers county. Dr. J. W. Mallet, analyst.
3. Porous limonite, brown and reddish colors, Chilton county. Eugene A. Smith, analyst.
4. Ocherous earthy limonite traversed by quartz veins, Chilton county. Eugene A. Smith, analyst.
5. Compact and fibrous interior, outer surface glazed black, Chilton county. Eugene A. Smith, analyst.
6. Porous limonite (gossan) consisting of alternate shells of compact brown and red color, some ocherous matter contained, Chilton county. Eugene A. Smith, analyst.

SILURIAN ORES.

The equivalents in the more northern States, of the Appalachian region, of the Lower Silurian strata of Alabama, have not yet been satisfactorily made out, so that a few words of explanation may not be out of place.

Following Professor Safford's example, I have classed with the Silurian a great mass of semi-metamorphic slates and a conglomerate, which together make a bold mountain range forming the eastern boundary of the Coosa valley, and the western of the metamorphic region above spoken of. These slates and conglomerate from their position seem to be at the base of the Silurian system of Alabama, and they have been referred to the Acadian of Professor Dana.

Next above these is a series of heavy bedded sandstones with shales, the sandstones characterized by the presence of small cylindrical impressions (called *Scolithus* rods), and occurring in mountainous masses which rise up abruptly from the plain, sometimes to the height of 2,500 feet, and forming an interrupted range approximately parallel with the preceding and distant from it towards the west some ten or fifteen miles. With this sandstone, which is usually supposed to be the equivalent of the Potsdam sandstone of New York, and the Chilhowee sandstone of Tennessee, are associated siliceous and argillaceous shales of considerable thickness.

Between this sandstone and the base of a limestone formation which has been pretty well identified as the equivalent of the Chazy limestone of New York and the Maclurea limestone of Tennessee (so called from its characteristic fossil), intervene the formations which constitute the Knox group of Professor Safford of Tennessee. The subdivisions of this group in Alabama are entirely analogous to those of Tennessee, being a calcareous sandstone, followed above by a mass of calcareous shales or shaly limestones traversed by seams of calcite, and this in turn overlain by a great thickness of dolomites or magnesian limestones, the upper strata of which are filled with concretionary masses of flint or chert. From the character of the prevailing rock, Professor Safford has named these divisions the Knox sandstone, the Knox shale, and the Knox dolomite, and he considers the first equivalent to the Calciferous of the New York series, and the two last the equivalents of the Quebec group, as defined by Professor Dana.

At Cedar Bluff, on the Coosa river, I collected some trilobites from the argillaceous shaly limestones of the middle division above given, and submitted them to Professor R. P. Whitfield for examination and determination. They were mostly new species of *Crepicephalus*, but were referred by Professor Whitfield to the horizon of the Potsdam of New York, and not to that of the Quebec. Other trilobites collected at Helena, from shales of this formation, were referred by Prof. James Hall likewise to the Potsdam horizon. The dolomite is almost devoid of fossils in Alabama as well as in Tennessee, but the upper cherty portion of this group at Pratt's Ferry, in Bibb county, Alabama, has yielded a few recognizable forms which were referred by Professor Whitfield to the horizon of the Calciferous.

It will thus be evident that the exact equivalents of the beds intervening between the sandstone containing *Scolithus linearis* and the base of the Chazy limestone are as yet undetermined. It will be sufficient for our present purposes to speak of them as the *sandstone*, the *shale*, and the *dolomite*, with the understanding that they are, both lithologically and in topographical character, identical with the corresponding divisions of the Knox group of Tennessee.

From the Chazy limestone to the top of the Silurian series, the geological position of the Alabama strata can, in most if not all cases, be readily made out upon the evidence of their fossil contents.

The iron ores which occur in the Silurian formation are essentially of two varieties, viz., the brown hematites and the fossiliferous or lenticular red hematite. The other varieties are confined to the Potsdam or *Scolithus* sandstone, and are either specular iron or magnetite. Both these ores occur disseminated through slaty sandstones of this horizon in localities where the sandstone has been partially metamorphosed, as in the southeastern part of Talladega county. Some of the slaty sandstones are impregnated with magnetite to such an extent as to exhibit very strong magnetic polarity. Hopes have been entertained of discovering ore in these localities in sufficient quantities to be of commercial value, but thus far without realization.

In other localities where the Potsdam sandstone has not been altered, the iron ore is usually limonite, which appears as a superficial coating on the exposed surfaces, or as small deposits filling the spaces between detached fragments of the sandstone. Occasionally the limonite is found, as in good specimens, with botryoidal surfaces and radiately fibrous texture, but not, so far as yet known, in large quantity.

Limonite occurs also sparingly associated with the two next overlying divisions, viz., the sandstone and the shale, but the dolomite must be considered as the great limonite-bearing formation of Alabama, as it is of Tennessee. All the limonites at present mined in Alabama to supply furnaces come from this formation.

The ore is of concretionary nature, and geodes are often found lined inside with mammillary and botryoidal surfaces, with velvety goethite, etc. The solid masses are sometimes compact, breaking with more or less conchoidal fracture, of liver brown color; sometimes fibrous, sometimes made up of cylindrical columns of radiating fibers, the outer surfaces often coated with a dark or nearly black glaze. The ore has evidently been derived from the disintegration of the calcareous rocks of this formation, and it is usually imbedded in red colored clayey loams, mingled with fragments of chert and other débris of these rocks. In some places the clay has been partially removed by denudation, and the limonite is seen in hillocks of considerable size and nearly destitute of soil. In the vicinity of large accumulations of the ore, the deep red-colored soil is often partially covered with rounded fragments of limonite resembling pebbles; and these limonite pebbles, where exposures are made by gullies, are seen embedded in the red clay to some depth, as wash ore.

In the ore deposits of this formation in Alabama, it is difficult, if not impossible, to discover anything like stratification in the masses of ore, and it is almost equally difficult to trace any connection between the distribution of the ore banks and the various strata of the formation with which they are associated, beyond the fact that they follow, in general, the outcrop of the dolomite, sometimes over one series of beds in this formation and sometimes over another.

In the Coosa valley some of the most important ore beds are worked upon the slopes and along the bases of the mountains of Potsdam sandstone, though the association of cherty fragments and other débris points to the connection of the ore with the dolomite.

The ores in the eastern part of the Coosa valley are least favorably situated with reference to the coal supply, and most of the furnaces use charcoal furnished by the long-leaf pine forests of this valley. In the narrow anticlinal valleys to the northwest of the Coosa valley the ore is always within five or six miles of productive Coal Measures, with no serious topographical obstruction intervening. To this circumstance are, in great measure, due the exceptional advantages of this region, of which Birmingham is the center, in the production of iron.

The next horizon at which we find iron ore is at the summit of the dolomite, or at the base of the Chazy limestone. The ore is a lenticular, red hematite, scarcely distinguishable from a similar ore occurring in the Clinton formation above. This occurrence of oölitic ore was first observed in the vicinity of Pratt's Ferry, in Bibb county, where a bed of it about 4½ feet in thickness lies conformably beneath the Chazy limestone with its characteristic fossils. The ore itself contains traces of fossils, but none were well enough preserved for indentification. This bed was subsequently traced by its outcrops along the anticlinal valley (Roup's and Jones's) nearly to Birmingham, and it occurs on both sides of the valley.

Analyses of Alabama Silurian ores. (Dolomite.) Limonites.

	Coosa Valley.														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Specific gravity	3.63	3.69	3.80	3.29	......	3.40	3.73	3.81	3.36	......	......	......	......	......	......
Combined water	14.62	13.36	12.78	12.70	13.21	10.89	9.77	11.07	11.55	13.76	9.30	9.25	3.80	11.86	11.52
Siliceous matter	0.29	1.19	0.15	3,21	16.24	20.02	15.49	1.78	13.85	5.17	22.37	7.06	11.74	7.58	11.71
Ferric oxide	82.82	84.32	84.37	82.45	69.22	68.13	73.64	85.72	72.18	76.84	65.65	78.86	81.35	77.54	68.93
Alumina	0.35	0.89	1.24	0.77	......	0.46	1.41	0.09	0.73	2.34	0.92	2.37	1.59	2.07	3.59
Oxide of manganese	0.77	0.41	Trace.	0.63	0.98	0.46	0.13	......	1.92	0.37	1.33	1.49	0.75	......	3.77
Lime	Trace.	......	0.08	Trace.	......	......	......	......	......	......	......	0.58	0.57	0.07	0.10
Magnesia	......	......	......	Trace.	......	......	......	......	......	Trace.	......	Trace.	0.12	0.03	0.05
Phosphorus	0.06	Trace.	0.24	Trace.	0.04	0.01	Trace.	0.05	Trace.	0.47	0.05	0.16	0.05	0.13	0.06
Sulphur	......	......	......	......	......	......	......	......	......	......	......	0.14	0.16	......	......
Metallic iron	57.97	59.02	59.06	57.71	48.45	47.69	51.55	60.00	50.53	53.79	45.95	55.20	56.19	54.28	48.25

1. Limonite of radiating fibrous texture. Shelby Iron Works, Shelby county. Dr. J. W. Mallet, analyst.
2. Limonite, with botryoidal protuberances of radiating fibrous texture, black glazed surface. Near Oxford, Calhoun county. Dr. Mallet, analyst.
3. Limonite, similar to No. 2. Near Oxford, Calhoun county. Dr. Mallet, analyst.
4. Limonite, compact, partly cellular, with traces of yellow earthy powder. Near Anniston, Calhoun county. Dr. Mallet, analyst.
5. Cellular ore, thin sheets of compact fibrous ore, earthy ocherous material filling some of the cavities. Near Oxford, Calhoun county. Dr. Mallet, analyst.
6. Like No. 5, less cellular, but containing more soft ocherous matter. Near Anniston, Calhoun county. Dr. Mallet, analyst.
7. Dark brown compact ore, with large cavities filled with ocher or white earthy matter, or empty glazed surface. Near Anniston, Calhoun county. Dr. Mallet, analyst.
8. Dense compact ore, light brown color, very little ocherous matter. Near Oxford, Calhoun county. Dr. Mallet, analyst.
9. Generally like No. 9, fibrous in places, ocher in cavities. Near Oxford, Calhoun county. Dr. Mallet, analyst.
10. Made up in great part of soft yellow and red ocher, filling large cavities in compact brown ore. Near Anniston, Calhoun county. Dr. Mallet, analyst.
11. Light cinnamon brown ore, very cellular, and containing much intermixed yellow ocher. Near Oxford, Calhoun county. Dr. Mallet, analyst.
12. Limonite from ore banks of Shelby Iron Company. Near Columbiana, Shelby county. Prof. C. F. Chandler, analyst.
13. Roasted ore from ore banks of Shelby Iron Company. Near Columbiana, Shelby county. Prof. C. F. Chandler, analyst.
14. Average sample of ore from the Seay bank, Talladega county. J. B. Britton, analyst.
15. Average sample of ore from the Irona bank, Talladega county. J. B. Britton, analyst.

Analyses of Alabama Silurian ores. (Dolomite.) Limonites—Continued.

	Cahaba valley.									Roup's valley.						
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Specific gravity	....	....	....	3.81	3.78	....	....	3.61	....	3.75	3.56	3.43	....	....	....	....
Combined water	10.49	12.44	12.72	7.41	8.54	10.49	11.19	11.27	11.98	11.35	12.14	11.55	....	12.51	13.09	8.55
Siliceous matter	6.04	7.84	5.61	3.06	2.34	14.11	3.09	13.49	1.50	2.46	12.16	2.98	9.80	3.28	3.10	34.03
Ferric oxide	79.93	73.10	78.63	82.84	87.49	76.15	84.10	73.44	84.03	84.46	75.04	82.83	72.37	83.89	84.25	57.46
Alumina	1.43	1.47	1.36	0.35	0.27	2.65	0.27	1.03	0.20	0.91	0.30	1.39	3.75	....	....	....
Oxide of manganese	0.92	3.36	0.11	0.95	0.12	0.41	Trace.	0.00	0.20	0.33	0.00	1.02	0.00	....	....	....
Lime	0.07	0.11	0.06	1.02	0.82	0.11	1.02	0.38	0.24	0.26	0.41	Trace,	....	....	....	....
Magnesia	Trace.	0.12	0.10	0.19	0.33	0.07	0.08	0.08	Trace.	0.04	0.06	0.12	....	....	....	....
Phosphorus	0.45	0.58	0.57	0.24	Trace.	0.35	0.09	0.14	0.49	0.25	0.00	Trace.	0.12	Trace.	Trace.	Trace.
Sulphur	0.00	0.00	0.00	0.45	0.48	0.00	0.46	0.28	0.03	0.14	0.14	0.14	0.00	....	....	....
Metallic iron	56.10	51.96	55.05	57.91	61.27	50.07	58.89	51.43	58.82	59.15	52.55	58.01	50.68	58.75	59.00	40.24

1. Limonite from bank No. 1, Ashby Iron Company's land, Bibb county. Average sample. J. B. Britton, analyst.
2. Limonite from bank No. 2, Ashby Iron Company's land, Bibb county. Average sample. J. B. Britton, analyst.
3. Limonite from bank No. 3, Ashby Iron Company's land, Bibb county. Average sample. J. B. Britton, analyst.
4. Compact liver-brown limonite. Ashby Iron Company's land, Bibb county. Average sample. Eugene A. Smith, analyst.
5. Pipe ore, stalactitic, outer surface brown, red streak; body of ore reddish brown, dark red streak. Ashby Iron Company's land, Bibb county. Eugene A. Smith, analyst.
6. Average sample of limonite from Dr. Starr's. Near Pratt's Ferry, Bibb county. J. B. Britton, analyst.
7. Fibrous limonite, exterior surface smooth, interior rough, ocherous; six miles northeast of Montevallo, Shelby county. Eugene A. Smith, analyst.
8. Compact limonite, breaking with smooth conchoidal fracture, liver-brown color. Same locality as 7. Eugene A. Smith, analyst.
9. Limonite, five miles northeast of Helena, Shelby county. Eugene A. Smith, analyst.
10. Limonite, cellular, fibrous, and compact, smooth botryoidal glazed surface. Near Woodstock, Tuscaloosa county. Prof. N. T. Lupton, analyst.
11. Limonite, fibrous and compact texture. Same locality as No. 10. Prof. N. T. Lupton, analyst.
12. Limonite, cellular, fibrous, and compact texture. Same locality as No. 10. Prof. N. T. Lupton, analyst.
13. Limonite from head of Coffee's branch, Tuscaloosa county. Dr. T. M. Drown, analyst.
14. Limonite from Edwards's bank, near Greenpond, Bibb county. Professor Roepper, analyst.
15. Limonite from Edwards's bank, near Greenpond, Bibb county. Professor Roepper, analyst.
16. Limonite from Edwards's bank, near Greenpond, Bibb county. Professor Roepper, analyst.

In the Clinton group of the Niagara formation the fossiliferous, oölitic, or lenticular red hematite, dye-stone ore, lies interstratified with sandstones which form very conspicuous ridges on each side of the anticlinal valleys above spoken of. These are known as Red Mountain ridges in Alabama, and as Dye-stone ridges in Tennessee. In Roup's and Jones's valley, the ridge on the western side of the valley is duplicated, and both ridges hold good ore. The ore is most extensively mined in the ridge along the eastern side of the valley, at several points southwest of Birmingham. In one mine the ore bed is 12 to 13 feet in thickness, and at some distance below the outcrop it becomes calcareous, as usual.

In Wills's valley at Atalla, and in the Coosa valley, at Gadsden, Round mountain, and Gaylesville, this ore is also mined. The character of the red ore is about the same as in Tennessee and other States, and the distribution of the red ore ridges in Alabama is shown on the map accompanying the report of progress of the State Geological Survey for the years 1881–'82. The thickness of the ore beds and the quality of the ore vary from place to place in the ore ridges.

Analyses of Alabama Silurian ores. (Clinton.) Fossiliferous red hematites.

	Coosa valley.				Canoe Creek valley.		Jones' valley.								Roup's valley.		
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Specific gravity	4.01	3.87	....	....	3.17	3.43	3.23	....	....	....	....	....	....	....	....	....	....
Water	....	....	....	....	....	7.47	....	....	....	....	....	....	....	....	....	....	0.60
Siliceous matter	11.59	20.74	23.45	29.06	27.74	16.24	37.58	16.31	31.62	32.04	31.83	31.16	31.91	16.37	17.38	10.39	18.60
Ferric oxide	88.02	76.87	70.08	63.80	51.46	70.39	61.87	78.55	62.45	59.97	60.51	59.87	60.32	66.84	72.57	79.26	71.93
Alumina	0.07	1.55	}		2.32	3.31	0.26	3.76	4.14	5.13	4.44	4.64	4.05	2.01	0.06	5.37	5.25
Oxide manganese	Trace.	0.51	} 5.58		0.24	0.26	0.05	....	....	....	....	....	....	....	....	....	....
Lime	0.05	....	}	....	*a*17.89	0.94	0.03	0.68	1.03	....	....	....	....	....	....	....	*a*2.86
Magnesia	....	....	}		....	0.31	....	0.21	0.34	....	....	....	....	....	....	....	....
Phosphorus	0.04	Trace.	0.34	0.30	0.05	0.61	0.01	0.22	0.18	0.19	0.19	0.19	0.19	0.16	0.09	0.06	0.14
Sulphur	....	....	0.11	....	....	0.60	....	Trace.	....	....	....	....	....	....	....	0.08	....
Metallic iron	61.61	53.81	49.08	44.61	36 02	49.40	43.31	54.98	43.71	41.98	42.36	41.91	42.22	46.79	50.82	55.51	....

a Carbonate of lime.

1. Fossiliferous ore, consisting of flattened globules and impressions of small shells; dark cinnabar-red color. Gaylesville, Cherokee county. Dr. J. W. Mallet, analyst.
2. Dense, hard, deep red-colored ore, containing numerous minute grains of quartz uniformly disseminated through it. Mountain near Columbiana, Shelby county. Dr. Mallet, analyst.
3. Red hematite ore, compact, &c., from mountain near Columbiana, Shelby county. Dr. C. F. Chandler, analyst.
4. Red hematite ore, compact, &c., from mountain near Columbiana, Shelby county. J. B. Britton, analyst.
5. Fossiliferous ore, containing a great number of flattened globules. Pierson's Mill, southwest of Springville, Saint Clair county. Dr. Mallet, analyst.
6. Lenticular red, somewhat weathered. Near Springville, Saint Clair county. Eugene A. Smith, analyst.
7. Fossiliferous ore, small flattened grains. David Hanby's, on Turkey Creek, Jefferson county. Dr. Mallet, analyst.

8 to 14, inclusive. Red ores from Red Mountain, east and southeast of Birmingham, Jefferson county (from seven distinct beds). Dr. Otto Wuth, analyst.

15. Red ore from western side of valley, near Tannehill, Jefferson county. J. B. Britton, analyst.
16. Red ore from western side of valley, near Tannehill, Jefferson county. Dr. Thomas M. Drown, analyst.
17. Red ore from western side of valley, near Greenpond, Bibb county. A. W. Kinzie, analyst.

CARBONIFEROUS ORES.

Sub-Carboniferous.—The lower or siliceous division of this formation in Alabama has many points of resemblance to the dolomite above mentioned. Both formations are widely distributed; cherty limestones prevail in both, and both are iron-bearing. The chert of the sub-Carboniferous is bedded, while that of the dolomite is concretionary. The ore of the sub-Carboniferous is limonite, and closely resembles that of the dolomite in its mode of occurrence and in the general appearance of the ore masses, which exhibit here all the varieties already spoken of under the dolomite. In both cases the ore has evidently been derived from cherty argillaceous limestones, and the ore masses are here, as in the dolomite, embedded in red sandy clays, and associated with fragments of the broken-down chert beds of the formation. The quality of the ore is also essentially the same as that of the dolomite, though in some localities rather more siliceous.

Distribution.—The valley of the Tennessee, in north Alabama, is in great measure based upon the siliceous limestones of this formation, and there are several valuable and extensive ore banks, especially in the western part of the valley in Franklin county. In several localities these ore banks furnished the material to Catalan forges before the war. At present there are no furnaces using this ore.

In the anticlinal valleys above mentioned the red ore ridges are made up of the rocks of three formations, viz.: the Clinton, the black shale (which represents in Alabama the entire Devonian), and the lower or cherty division of the sub-Carboniferous. The angular cherty fragments and other débris of the last-named formation usually cover that side of red ore ridges which is farthest from the center of the valley. Among these remnants of the siliceous limestones, limonite usually holds a prominent place, but it is seldom of sufficient purity or in large enough quantity to be of value. There is no place in these anticlinals where the sub-Carboniferous ore is or has been used for supplying furnaces, for it is usually too siliceous, and often contains a high percentage of phosphorus.

In north Alabama and in Tennessee, where these sub-Carboniferous limestones are much less siliceous as a rule, the associated ores are of better quality, and have been extensively used.

Coal Measures.—The two ores found in this formation are clay ironstone, and black band. Clay ironstone has been found in many localities in Jefferson, Walker, and Fayette counties, but it has not yet been used, although the quality is good enough. As the Alabama coal fields become better known and more extensively worked, these ores will doubtless be of commercial importance. At New Castle and Warrior Stations, on the South and North Alabama railroad, seams of black band occur, but they have not been used except experimentally and on a very small scale.

Analyses of Alabama Carboniferous ores.

	A.—LIMONITES OF SUB-CARBONIFEROUS.					
	Valley of the Tennessee in north Alabama.			Yellow Creek valley.		
	1.	2.	3.	4.	5.	6.
Specific gravity	3.26	3.62	3.80	3.42	3.39	3.46
Combined water	12.37	10.44	11.85	12.47	8.16	12.37
Siliceous matter	5.58	3.16	2.86	4.37	4.51	4.37
Ferric oxide	80.65	84.70	83.51	78.28	81.17	80.05
Alumina	0.09	0.22	0.14	0.76	1.34	0.22
Oxide of manganese	0.26	0.87	0.19	0.00	0.07	0.19
Lime	....	0.44	0.41	0.81	0.30	0.41
Magnesia	....	0.03	0.05	0.39	0.03	0.05
Phosphorus	0.40	0.33	0.33	0.27	0.12	0.27
Sulphur	....	0.06	0.08	0.13	0.14	0.08
Metallic iron	56.45	59.29	58.46	54.80	56.82	56.04

	B.—CARBONATES OF THE COAL MEASURES.			
	Warrior field.			
	7.	8.	9.	10.
Specific gravity	3.50	3.86	3.56	2.42
Water and volatile combustible matter	1.17	0.84	1.44	24.25
Siliceous matter	6.37	14.94	5.21	0.71
Ferric oxide	0.43	1.20	7.92	8.03
Ferrous carbonate	86.85	70.84	67.78	62.35
Calcium carbonate	2.12	2.31	4.32	2.75
Magnesium carbonate	0.12	7.64	6.97	0.61
Manganous carbonate	3.04	1.53	0.30	0.00
Alumina	0.06	0.13	4.05	1.18
Phosphorus	....	....	0.15	Trace.
Sulphur	....	....	0.32	Trace.
Metallic iron	42.23	35.04	35.00	35.75

1. Reddish-brown cellular mass; traces of fine fibrous texture, very dense and hard. Bluff creek, Limestone county, north Alabama. Dr. J. W. Mallet, analyst.
2. Limonite from 1 mile east of Russellville, Franklin county, north Alabama. Henry McCalley, analyst.
3. Fibrous limonite; smooth, glazed exterior; liver color. Near Russellville, Franklin county, north Alabama. Henry McCalley, analyst.
4. Mass of compact brown ore, with yellow and red ocher between the shells. Hale & Murdock ore bank, near Vernon, Lamar county. Henry McCalley, analyst.
5. Compact limonite, with few cavities; some filled with red ocher. Hale & Murdock ore bank, near Vernon, Lamar county. Henry McCalley, analyst.
6. Concretionary limonite of uniform texture; yellow ocher in cavities in same. Hale & Murdock ore bank, near Vernon, Lamar county. Henry McCalley, analyst.
7. Clay ironstone; compact, brownish gray. Jefferson county. Dr. J. W. Mallet, analyst.
8. Clay ironstone; close, compact, uniform dark gray color. Walker county. Dr. J. W. Mallet, analyst.
9. Clay ironstone; compact, brownish gray. Headwaters of Clear creek, Winston county. Henry McCalley, analyst.
10. Black band ore; compact, earthy, black, with reddish-brown streak. Jefferson county. N. T. Lupton, analyst.

ORES OF LATER FORMATIONS.

None of the formations later than the Carboniferous are ore-bearing except, perhaps, the stratified drift. The sands and loams of this formation are, as a rule, more or less colored by iron, and in some localities this material is accumulated to the extent almost of forming ore-banks. Generally, however, the iron is disseminated as coloring matter, or as a cement binding together the grains of sand or pebbles, in the ferruginous sandstones and conglomerates which characterize the drift in the Southern States. Near the borders of the Paleozoic formations the drift is often highly ferruginous, and in places the iron forms ore banks. In Lamar county, near Vernon, ore of this kind has been used in a furnace. The source of this ore seems evidently to be the sub-Carboniferous limestones, which do not, however, come to the surface very near to the locality mentioned. In this ore bank specimens occur showing twigs and small pieces of wood, converted into limonite, thus giving evidence of the mode of formation of the ore. In the southern parts of the State the drift contains, so far as yet known, no large accumulations of ore, though isolated specimens of very good limonite are not at all rare, and the strata are in many places of deep red color from disseminated iron.

RELATIVE IMPORTANCE OF THE ORES OF THE DIFFERENT FORMATIONS IN ALABAMA.

The old Catalan forges in Alabama were set up where good water power and easily reducible ore were to be found in close proximity. We find them, therefore, in north Alabama along the foot of the escarpment of Coal Measures, using the rich limonites of the sub-Carboniferous formation of Russell's valley; and in middle Alabama, amongst the mountains of the eastern part of the Coosa valley, using mostly the limonites of the lower Silurian dolomite, but in one instance at least limonites from the metamorphic region adjacent; and in the defiles along the borders of the anticlinal valleys, where the lower Silurian limonites likewise served as ores. The blast furnaces, on account of their greater production, were located with more regard to the means of transportation. The earliest blast furnaces were upon the line of the Selma, Rome, and Dalton railroad, the first road traversing the iron-ore region of the Coosa valley, and upon the Coosa river, at Round mountain and Cornwall, where the red ores of the ridges at the foot of Lookout mountain were used. Along the railroad the ores used were the limonites of the dolomite. With the building of the Alabama Great Southern railroad, which follows the anticlinal valleys from near Tuscaloosa to Chattanooga, and the South and North Alabama railroad, which crosses the preceding at Birmingham, the limonites of these narrow anticlinal valleys, as well as the red fossiliferous ores of the red ridges on each side of the same, came into use, and charcoal was very soon replaced by coke as fuel. The close proximity of the iron ores of these anticlinals to the Coal Measures on each side cannot fail to influence the location of the coke furnaces yet to be built, and while some of the charcoal furnaces of the Coosa valley have more than doubled their capacity within the past few years, the position of the iron-producing center of the State will naturally be determined by that of the furnaces using coke. The red and brown ores of the Silurian formation are therefore likely for many years to come to supply the material for the greater proportion, if not all, of the iron produced in Alabama.

In the order of their relative importance in the production of iron, the Alabama ores stand as follows:

1st. The limonites of the dolomite and the fossiliferous red ores of the Clinton group of the Silurian formation.

2d. The limonites of the sub-Carboniferous, metamorphic, and drift formations. (The only occurrence of drift ore which has been worked might probably be classed as sub-Carboniferous).

3d. The magnetites of the metamorphic region, and the carbonates of the Coal Measures.

Whether the ores of the third-named class will ever be of commercial value remains yet to be shown. The ores enumerated under the second head, though not now worked, have in the past been used in furnaces and forges, and may yet again be mined. At the present time the Silurian formation yields all the iron ore mined in Alabama.(a)

UTILIZATION OF BLAST-FURNACE SLAG.

Mineral wool.—"Mineral wool," sometimes known as "silicate cotton," is the slag of blast furnaces converted into a fibrous state. The process consists in subjecting a small stream of the molten slag to the impelling force of a jet of steam or compressed air, which divides it into innumerable small shot or spherules, forming a spray of spark-like objects. The threads are spun out immediately upon the detachment of the slag particles from the main body of the stream, their length and fineness being dependent upon the fluidity and composition of the material under treatment. When the slag is of the proper consistency the spherules are small at the outset, and are to some extent absorbed into the fiber, but in no case will they entirely disappear; so that a great portion of the wool contains them, and is only separated from them by riddling. That portion of the mineral wool which is carried away from the shot by air currents is very light (14 pounds per cubic foot), and forms the "extra" grade, while the balance has a working weight of 24 pounds per cubic foot, and is called "ordinary." A cubic foot of slag weighs 192 pounds. By preference, slags of slightly acidic composition are used, though it is said that any scoriaceous substances can be utilized. When gathered up, the fragments appear to lie in all possible directions with relation to

(a) Professor Smith's contribution ends here.

each other, in consequence of which there is no parallelism or common direction to the threads, so that the air spaces are angular in shape and microscopic in size. The wool is collected in a large chamber, where it settles in a bulky state, having a fleecy appearance. About 80 per cent. of the product has to be riddled, forming the ordinary grade, while the balance is separated by currents of air, and forms the extra grade.

An article in the *Microscopical Journal*, of London, contains the following description of the appearance of the wool under the microscope: "The sudden and violent explosive action by which the fibers and bulbs are formed would lead us to expect little regularity in their markings; but a considerable number exhibit a very beautiful and symmetrical ornamentation. The fibers vary in thickness from that of common spun glass to an extreme tenuity represented by fractions of a thousandth of an inch." The bulbs may be generally described as solid bodies containing more or less numerous vesicles or hollows. The more solid ones are transparent, or show iridescence. Many of the fibers are split, and occasionally several of them will be attached to the same bulb. When the fibers are crowded together they will form interstices of angular shape, so that free motion of the incased air is impossible; in consequence of which the material makes a poor conductor of heat. By calculation it is found that ordinary and extra mineral wool contain 88 and 93 per cent. of their volumes of air, respectively. This air circulates with such difficulty that the passage of heat is retarded, while the transmission of sound is prevented by its inelasticity or want of solidity. Another advantage claimed by the manufacturers is the irritation which the glass fibers cause both to insects and vermin. There is nothing in its composition which can help to breed or harbor insects, and no animal life will remain in it.

The manufacture of this substance was begun on a small scale in 1875 at the Clove furnace, at Greenwood, Orange county, New York, by Mr. R. D. A. Parrott. It is now made by an incorporated company, which has one factory in operation, making 70,000 pounds per month. Another factory is being constructed. In 1882 the product was 1,085 net tons of the ordinary grade, worth $27,125, and 92 net tons of extra, worth $5,520; total, 1,177 tons, worth $32,645. Up to the close of 1882 somewhat over 2,000 tons were in use. During the first six months of 1883 the product was 655 net tons of the ordinary grade, worth $13,100, and 47 net tons of extra, worth $2,820; total, 702 tons, worth $15,920. No regular exports have been made, though small trial lots have been sent to England, Italy, and Australia. Its main interest lies in the fact that its manufacture is a successful utilization of a waste product.

Mineral wool is used for insulating heated surfaces, for protection against cold, deadening sound, fire-proofing, vermin-proofing, and for cleansing galvanized wire, etc. It is applied loose, and is not offered as a substitute for asbestus. But, although one of the most valuable non-conducting substances, mineral wool requires to be used with precaution against the absorption of moisture, in which case it is liable to decompose, the sulphur originally contained in the slag oxidizing to sulphuric acid, and forming soluble sulphates, which attack the metallic surfaces on which mineral wool is used as a covering. Slag is an imperfect glass, varying greatly in composition, and always containing more or less excess of some of its components. It has been found that not only the mineral acids, but also organic acids, are capable of readily decomposing it in presence of moisture and heat, and the fine fibrous condition of the mineral wool renders it still more subject to decomposition than solid slag. As the non-conducting property of mineral wool depends upon its interstitial air space, it is also essential that it should not become packed.

Other utilizations.—Very many attempts, some ingenious and some unpractical, have been made to utilize blast-furnace slag, both in Europe and in this country, but especially in the former, where not only are close economy and the saving of waste products more carefully studied, but where also the slag is more of an incumbrance to iron-masters. It is stated that the accumulation of iron slag in Great Britain is progressing at the rate of nearly 8,000,000 tons annually. In all localities the question of disposing of the slag of iron works is analogous to the removal of tailings from amalgamation works. Slag, therefore, is often not merely a valueless product, but actually a heavy incumbrance; so that its value can only be expressed in figures preceded by the negative sign, owners of works being willing to pay for getting rid of it. In view of its being a serious drawback, and, on the other hand, of its many apparently useful characteristics, it seems strange that slag has not been utilized to a greater extent in some of the methods which have been proposed.

One of the simplest and most obvious ways of disposing of it is to use it for filling in lands, or, as in the north of England, extending land into the sea. Slag, broken by hand, or by rock breakers, is said to be a fair material for road-making, and it has been utilized to a small extent in this way in various parts of the world, more particularly on the continent of Europe, in places where stone suitable for the purpose is scarce. Slag has also been used to supplant stone for builders' work, as it can be readily molded into any required plain or ornamental shape. This mode of utilizing it has attracted the attention of many experimenters. The artificial stone thus made in Pennsylvania has, however, had an extremely limited application. It is stated that ground slag can be used as an ingredient in cement, mortar, and concrete. A large number of patents are based on variously compounded substances of this kind. Slag, being itself an impure glass, can be made to take the place of ordinary glass manufactures of the lowest grade, and it has even been made into bottles.

Attempts to recover the iron from ordinary slag have resulted in disappointment, the metal produced being inferior in quality, owing to the increased proportion of injurious elements which the slag contains as compared with the tenor of the original ore from which it is made; and it is extremely doubtful, as a matter of economy, whether this retreatment can be commercially successful on a large scale.

In short, notwithstanding the close and continued attention which has been devoted to the subject, and the immense numbers of suggestions and patented processes which have been put forth, it cannot be said that any very great progress has yet been made in this direction. There are, however, encouraging possibilities.

THE BOWER-BARFF PROCESS.(a)

By A. S. Bower.

Any process which has for its object the preservation of iron and steel from rust, and which will make these metals more applicable than they now are to the requirements of mankind, will be sure to meet with attention from all those who are either engaged in the extraction of the ore, its reduction to metal, or the subsequent application of the metal itself.

It is, perhaps, not too much to say that with iron and steel rendered secure against corrosion and decay they will be used to an indefinitely greater extent than they now are. The whole realm of science has, therefore, been explored in the attempt to discover some method by which the former article may be preserved, leaving its strength undiminished by the destructive action of rust. Paints, oils, varnishes, glazes, enamels, galvanizing, electro-depositing, and what is called "inoxidizing" are among the many systems now in vogue to effect the preservation of iron and steel from the corrosive action of air and water. The object of this paper is to show what may be done in protecting iron and steel from rust by forming upon their surface a film of magnetic oxide by an inexpensive process. It is no new thing to be told that magnetic oxide of iron is unaffected by exposure to the atmosphere or to salt water for any length of time. The black sand of Taranaka, in New Zealand, is a sufficiently good example of this. Dr. Percy has pointed out that the reason why Russia sheet iron is less affected by exposure than ordinary sheet iron is because of a coating of magnetic oxide; but this was not known until Dr. Percy discovered it. That such a coating is produced is quite certain, but it is only an accident of manufacture. To Professor Barff is due the credit of being the first to deliberately undertake to coat iron and steel with magnetic oxide, produced designedly for the purpose of protecting their surfaces from rust. Some sixteen or seventeen years ago my father was making a series of experi-

(a) Read at the Boston meeting of the American Institute of Mining Engineers, February, 18-3.

ments in the production of heating gases, one set of them being the decomposition of water by passing superheated steam through masses of red-hot iron. He noticed that the iron became less and less active, until it ceased to decompose at all, when, on examining it, he saw that it was coated with a kind of enamel. It at once occurred to him, on seeing this, that the process in question might be used to obtain such a coating, but he found, after a few days' exposure of the iron to the atmosphere, that the coating shelled off, and he pursued the matter no further. The iron employed in this case was rusty, but if it had been new my father would in all human probability have been the accidental author of the process which Professor Barff discovered ten years afterward. I only mention this to show how advisable it is to investigate the causes of unexpected effects. Professor Barff's process consists in subjecting iron or steel articles to the action of superheated steam, and when they are at a temperature sufficiently high, three equivalents of iron combine with four of oxygen, forming one equivalent of magnetic oxide, and setting eight of hydrogen free, or, symbolically:

$$(1) \quad . \; . \; . \; . \; . \; . \; . \quad Fe_3 + 4\,(H_2O) = Fe_3\,O_4 + 8\,H.$$

Upon reading a description of the Barff process in the London *Times*, it occurred to my father that what Professor Barff could effect with steam he might also effect with air, and several experiments were made to this end, which, however, were very varied in character, as also were they in the results obtained. The first was made with cast iron by placing the articles to be treated in a cast-iron retort, heated externally, and then passing superheated air over them, and it was successful, while nearly all others afterwards were quite the reverse, as sesquioxide was copiously produced as well as the magnetic. Another experiment was made by placing a bar of polished cast iron in the main duct of superheated air to a blast-furnace, and this, though covered with a red sesquioxide powder, easily brushed off, had a thin, but very firm and tenacious coating of magnetic oxide in contact with the iron. This bar has been exposed to the weather ever since, or over four years, without the slightest appearance of rust. Ultimately, when thinking over the fact that air is oxygen and nitrogen in mechanical combination only, I came to the conclusion that, to form the lower or magnetic oxide, the quantity of free oxygen, and so of the air employed, must bear some proportion to the surface of the articles exposed to its action, more especially when a comparatively low heat is employed. This is so, and it has been proved that the quantity of air passed through the retort during most of the unsuccessful experiments was 300 or 400 times more than was actually necessary. The reasons also why the first experiment was successful were that a great number of articles were in the muffle, that a very high heat was employed, and that the retort had been previously used for coal-gas making, and had a deposit of carbon in it, which to a great extent neutralized the effect of the large excess of air.

All the unsuccessfully treated articles were red with sesquioxide outside; but there was, nevertheless, a coating of magnetic oxide in close proximity with the iron, due to the reducing influence of the metal in contact with the sesquioxide at an elevated temperature. The general appearance, however, of iron so treated was disagreeable, to say the least of it. The mode of action I then adopted was to admit a few cubic feet of air into the retort at the commencement of every half-hour, and then to leave the iron and air to their own devices, the retort, of course, being tightly closed. During each half-hour a coating of magnetic oxide was formed, and the operation was repeated as often as was considered necessary. Effective as this was for cast iron, the cost of producing the coating was as great as by the Barff process, for both of them required that the chamber should be heated externally, and this, with large furnaces, is very expensive. Another plan that I adopted was to first find out approximately the extent of the surface of the goods to be treated, by first dipping them all into a tank of water of known area, lifting them out, and noticing the amount of water taken out of the tank by the wetted surface, and regulating accordingly a slow, continuous air supply by meter, of course keeping the temperature of the muffle as nearly constant as possible. This, too, was successful; but the same objections applied to that mode of procedure as to the other.

There was commenced a series of experiments with carbonic acid chemically produced by the decomposition of chalk, the idea being that three equivalents of iron would unite with four of carbonic acid, forming one equivalent of magnetic oxide and four of carbonic oxide, if the heat were sufficiently high. This reaction is expressed symbolically thus:

$$(2) \quad . \; . \; . \; . \; . \; . \quad 3Fe+4\,(CO_2)=Fe_3O_4+4\,(CO).$$

This is the simplest action that could take place, but it was evident from the results that something quite different was obtained, inasmuch as the coating was very light in color, pleasing to the eye, but easily removed, and in that sense entirely differing from the articles since made. This coating, from effects exactly similar and designedly produced by a studied manipulation in the furnaces in successful operation in England, France, and here, proves pretty conclusively that carbonic acid, practically pure, produces upon iron, at an elevated temperature, a film which is, in composition, a mixture of FeO and Fe_3O_4, or, at all events, it is nearer the metallic state than is magnetic oxide. But even supposing that the results obtained by the carbonic acid had been successful as then carried out, the objections referred to concerning the air process would still exist, as external heat and a closed iron muffle would always be necessary. I therefore proposed to use a fuel-gas producer, similar in principle to the Siemens generator, but altered practically to suit other requirements, to burn the combustible gases thus produced with a slight excess of air over and above that actually required for perfect combustion, and to heat and oxidize the iron articles, placed in a suitable brick chamber, by these products of combustion. I also arranged a continuous regenerator of fire-clay tubes underneath the furnace, so that the products of combustion leaving the oxidizing chamber passed outside the tubes, imparting a portion of the waste heat to them, which was taken up by the ingoing cold air passing through their interior on its way to the combustion chamber. I had hoped in this way to be able to so regulate the excess of air over that required for complete combustion as to be able to produce magnetic oxide directly, instead of the lower and useless oxide or combination of oxides produced by carbonic acid alone. I obtained some beautiful results, and some again were unaccountably bad, and I soon found that it was as difficult to regulate the precise amount of oxidation as it first was in the Bessemer process, and I was fortunate enough to hit upon an almost parallel remedy—that is to say, I increased the quantity of free oxygen mixed with the products of combustion, and oxidized the iron articles to excess during a fixed period of generally forty minutes, when magnetic oxide was formed close to the iron and sesquioxide over all. Then for twenty minutes I closed the air inlet entirely, leaving the gas-valve open, and so reduced the outside coating of sesquioxide to magnetic oxide by the reducing action of the combustible gases alone.

The excess of oxygen in the first instance produces Fe_2O_3, or sesquioxide of iron, and the under surface of this, being in contact with metallic iron, undergoes reduction to magnetic oxide in the following manner: Four equivalents of sesquioxide unite with one of metallic iron, forming three equivalents of magnetic oxide, or, symbolically:

$$(3) \quad . \ . \ . \ . \ . \ . \ . \ . \quad 4\,(Fe_2O_3) + Fe = 3\,(Fe_3O_4).$$

When deoxidizing by combustible gases, consisting mainly of carbonic oxide, three equivalents of sesquioxide unite with one of carbonic oxide and form two equivalents of magnetic oxide and one of carbonic acid, and, symbolically:

$$(4) \quad . \ . \ . \ . \ . \ . \quad 3\,(Fe_2O_3) + CO = 2\,(Fe_3O_4) + CO_2.$$

Another method of reduction is by carbon itself, when the formula stands thus:

$$(5) \quad . \ . \ . \ . \ . \ . \ . \quad 3\,(Fe_2O_3) + C = 2\,(Fe_3O_4) + CO.$$

Formula (4) is also the reaction when rusty iron is reduced by producer gases, and which consist largely of carbonic oxide, and by the specimens exhibited it will be seen that articles completely pitted with rust may have their surfaces rendered rustless. In this case the periods of oxidizing and deoxidizing are reversed—that is to say, the latter occupies forty and the former twenty minutes. No oxidizing is theoretically necessary, but practically a certain amount is requisite to keep up the heat in the chamber, which, of course, could not be done unless combustion took place some time or other. I only mention the reduction by carbon as exemplified by formula No. 5 because, while experimenting with a furnace, I was asked by the proprietors of a valuable red-oxide deposit, which was found in so finely divided a state as to be capable of being used at once as a paint, whether I could reduce it to a magnetic oxide. I tried to do so by carbonic oxide, but I found that only the surface of it was affected, and that even this, when taken out of the furnace, speedily returned to its original red color by the combined actions of the hot unconverted material underneath and the air above. It will be found from formula (5) that 2½ pounds of carbon are required to reduce 100 pounds of red oxide. This I mixed intimately, in the shape of powder, with the red oxide, brought the mixture to a red heat, and the result was black magnetic oxide. Not only this, but by adding more carbon I could make the color lighter and lighter, until it was almost identical with the coating produced in my previous experiments with carbonic acid; and by reducing the quantity of carbon below 2½ per cent. various shades of purple were obtained, the red appearing more and more prominent as the quantity of carbon was diminished.

It will be as well, before I make any comparison between Professor Barff's process and those patented by my father and myself, to state that the whole of Professor Barff's patents, wherever existing, have been purchased by my father, so that in this case at least I hope it will not be said that "comparisons are odious." Professor Barff's process is better than ours for wrought iron, and perhaps for polished work of all kinds, as iron commences to decompose steam at a very low temperature, in fact much below visible redness. Only the other day, at the annual meeting of the Association of American Stove Manufacturers, held in New York, I was asked whether stove patterns might not be made of cast iron, polished, and then oxidized? Here is one among many instances where the steam process is almost invaluable. For ordinary cast iron, and especially that quality which contains much carbon, the Barff process is much too slow in its action, and some specimens that I have treated in England have taken as much as thirty-six hours to coat effectually, which could readily have been finished off in five hours by the Bower process.

The main distinction between the two is that the Bower is much more energetic in its action than the Barff process. The carbon in cast iron impedes oxidation, and so, while cast is far more readily treated in the Bower furnace, wrought iron is apt to scale unless it is rusted beforehand. The rust then eats into the metallic surface, under the influence of heat, and forms a tenacious combination with it. The objection to the use of a closed muffle externally heated in the Barff process has been almost entirely overcome by simply putting wrought iron into a Bower furnace, previously well heated, then shutting off both the gas and air supplies, and admitting steam into the regenerator tubes. The steam thus passes through the red-hot tubes, then through the combination chamber and its contingent passages, already highly heated, over the articles in the oxidizing chamber, heating and oxidizing them, and thence over the outside of the regenerator tubes, depositing a great portion of its heat there before passing to the chimney, and which is again picked up by the ingoing fresh, cool steam. In this way the heat in the chamber is highest shortly after the commencement of the operation, and gets gradually lower during the time of exposure, which varies, according to the class of goods, from five to ten hours. At the close of the operation, just before the articles are taken out, everything is moderately cool, and this for steam is the perfection of action, as stated by Professor Barff himself. Steel, I consider, can be equally well treated by both processes, and, indeed, it is natural to expect this, steel being, so far as the quantity of carbon it contains is concerned, between cast and wrought iron. Polished steel, however, is better treated in a low-temperature Barff furnace.

With regard to the quality of fuel burned in the gas-producers, a non-coking gas coal is the best, and Virginia splint has suited very well in this country; and of this about 1 ton every three days is required for a furnace with an oxidizing chamber 13 feet long, 4 feet 3 inches wide, and 4 feet 3 inches high. When a gas coal is employed it should be fed through the charging hoppers just before each deoxidizing operation, when a smoky flame is of great advantage. I have, however, discovered that anthracite can be used as well as a gas coal, by simply allowing petroleum to drop at the rate of 1 gallon per hour upon the red-hot surface of the coal in one of the gas-producers. This method has been exclusively used in the coating of the articles treated at the works of Messrs. Poulson & Eger, architectural engineers, at North Eleventh and Third streets, Brooklyn, E. D., New York, to whom I am much indebted, not only for these beautiful castings, but for the constant courtesy and energy they have always exhibited during the erection of their furnaces. At present they have two erected, one a Bower furnace of the size before mentioned, and the other a small Barff furnace for the treatment of very delicate or polished articles. These magnetic-oxide processes not only protect from rust, but the coating is of such a beautiful color as to render articles ready for the market as soon as they are out of the furnace and cooled. One remarkable feature of them is that there is no more cost (except in the labor of handling them) in treating 2,240 articles, each weighing a pound, than there is in coating a cube of metal weighing a ton, and so penetrating is the process that, no matter how intricate the pattern may be, every crevice—which it would be almost impossible to get at with a paint brush—is as effectively coated as the plainest surfaces. For art purposes the French gray color, with shades approaching to black, might not always be suitable; but if it should be necessary to use paint on the iron so coated, there is the absolute certainty that it will remain on in the same way as it does on wood or stone, and thus iron may be used for constructive work in a thousand directions in which it has not up to the present time been possible, on account of its liability to rust, no matter what the coating used to protect it has been.

I can give an instructive instance of this. A company in Paris had expended a very large sum over Dode's inoxidizing process, which process consists in the depositing of a layer of borate of lead on iron or steel, and then gilding, platinizing, or bronzing them, and certainly the articles so treated were exceedingly beautiful to look at; but the iron ultimately rebelled and threw off the coating, so that the shareholders were in a fair way of losing all their capital, when it was suggested to the directors that if their compositions could be deposited direct upon magnetic oxide they would conquer the difficulty. They then applied to my father for specimens of coated iron to experiment upon, and they were so satisfied with the result that the company purchased all our European patents except for England, and are carrying on the combined processes on a large scale. They have, besides their furnaces for the Dode process, four large Bower ones, two being 36 feet long by about 6 feet 6 inches wide and 6 feet high, and a Bower-Barff furnace, also of large size. Others, however, are in course of erection.

Engineers and manufacturers appear far more ready to apply the processes here and on the continent of Europe than up to the present time they have been in England; but perhaps the reason has been that so far as Professor Barff's process is concerned it has only just been shown how large masses can be dealt with—namely, by the use of the Bower furnace—and I can show that for the treatment of underground pipes, wrought-iron sleepers, roofing, and the like, the process can be readily applied, and at a cost much less than that of galvanizing, and it will at the same time be infinitely more durable; while for ornamental cast and wrought iron it is scarcely possible to imagine anything more artistic in color than some of the articles after they have been treated. For ordinary hollow-ware for kitchen use, whether of cast or wrought iron, this process is admirably adapted, and though I have been told that the gray or black color will probably be objectionable, yet I imagine if it can be shown, as we can do, that the magnetic oxide is more durable, more easily cleaned, and much cheaper than even the common tinted article, a market will soon be created. Anyhow the new combined processes are so far developed, and they have been so thoroughly examined by scientific and practical men both here and in Europe (whose testimony to the value and efficacy of them is voluminous), that they have passed from the region of theoretical investigation into that of practical application, and means have been taken for establishing works in different centers in Europe, as will also be done here, for the purpose of coating iron and steel as a trade operation. One firm alone in Scotland, Messrs. Walter Macfarlane & Co., have adopted the process, their output of ornamental castings per day exceeding 100 tons. It is intended to apply the process to cast-iron gas and water pipes, and, as the former have comparatively no pressure to bear, they may be made much lighter than they now are, if rendered incorrodible; while for water it will be a great advantage to have both the main and service pipes rendered safe from rust, which not only discolors the water, but forms the nucleus of very troublesome deposits. There is no reason now why wrought-iron or mild-steel pipes should not be used for the same purposes, especially for the interior towns of distant countries, where the first cost of the pipes is but small as compared with the cost of carriage.

My father has himself used gas and water pipes where the cost on arrival at their destination has been five times greater than their first cost in England. If, then, light wrought-iron or steel pipes could be used, not weighing one-third of those made of cast iron, and rendered practically indestructible, an enormous saving will be effected. Again, in the case of railway sleepers in iron and steel, which are now almost wholly used in Germany, the process is likely to prove of much advantage, so at least I am told by engineers both in Belgium and in Germany; and if there why not here? For fountains, railings, and all architectural work the process is invaluable, and iron may now be used in many instances instead of bronze. It will naturally be asked, what is the cost of the process? I cannot do better than answer the question by quoting from the report of Professor Flamache, the engineer-in-chief of the State railways in Belgium, who was sent over specially to England to report on the process by the public works department of that country. His estimate of cost, after a very careful examination and testing of the process, was 7½ francs per 1,000 kilograms, or nearly $2 per ton, at, of course, the Belgian rate of expenses. He also gives the cost of coating a certain extent of surface, but this I consider to be completely valueless, as, for example, I have had a furnace full of 56-pound weights, and another time I have had it full of gas-governor tops, the surface in the latter case being perhaps one hundred times more in extent than in the former, while the actual cost of oxidizing would be the same in both cases. He also says that this cost may be reduced, as instead of one workman attending to one furnace, he can attend to three or four; also by a better system of taking the articles out than existed in the experimental furnace that he saw. Sir Joseph Whitworth, feeling much interest in Professor Barff's process, sent to him some steel to be oxidized, so that he might ascertain whether it did or did not lose in strength by the operation, and the result of Sir Joseph's testing was that there had been no alteration whatever. Theoretically, one would rather expect that iron and steel would be somewhat toughened, as the tendency of the process is to anneal, and would, no doubt, if continued long enough, render some classes of cast iron malleable. A very thin article, if excessively coated, might probably be weakened, due to the fact that the coat of magnetic oxide would form an appreciable percentage of the bulk of the article; but this, of course, is a very extreme case, and one which is not likely ever to occur in practice.

GOLD AND SILVER.

Limited scope of the discussion.—The act of Congress providing for the collection and publication of mineral statistics under the auspices of the United States Geological Survey restricted the field to mineral products other than gold and silver. No attempt, therefore, has been made in the way of original investigation of this very important branch of the mining industry. In order, however, to present as complete a view of the total mineral output as possible, the best available figures of the production of the precious metals are here presented in a concise form.

Production in 1881 *and* 1882.—The following table shows the yield of gold and silver in the United States during the calendar years 1881 and 1882, as estimated by Hon. Horatio C. Burchard, Director of the Mint; and these results are accepted authoritatively in further computations in this report. The figures for 1882 have been kindly furnished in advance of their publication by Mr. Burchard. The amounts are stated at the coining value, the actual market price of the silver being considerably lower than the figure given, while in the case of gold the actual net receipts by the miners are also slightly under the nominal value, owing to the large amounts of placer gold which are sold by them at a small discount.

***Production of gold and silver in the United States during the calendar years* 1881 *and* 1882.**

States and Territories.	1881.			1882.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Alaska	$15,000	....	$15,000	$150,000	....	$150,000
Arizona	1,060,000	$7,300,000	8,360,000	1,065,000	$7,500,000	8,565,000
California	18,200,000	750,000	18,950,000	16,800,000	845,000	17,645,000
Colorado	3,300,000	17,160,000	20,460,000	3,360,000	16,500,000	19,860,000
Dakota	4,000,000	70,000	4,070,000	3,300,000	175,000	3,475,000
Georgia	125,000	....	125,000	250,000	....	250,000
Idaho	1,700,000	1,300,000	3,000,000	1,500,000	2,000,000	3,500,000
Maine	....	5,000	5,000	....	....	....
Montana	2,330,000	2,630,000	4,960,000	2,550,000	4,370,000	6,920,000
Nevada	2,250,000	7,060,000	9,310,000	2,000,000	6,750,000	8,750,000
New Mexico	185,000	275,000	460,000	150,000	1,800,000	1,950,000
North Carolina	115,000	....	115,000	190,000	25,000	215,000
Oregon	1,100,000	50,000	1,150,000	830,000	35,000	865,000
South Carolina	35,000	....	35,000	25,000	....	25,000
Tennessee	5,000	....	5,000	....	....	....
Utah	145,000	6,400,000	6,545,000	190,000	6,800,000	6,990,000
Virginia	10,000	....	10,000	15,000	....	15,000
Washington	120,000	....	120,000	120,000	....	120,000
Wyoming	5,000	....	5,000	5,000	....	5,000
Total	34,700,000	43,000,000	77,700,000	32,500,000	46,800,000	79,300,000

Rank of the States and Territories in 1882.—The relative production of gold and silver, and of both metals combined, in the several States and Territories is perhaps more clearly shown in the following statement, in which the order of the States and Territories according to their respective outputs is based on the figures given by Mr. Burchard for 1882:

Rank of the States and Territories in the production of gold and silver in 1882.

Gold.	Silver.	Total.
1. California.	1. Colorado.	1. Colorado.
2. Colorado.	2. Arizona.	2. California.
3. Dakota.	3. Utah.	3. Nevada.
4. Montana.	4. Nevada.	4. Arizona.
5. Nevada.	5. Montana.	5. Utah.
6. Idaho.	6. Idaho.	6. Montana.
7. Arizona.	7. New Mexico.	7. Idaho.
8. Oregon.	8. California.	8. Dakota.
9. Georgia.	9. Dakota.	9. New Mexico.
10. Utah, North Carolina.	10. Oregon.	10. Oregon.
12. New Mexico, Alaska.	11. North Carolina.	11. Georgia.
14. Washington.		12. North Carolina.
15. South Carolina.		13. Alaska.
16. Virginia.		14. Washington.
17. Wyoming.		15. South Carolina.
		16. Virginia.
		17. Wyoming.

Production in first six months of 1883.—Mr. R. E. Preston, Acting Director of the Mint, in answer to a request for his estimate of the production during the first six months of the calendar year 1883, writes, under date of June 13, 1883: "The production since January 1, 1883, has continued at about the same rate as in 1882. In some States and Territories there has been a slight increase, and in others a trifling decrease; but the average rate can be said to have been maintained." The opinion of the mint authorities may be accepted as being the most reliable guide in the absence of actual statistics for the first half of 1883, which of course have not yet been collected. The following statement shows the quantities as well as the values of the product of 1882, and also the corresponding estimated amounts for the first half of 1883; the weights of metals being computed from the values quoted, on the American standard of $20.671834 per troy ounce gold, and $1.2929 per troy ounce silver:

Quantities and values of the precious-metal product, 1882 *and first six months of* 1883.

	Product in calendar year 1882.		Product in first six months of 1883.	
	Troy ounces.	Coining value.	Troy ounces.	Coining value.
Gold	1,572,186	$32,500,000	786,093	$16,250,000
Silver	36,197,695	46,800,000	18,098,847	23,400,000
Total ..	....	79,300,000	....	39,650,000

Mr. Valentine's statistics for 1882.—Mr. J. J. Valentine, vice-president and general superintendent of Wells, Fargo & Co., a corporation which handles the greater part of the bullion product of the Far West, presents the following estimates of the production in 1882. It is hardly necessary to allude to the superior sources of information possessed by Mr. Valentine, nor to the painstaking care and public spirit with which he has conducted this investigation during a long series of years. The most serious discrepancies between Mr. Valentine's results and those reached by the Director of the Mint are in the relative quantities of gold and silver; which may be accounted for in the main by the fact that a large part of the doré bullion, containing a considerable proportion of gold, is registered as "silver bullion." There is also some indefiniteness regarding the precise amount of the precious metals which reach the markets through other channels than those of the express companies; and the frequent reshipments of bullion from central distributing points give rise to similar uncertainties and sometimes to possible duplications. The table contains Mr. Valentine's estimates, by States and Territories, for the country lying west of the Missouri river, and also including the partial products of British Columbia, and of the west coast of Mexico. In this exhibit the value of the lead and copper is not segregated from that of the precious metals; the figures for which, according to Mr. Valentine, are $30,193,355 gold, $50,155,288 silver, and $80,348,643 total; together with copper $4,055,037, and lead $8,008,155.

Bullion product of the States and Territories west of the Missouri river in 1882, including value of base bullion (lead and copper), and also including the partial products of British Columbia and the west coast of Mexico.

[Estimated by Mr. J. J. Valentine.]

State or Territory.	Gold dust and bullion by express.	Gold dust and bullion by other conveyances.	Silver bullion by express.	Ores and base bullion by freight.	Total.
California	$14, 733, 643	$736, 682	$509, 342	$352, 831	$16, 332, 498
Nevada	752, 506		6, 588, 023	3, 022, 847	10, 363, 376
Oregon	431, 024	215, 512			646, 536
Washington	93, 892	46, 946			140, 838
Alaska		240, 000			240, 000
Idaho	1, 091, 208	191, 568	882, 890	1, 160, 072	3, 325, 738
Montana	2, 150, 000	215, 000	4, 065, 000	1, 574, 000	8, 004, 000
Utah	76, 954	6, 201	3, 139, 020	4, 921, 000	8, 143, 175
Colorado	2, 536, 500		4, 803, 925	18, 592, 840	25, 933, 265
New Mexico	43, 728	21, 864	919, 047	2, 682, 493	3, 667, 132
Texas			257, 597		257, 597
Arizona	386, 517	100, 000	5, 631, 083	3, 180, 667	9, 298, 267
Dakota	2, 595, 570	259, 557			2, 855, 127
Mexico (west coast)	510, 192		1, 710, 249	312, 000	2, 532, 441
British Columbia	537, 476	134, 369			671, 845
Total	25, 939, 210	2, 167, 699	28, 506, 176	35, 798, 750	92, 411, 835

The gross yield for 1882 shown above, segregated, is approximately as follows:

Gold, 32.67 per cent	$30, 193, 355
Silver, 54.27 per cent	50, 155, 288
Copper, 4.39 per cent	4, 055, 037
Lead, 8.67 per cent	8, 008, 155
	92, 411, 835

Alluding to these figures, Mr. Valentine says: "California shows a decrease in gold of $1,696,351. Nevada shows a total falling off of $1,484,188; the yield from the Comstock being $1,333,018 as against $1,726,162 in 1881, a decrease of $393,144. The product of the Eureka district is $3,176,656 as against $4,127,265 in 1881, a decrease of $953,609. Utah, Colorado, New Mexico, and Arizona each show a notable increase on the products of last year. The increase of transportation facilities for carrying bullion, pig metal, ores, etc., has increased the difficulty of verifying the reports of products from several important localities, and the general tendency is to exaggeration when the actual values are not obtainable from authentic sources, but the aggregate result as shown we think may be relied on with reasonable confidence."

Mr. Valentine's statistics for thirteen years.—The value of the gold and silver production of the States and Territories west of the Missouri river during the past thirteen years, as estimated by Mr. Valentine, is shown in the following table, from which the production of British Columbia and the west coast of Mexico, and the values of the lead and copper, have been excluded:

Mr. Valentine's estimates of the production of gold and silver in the States and Territories west of the Missouri river from 1870 *to* 1882, *inclusive.*

Years.	Gold.	Silver.	Total.
1870	33, 750, 000	17, 320, 000	51, 070, 000
1871	34, 398, 000	19, 286, 000	53, 684, 000
1872	38, 177, 395	19, 924, 429	58, 101. 824
1873	39, 206, 558	27, 483, 302	66, 689, 860
1874	38, 466, 488	29, 699, 122	68, 165, 610
1875	39, 968, 194	31, 635, 239	71, 603, 433
1876	42, 886, 935	39. 292, 924	82, 179, 859
1877	44, 880, 223	45, 846, 109	90, 726, 332
1878	37, 576, 030	37, 248, 137	74, 824, 167
1879	31, 420, 262	37, 032, 857	68, 453, 119
1880	32, 559, 067	38, 033, 055	70, 592, 122
1881	30, 653, 959	42, 987, 613	73, 641, 572
1882	29, 011, 318	48, 133, 039	77, 144, 357

The census statistics.—The results of the census investigation for the year ending May 31, 1880, as compiled by the writer under the direction of the Hon. Clarence King, Special Agent of the Census, are shown in the following tables:

Production of gold and silver in the United States during the census year ending May 31, 1880, segregated according to class of mines.

States and Territories.	Deep mines.					Placer mines.					All mines.				
	Gold.		Silver.		Total.	Gold.		Silver. (a)		Total.	Gold.		Silver.		Total.
	Ounces.	Dollars.	Ounces.	Dollars.	Dollars.	Ounces.	Dollars.	Ozs.	Dolls.	Dollars.	Ounces.	Dollars.	Ounces.	Dollars.	Dollars.
Alabama	62. 9	1, 301	...	...	1, 301	...	...	...	...	...	62. 9	1, 301	...	...	1, 301
Alaska	...	...	...	...	...	287. 9	5, 951	b39. 4	b51	6, 002	287. 9	5, 951	39. 4	51	6, 002
Arizona	b8, 802. 6	b181, 966	b1, 798, 722	b2, 325, 568	b2, 507, 534	b1, 451. 2	b29, 999	198. 8	b257	b30, 256	b10, 253. 8	b211, 965	b1, 798, 920. 8	b2, 325, 825	b2, 537, 790
California	414, 571. 7	8, 569, 959	837, 354	1, 082, 616	9, 652, 575	415, 105. 0	8, 580, 982	52, 804. 2	68, 271	8, 649, 253	829, 676. 7	17, 150, 941	890, 158. 2	1, 150, 887	18, 301, 828
Colorado	125, 685. 7	2, 598, 153	12, 799, 067	16, 547, 913	19, 146, 066	4, 921. 9	101, 745	1, 052. 8	1, 361	103, 106	130, 607. 6	2, 699, 898	12, 800, 119. 8	16, 549, 274	19, 249, 172
Dakota	157, 459. 8	3, 254, 984	54, 577	70, 563	3, 325, 547	2. 460. 3	50, 859	193. 1	250	51, 109	159, 920. 1	3, 305, 843	54, 770. 1	70, 813	3, 376, 656
Georgia	685. 3	14, 166	...	...	14, 166	3, 234. 5	66, 863	256. 6	332	67, 195	3, 919. 8	81, 029	256. 6	332	81, 361
Idaho	29, 025. 4	600, 009	347, 676	449, 510	1, 049, 519	42, 552. 8	879, 644	11, 633. 1	15, 040	894, 684	71, 578. 2	1, 479, 653	359, 309. 1	464, 550	1, 944, 203
Maine	145. 1	2, 999	5, 569	7, 200	10, 199	...	...	...	...	...	145. 1	2, 999	5, 569. 0	7, 200	10, 199
Michigan	...	...	b20, 000	b25, 858	b25, 858			...	...	...	...	...	b20, 000. 0	b25, 858	b25, 858
Montana	31, 098. 4	642, 861	2, 240, 597	2, 896, 869	3, 539, 730	56, 255. 6	1, 162, 906	6, 341. 4	8, 199	1, 171, 105	87, 354. 0	1, 805, 767	2, 246, 938. 4	2, 905, 068	4, 710, 835
Nevada	234, 050. 0	4, 838, 243	9, 614, 230	12, 430, 239	17, 268, 482	b2, 418. 7	b49, 999	b331. 3	b428	b50, 427	236, 468. 7	4, 888, 242	9, 614, 561. 3	12, 430, 667	17, 318, 909
New Hampshire	532. 1	10, 999	12, 375	16, 000	26, 999	...	...	...	...	...	532. 1	10, 999	12, 375. 0	16, 000	26, 999
New Mexico	2, 387. 5	49, 354	303, 455	392, 337	441, 691	...	...	...	...	...	2, 387. 5	49, 354	303, 455. 0	392, 337	441, 691
North Carolina	5, 527. 7	114, 267	77	100	114, 367	b226. 7	b4, 686	b31. 0	b40	b4, 726	5, 754. 4	118, 953	108. 0	140	119, 093
Oregon	8, 289. 8	171, 365	15, 165	19, 607	190, 972	44, 811. 5	926, 336	6, 331. 2	8, 186	934, 522	53, 101. 3	1, 097, 701	21, 496. 2	27, 793	1, 125, 494
South Carolina	314. 4	6, 499	...	...	6, 499	316. 4	b6, 541	b43. 3	b56	b6, 597	630. 8	13, 040	43. 3	56	13, 096
Tennessee	96. 7	1, 998	...	...	1, 998	...	...	...	...	...	96. 7	1, 998	...	...	1, 998
Utah	13, 138. 0	271, 587	3, 668, 433	4, 742, 916	5, 014, 503	967. 5	b20, 000	b132. 5	b171	b20, 171	14, 105. 5	291, 587	3, 668, 565. 5	4, 743, 087	5, 034, 674
Virginia	450. 9	9, 321	...	...	9, 321	...	...	...	...	...	450. 9	9, 321	...	...	9, 321
Washington	812. 7	16, 800	...	...	16, 800	5, 756. 6	b119, 000	b788. 6	b1, 019	b120, 019	6, 569. 3	135, 800	788. 6	1, 019	136, 819
Wyoming	837. 9	17, 321	...	...	17, 321	...	...	...	...	...	837. 9	17, 321	...	...	17, 321
Total	1, 033, 974. 6	21, 374, 152	31, 717, 297	41, 007, 296	62, 381, 448	580, 766. 6	12, 005, 511	80, 177. 3	103, 661	12, 109, 172	1, 614, 741. 2	33, 379, 663	31, 797, 474. 3	41, 110, 957	74, 490, 620

a The silver contained in placer gold, amounting to about $100,000 annually, is usually disregarded by statisticians.
b Estimated.

Production of gold and silver in the United States during the census year ending May 31, 1880, segregated according to broad geographical divisions.

PACIFIC DIVISION.

States and Territories.	Product.		
	Gold.	Silver.	Total.
Alaska	$5, 951	$51	$6, 002
Arizona	211, 965	2, 325, 825	2, 537, 790
California	17, 150, 941	1, 150, 887	18, 301, 828
Idaho	1, 479, 653	464, 550	1, 944, 203
Nevada	4, 888, 242	12, 430, 667	17, 318, 909
Oregon	1, 097, 701	27, 793	1, 125, 494
Utah	291, 587	4, 743, 087	5, 034, 674
Washington	135, 800	1, 019	136, 819
Total	25, 261, 840	21, 143, 879	46, 405, 719

DIVISION OF THE ROCKY MOUNTAINS.

Colorado	$2, 699, 898	$16, 549, 274	$19, 249, 172
Dakota	3, 305, 843	70, 813	3, 376, 656
Montana	1, 805, 767	2, 905, 068	4, 710, 835
New Mexico	49, 354	392, 337	441, 691
Wyoming	17, 321		17, 321
Total	7, 878, 183	19, 917, 492	27, 795, 675

EASTERN DIVISION.

Alabama	$1, 301		$1, 301
Georgia	81, 029	$332	81, 361
Maine	2, 999	7, 200	10, 199
Michigan		25, 858	25, 858
New Hampshire	10, 999	16, 000	26, 999
North Carolina	118, 953	140	119, 093
South Carolina	13, 040	56	13, 096
Tennessee	1, 998		1, 998
Virginia	9, 321		9, 321
Total	239, 640	49, 586	289, 226

SUMMARY.

Pacific division	$25, 261, 840	$21, 143, 879	$46, 405, 719
Division of the Rocky mountains	7, 878, 183	19, 917, 492	27, 795, 675
Eastern division	239, 640	49, 586	289, 226
Total	33, 379, 663	41, 110, 957	74, 490, 620

Additional production, not accounted for in the two preceding tables.

	Gold.	Silver.	Total.
Bullion product shown in preceding tables	$33, 379, 663	$41, 110, 957	$74, 490, 620
Estimated value of specimens hoarded	150, 000	50, 000	200, 000
Estimated value of gold quartz made into jewelry and souvenirs	50, 000		50, 000
Estimated value of gold dust lost in handling as currency	10, 000		10, 000
Estimated loss in melting and assaying, assay grains, etc	20, 000	10, 000	30, 000
Total	33, 609, 663	41, 170, 957	74, 780, 620

Average product of gold and silver in the census year, per square mile and per capita.

States and Territories.	Per square mile.			Per capita.		
	Gold.	Silver.	Total.	Gold.	Silver.	Total.
Alabama	$0.02	....	$0.02	$0.001	....	$0.001
Alaska	0.01	....	0.01	0.20	....	0.20
Arizona	1.87	$20.58	22.45	5.24	$57.51	62.75
California	108.30	7.27	115.57	19.83	1.33	21.16
Colorado	25.98	159.24	185.22	13.89	85.16	99.05
Dakota	22.17	0.48	22.65	24.46	0.52	24.98
Georgia	1.36	0.01	1.37	0.05	0.0002	0.05
Idaho	17.45	5.48	22.93	45.37	14.25	59.62
Maine	0.09	0.22	0.31	0.005	0.011	0.016
Michigan	....	0.44	0.44	....	0.02	0.02
Montana	12.36	19.89	32.25	46.11	74.19	120.30
Nevada	44.16	112.29	156.45	78.51	199.63	278.14
New Hampshire	1.18	1.72	2.90	0.03	0.05	0.08
New Mexico	0.40	3.20	3.60	0.41	3.28	3.69
North Carolina	2.28	0.003	2.28	0.08	0.0001	0.08
Oregon	11.43	0.29	11.72	6.28	0.16	6.44
South Carolina	0.43	....	0.43	0.01	....	0.01
Tennessee	0.05	....	0.05	0.001	....	0.001
Utah	3.43	55.82	59.25	2.03	32.94	34.97
Virginia	0.22	....	0.22	0.006	....	0.006
Washington	1.96	0.015	1.98	1.81	....	1.81
Wyoming	0.18	....	0.18	0.83	....	0.83
United States (including Alaska)	9.31	11.44	20.75	0.66	0.82	1.48
United States (not including Alaska)	11.03	13.59	24.62	0.66	0.82	1.48
United States (including only the States and Territories producing gold and silver, with Alaska)	14.68	18.02	32.70	2.60	3.20	5.80
United States (including only the States and Territories producing gold and silver, and not including Alaska)	19.44	23.94	43.38	2.61	3.21	5.82
Average for Colorado, California, Nevada, Utah, Montana, Dakota, Arizona, and Idaho	33.47	42.74	76.21	21.04	26.87	47.91

Rank of the States and Territories in the production of gold and silver in the census year.

Gold.	Silver.	Total.
1. California.	1. Colorado.	1. Colorado.
2. Nevada.	2. Nevada.	2. California.
3. Dakota.	3. Utah.	3. Nevada.
4. Colorado.	4. Montana.	4. Utah.
5. Montana.	5. Arizona.	5. Montana.
6. Idaho.	6. California.	6. Dakota.
7. Oregon.	7. Idaho.	7. Arizona.
8. Utah.	8. New Mexico.	8. Idaho.
9. Arizona.	9. Dakota.	9. Oregon.
10. Washington.	10. Michigan.	10. New Mexico.
11. North Carolina.	11. Oregon.	11. Washington.
12. Georgia.	12. New Hampshire.	12. North Carolina.
13. New Mexico.	13. Maine.	13. Georgia.
14. Wyoming.		14. New Hampshire.
15. South Carolina.		15. Michigan.
16. New Hampshire.		16. Wyoming.
17. Virginia.		17. South Carolina.
18. Alaska.		18. Maine.
19. Maine.		19. Virginia.
20. Tennessee.		20. Alaska.
21. Alabama.		21. Tennessee.
		22. Alabama.

Rank of the States and Territories in production of gold and silver, per square mile, in the census year.

Gold.	Silver.	Total.
1. California.	1. Colorado.	1. Colorado.
2. Nevada.	2. Nevada.	2. Nevada.
3. Colorado.	3. Utah.	3. California.
4. Dakota.	4. Arizona.	4. Utah.
5. Idaho.	5. Montana.	5. Montana.
6. Montana.	6. California.	6. Idaho.
7. Oregon.	7. Idaho.	7. Dakota.
8. Utah.	8. New Mexico.	8. Arizona.
9. North Carolina.	9. Dakota.	9. Oregon.
10. Washington.	10 Michigan.	10. New Mexico.
11. Arizona.	11. Maine.	11. New Hampshire.
12. Georgia.	12. Oregon.	12. North Carolina.
13. New Hampshire.	13. North Carolina.	13. Washington.
14. South Carolina.		14. Georgia.
15. New Mexico.		15. Michigan.
16. Virginia.		16. SouthCarolina
17. Wyoming.		17. Maine.
18. Maine.		18. Virginia.
19. Tennessee.		19. Wyoming.
20. Alabama.		20. Tennessee.
21. Alaska.		21. Alabama.
		22. Alaska.

Rank of the States and Territories in production of gold and silver, per capita, in the census year.

Gold.	Silver.	Total.
1. Nevada.	1. Nevada.	1. Nevada.
2. Montana.	2. Colorado.	2. Montana.
3. Idaho.	3. Montana.	3. Colorado.
4. Dakota.	4. Arizona.	4. Arizona.
5. California.	5. Utah.	5. Idaho.
6. Colorado.	6. Idaho.	6. Utah.
7. Oregon.	7. New Mexico.	7. Dakota.
8. Arizona.	8. California.	8. California.
9. Utah.	9. Dakota.	9. Oregon.
10. Washington.	10. Oregon.	10. New Mexico.
11. Wyoming.	11. New Hampshire.	11. Washington.
12. New Mexico.	12. Michigan.	12. Wyoming.
13. Alaska.	13. Maine.	13. Alaska.
14. North Carolina.		14. North Carolina.
15. Georgia.		15. New Hampshire.
16. New Hampshire.		16. Georgia.
17. South Carolina.		17. Michigan.
18. Virginia.		18. Maine.
19. Maine.		19. South Carolina.
20. Tennessee.		20. Tennessee.
21. Alabama.		21. Virginia.
		22. Alabama.

Total output to date.—It may seem strange to say that one of the most perplexing statistical questions is to state the total gold and silver production of the United States from the beginning of mining operations to the present. The difficulty lies not so much in the dearth of material as in the embarrassing abundance of statistics, actual and estimated, made by different persons at different times; covering overlapping periods and occasionally showing gaps; including and omitting the product of the Southern States; sometimes including the partial output of the west coast of North America beyond the limits of the United States; estimated on the basis of the calendar year or of the fiscal year; revised, changed, and corrected, until the whole subject seems lost in confusion. And yet there is sufficient reliable evidence upon which to reconstruct an estimate believed to have a probable error not exceeding 5 per cent.

First, we have Prof. J. D. Whitney's study of the gold output of the Southern States from 1804 to 1850, inclusive, showing the following results:

Professor Whitney's estimate of the gold production of the Southern States from 1804 *to* 1850, *inclusive, by periods of calendar years.*

1804–'23	$47,000
1824–'30	715,000
1831–'40	6,695,000
1841–'50	7,715,300
Total	15,172,300

Professor Whitney's estimate of the production, by States, during the same time.

Georgia	$6,048,900
North Carolina	6,842,900
South Carolina	818,100
Tennessee and Alabama	263,800
Virginia	1,198,600
Total	15,172,300

This carries the history of production up to, and two and a half years later than, the discovery of gold in California. In the subsequent summary a deduction has been made from Professor Whitney's total, in order to adjust these statistics to that most important date. From the $7,715,300 estimated for the decade 1841 to 1850 one-quarter has been subtracted; thus reducing the estimate for the total production of the Southern States up to the turning point in the output of the United States to $13,243,475. After the year 1850 the small production from this region has been usually disregarded altogether, until quite recently, when it again appears as an item in mining statistics. It is highly probable that during this intermediate period the total production of the country has been overestimated to an extent at least equal to the amount produced in the South; and, indeed, where the estimates for California during the time of its greatest output vary as much as

$5,000,000 or even $10,000,000 for a single given year, it would be a useless over-refinement to attempt now to correct the accepted figures by adding the insignificant amounts produced at that time in the Southern States.

Prof. W. P. Blake has carried the figures through the second natural time division (that is, the period during which California and Oregon may be considered to have been practically the sole producers) and up to the close of 1863, or somewhat beyond the proper limits of this epoch. The Comstock lode was discovered in 1859, began production in 1860, and by 1863 had made its influence largely felt. In 1863, prospectors were scouring Nevada, Idaho, and Washington Territory; and a considerable production began to come from other sources than California, Oregon, and the Comstock lode. Professor Blake's estimate of the actual gold exports from San Francisco, which has formed the basis for the figures now accepted, is as follows:

Declared exports of gold from San Francisco from 1848 *to* 1863, *inclusive, with estimates of the actual movement, by Prof. W. P. Blake.*

Year.	Declared gold export.	Estimated actual gold export.
1848		$10,000,000
1849	$66,000,000	40,000,000
1850		50,000,000
1851 up to May 1	11,497,000	55,000,000
1851	34,960,895	
1852	45,779,000	60,000,000
1853	54,965,000	65,000,000
1854	52,045,633	60,000,000
1855	45,161,731	55,000,000
1856	50,697,434	55,000,000
1857	48,976,692	55,000,000
1858	47,548,026	50,000,000
1859	47,640,462	50,000,000
1860	42,325,916	42,325,916
1861	40,676,758	39,176,758
1862	42,561,761	36,061,761
1863	46,071,920	33,071,920
Total	676,908,228	755,636,355

These figures do not show any silver production; in fact, silver mining in the United States may be said to have only begun in 1860. The value of the silver contents of the gold, however, has been added in the compilations which are now generally accepted; and though the computation has been made in a very rough way, the value of the silver was so small as compared with that of the gold that a revision seems hardly necessary.

Various authorities have been quoted for the period up to the time when a United States mining commissioner was appointed, and when Mr. Valentine began the publication of his estimates based upon the express returns. Mr. J. Ross Browne, in his reports as commissioner (1866 and 1867), gave the then accepted figures, which, however, were undoubtedly overestimated, and they have since been materially reduced. Dr. R. W. Raymond, mining commissioner from 1868 to 1875 inclusive, made a very careful study of the subject, and his results, as published in his series of admirable reports, are generally accepted, though in a few cases overestimates, which there was no means of checking, could not be eliminated. The following table gives Dr. Raymond's estimates:

Dr. R. W. Raymond's estimate of the gold and silver product from 1868 *to* 1875 *inclusive (calendar years).*

States and Territories.	1868.	1869.	1870.	1871.
California	$22, 000, 000	$22, 500, 000	$25, 000, 000	$20, 000, 000
Nevada	14, 000, 000	14, 000, 000	16, 000, 000	22, 500, 000
Montana	15, 000, 000	9, 000, 000	9, 100, 000	8, 050, 000
Idaho	7, 000, 000	7, 000, 000	6, 000, 000	5, 000, 000
Oregon and Washington	4, 000, 000	3, 000, 000	3, 000, 000	2, 500, 000
Arizona	500, 000	1, 000, 000	800, 000	800, 000
New Mexico	250, 000	500, 000	500, 000	500, 000
Colorado and Wyoming	3, 250, 000	4, 000, 000	3, 775, 000	4, 763, 000
Utah	....	....	1, 300, 000	2, 300, 000
From other parts	1, 000, 000	500, 000	525, 000	250, 000
Total	67, 000, 000	61, 500, 000	66, 000, 000	66, 663, 000

States and Territories.	1872.	1873.	1874.	1875.
California	$19, 049, 098	$18, 025, 722	$20, 300, 531	$17, 753, 151
Nevada	25, 548, 801	35, 254, 507	35, 452, 233	40, 478, 369
Montana	6, 068, 339	5, 187, 047	3, 844, 722	3, 573, 600
Idaho	2, 695, 870	2, 500, 000	1, 880, 004	1, 750, 000
Oregon and Washington	2, 000, 000	1, 585, 784	763, 605	1, 246, 978
Arizona	625, 000	500, 000	487, 000	750, 000
New Mexico	500, 000	500, 000	500, 000	325, 000
Colorado and Wyoming	4, 761, 465	4, 070, 263	5, 188, 510	5, 302, 810
Utah	2, 445, 284	3, 778, 200	3, 911, 601	3, 137, 688
From other parts	250, 000	250, 000	100, 000	500, 000
Total	63, 943, 857	71, 651, 523	72, 428, 206	74, 817, 596

Dr. Adolf Soetbeer (in Petermann's *Mittheilungen*, Ergänzungsheft No. 57) published conclusions reached by him as to the bullion product of the United States up to the close of 1875, based upon a study and comparison of the literature of the subject. In the following table Dr. Soetbeer's results are shown, kilograms being converted into troy ounces and German marks into United States money. The production is given by periods of years.

Dr. Soetbeer's estimate of the production of the precious metals in the United States to the close of 1875.

Periods.	Number of years.	Gold product.			Silver product.		
		Total.	Yearly average.	Value.	Total.	Yearly average.	Value.
		Ounces.	*Ounces.*		*Ounces.*	*Ounces.*	
1804–'20	17	1, 929	113	$39, 876	....	....	....
1821–'30	10	35, 368	3, 537	731, 121	....	....	....
1831–'40	10	273, 295	27, 329	5, 649, 509	....	....	....
1841–'50	10	5, 658, 825	565, 883	116, 978, 291	....	....	....
1851–'55	5	14, 275, 673	2, 855, 135	295, 104, 343	1, 334, 325	266, 865	$1, 725, 149
1856–'60	5	12, 394, 757	2, 478, 951	256, 222, 359	996, 725	199, 345	1, 288, 666
1861–'65	5	10, 722, 832	2, 144, 566	221, 660, 603	27, 972, 602	5, 594, 520	36, 165, 777
1866–'70	5	12, 217, 918	2, 443, 584	252, 566, 773	48, 389, 387	9, 677, 877	62, 562, 638
1871–'75	5	9, 565, 344	1, 913, 069	197, 733, 203	90, 798, 425	18, 159, 685	117, 393, 284
Total	72	65, 145, 941	12, 432, 167	1, 346, 678, 078	169, 491, 464	33, 898, 292	219, 135, 514

The figures which, partly by repeated official publication, are now most generally credited are shown in the following table, which includes the estimates for the fiscal years from 1848 to 1880 inclusive. This table is made the basis of the second and most important item in the recapitulation, with the exception of the year 1880, for which the census figures are substituted.

Estimate of the production of gold and silver from 1848 *to* 1880 *inclusive, by fiscal years, as generally accepted in official reports.*

Years.	Gold.	Silver.	Total gold and silver.
1848	$10, 000, 000	....	$10, 000, 000
1849	40, 000, 000	$50, 000	40, 050, 000
1850	50, 000, 000	50, 000	50, 050, 000
1851	55, 000, 000	50, 000	55, 050, 000
1852	60, 000, 000	50, 000	60, 050, 000
1853	65, 000, 000	50, 000	65, 050, 000
1854	60, 000, 000	50, 000	60, 050, 000
1855	55, 000, 000	50, 000	55, 050, 000
1856	55, 000, 000	50, 000	55, 050, 000
1857	55, 000, 000	50, 000	55, 050, 000
1858	50, 000, 000	50, 000	50, 050, 000
1859	50, 000, 000	100, 000	50, 100, 000
1860	46, 000, 000	150, 000	46, 150, 000
1861	43, 000, 000	2, 000, 000	45, 000, 000
1862	39, 200, 000	4, 500, 000	43, 700, 000
1863	40, 000, 000	8, 500, 000	48, 500, 000
1864	46, 000, 000	11, 000, 000	57, 000, 000
1865	53, 225, 000	11, 250, 000	64, 475, 000
1866	53, 500, 000	10, 000, 000	63, 500, 000
1867	51, 725, 000	13, 500, 000	65, 225, 000
1868	48, 000, 000	12, 000, 000	60, 000, 000
1869	49, 500, 000	12, 000, 000	61, 500, 000
1870	50, 000, 000	16, 000, 000	66, 000, 000
1871	43, 000, 000	23, 000, 000	66, 000, 000
1872	36, 000, 000	28, 750, 000	64, 750, 000
1873	36, 000, 000	35, 750, 000	71, 750, 000
1874	33, 490, 902	37, 324, 594	70, 815, 496
1875	33, 467, 856	31, 727, 560	65, 195, 416
1876	39, 929, 166	38, 783, 016	78, 712, 182
1877	46, 897, 390	39, 793, 573	86, 690, 963
1878	51, 206, 360	45, 281, 385	96, 487, 745
1879	38, 899, 858	40, 812, 132	79, 711, 990
1880	36, 000, 000	37, 700, 000	73, 700, 000
Total	1, 520, 041, 532	460, 422, 260	1, 980, 463, 792

Statistics of the production are now, as they formerly were and always should have been, prepared for calendar years. For the six months from July 1, 1880, to December 31, 1880, half of the product of the fiscal year ending June 30, 1881, as reported by the Director of the Mint, has been assumed. For the calendar years 1881 and 1882 the Mint figures are again quoted. For the first six months of 1883 the estimate is made by assuming, on the authority of Mr. Preston, the rate of production in 1882 to have been maintained during the first half of 1883. It is not probable that the complete statistics for 1883 will show this estimate to be very seriously in error.

Summing up the material thus briefly sketched, the following results are reached:

Production of gold and silver in the United States to June 30, 1883.

Periods.	Gold.	Silver.	Total.
Output of the Southern States up to the discovery of gold in California in 1848 (based on estimates of Prof. J. D. Whitney)	$13,243,475	....	$13,243,475
Product from 1848 to 1879 inclusive, by fiscal years (as published by the Directors of the Mint)	1,484,041,532	$422,722,260	1,906,763,792
Fiscal year ending June 30, 1880 (census figures, covering a period one month earlier, assumed)	33,379,663	41,110,957	74,490,620
July 1, 1880, to December 31, 1880 (estimated on the basis of half the product of the fiscal year 1881, as reported by Hon. Horatio C. Burchard, Director of the Mint)	18,250,000	21,050,000	39,300,000
Calendar years 1881 and 1882 (as reported by Hon. Horatio C. Burchard, Director of the Mint)	67,200,000	89,800,000	157,000,000
Total product of the United States to close of 1882	1,616,114,670	574,683,217	2,190,797,887
Estimated product in first six months of 1883	16,250,000	23,400,000	39,650,000
Total product of the United States to June 30, 1883	1,632,364,670	598,083,217	2,230,447,887

Up to June 30, 1883, the aggregate production of gold in the United States may be stated at $1,632,364,670, and of silver $598,083,217, making a grand total of $2,230,447,887. Reduced to the equivalent weights, the total gold output has been 78,965,572 troy ounces, or 2,707.4 avoirdupois net tons. The total for silver represents 462,590,469 troy ounces, or 15,860 tons. It will perhaps convey little meaning to say that the grand total is in excess of the national debt; but a better conception of the vastness of the amount may be had by considering that all the gold produced in the country to the present time, if brought together, would suffice to load 271 ordinary freight cars; the silver, supposed in the same way to be collected together as fine bullion, would require 1,586 cars for its transportation. The gold would tax the carrying capacity of a large ocean steamship; while the silver would suffice to form cargoes for a small fleet.

Present status of the industry.—From the foregoing figures the general deduction may be drawn that the annual precious-metal output of the United States during recent years may be stated at between $70,000,000 and $80,000,000, coining value, and that the fluctuations in the proportional amounts of gold and silver are greater than those of the total product. It is also safe to assume that this rate of production will be maintained for some time to come, and that the probability of a slight increase is greater than that of a decline. Experience has shown that as old districts become exhausted, or fall off in their rate of production, new localities are developed which fully take their place, and that the general result is therefore nearly uniform as compared year by year. By the time the country has been thoroughly explored for gold and silver deposits, a time which may be considered as indefinitely remote, the facilities for mining and working the ores will undoubtedly be such as to enable systematic and permanent development to be maintained in places and with ores which at present could not be profitable. The production of the precious metals appears to be the sole industry which is at all independent of changes in the relation between supply and demand, unless, indeed, the influence exerted by fluctuations in the market value of silver may be held to affect the production of that metal. With all other natural products the amount produced is necessarily limited by the amount consumed, whether in this or in foreign countries; notable examples of which effect may be seen in the case of quicksilver, which, at a certain demand and consequent market value, may be mined profitably, while if the price declines only a few cents per pound a number of mines are at once thrown out of operation, and the production falls off until an equilibrium is reached at which resumption of work is profitable. In the case of the great iron industry, in which, as is so often seen, overproduction brings its own remedy, and as is found to be true in other almost innumerable instances which might be cited, it would require very violent changes in the purchasing power of the precious metals to materially affect the rate of their production. It might even be said that the latter is apt to increase in cumulative ratio, for unusual success in any locality at once attracts attention and stimulates prospecting for new deposits and their exploitation, the ultimate result being a sympathetic increase throughout the mining region. But while natural causes are thus seen to influence the rate of production only slightly, artificial restraints, such as the crusade against hydraulic mining in California or the adoption of unwise laws, certainly make their influence felt, though for the country at large the effect is relatively small. In like manner the reaction from undue speculation has a slight depressing result, which shows itself in apparently returning cycles. Sudden changes in the normal supply of either of the precious metals bring about from time to time corresponding changes in the coinage laws of nations; the reflex action upon production, however, is hardly more than perceptible.

The production of gold and silver, like that of other commodities, is of course not one of clear profit. Indeed, a saying that it costs one dollar in coin to produce one dollar in bullion has gained more or less credit; and though this opinion has been abundantly shown to be unfounded, and while also any attempt to estimate the profit gained to the country by the mining of the precious metals is mere guesswork, it is still quite probable that $500,000,000 of the gross total has been net profit.

One-third of all the gold and one-half of all the silver annually produced in the world are supplied by the mines of the United States.

PETROLEUM.

By S. H. Stowell.

Definition of petroleum.—Petroleum is an inflammable, oily liquid, of a bituminous character, which exudes from the earth in certain parts of the world. Its varieties, of which there are many, form a series of hydrocarbons, beginning with asphaltum and ending with naphtha, the variety chiefly referred to in this article being of a dark greenish-brown color and of a somewhat offensive odor.

History of petroleum.—Petroleum has been known and used in Europe and Asia for centuries, being chiefly obtained from the surface of the water in springs and also from pits dug to collect it. The Chinese are also reported as having for hundreds of years drilled deep wells in search of it. It did not attract much attention, however, and its use was not extensive.

Its existence in America.—There is reason to believe that the prehistoric inhabitants of America were aware of the presence of petroleum in this country, and also followed the plan of digging pits to collect it, many of which, lined with roughly hewn wood, are yet to be found in the Pennsylvania oil regions. The many oil springs in western Pennsylvania and New York were also no doubt known to them, as were they to the Indians, who made use of the oil for various purposes. The French commander of Fort Duquesne, writing in 1750, regarding an expedition north of that post, speaks of the setting on fire of the oil on the surface of a small creek by the Indians as a part of a religious ceremony. At a considerably later period than this, the country becoming more settled, petroleum was collected from the surface of Oil creek, the Allegheny river, and other streams, and was sold somewhat extensively through the country under the name of "Seneca oil," and used for medicinal purposes. The oil thus became very well known, and in 1833 Prof. B. Silliman, sr., was led to make an investigation of a large oil spring in Allegany county, New York, a report of which was published at the time. In this he discusses the distribution, character, and probable origin of petroleum, in regard to the latter point advancing the theory that there was a connection between the petroleum and the bituminous Coal Measures of Pennsylvania. About the same time attention was attracted to the discovery of petroleum in the Muskingum and Kanawha valleys by parties sinking wells to obtain brine for making salt. Dr. S. P. Hildreth, of Marietta, Ohio, writing in 1833, describes several of these wells and the manner and character of their production very minutely, from which description it appears that the wells were bored to about the customary depth of oil wells at present, and produced oil in much the same manner. Further, the oil was conceded to be valuable and what was obtained was utilized; yet no effort was made to bore wells especially to obtain oil, nor was any endeavor made to increase the production. The oil seems to have been viewed chiefly as an unfortunate accident which spoiled good salt wells. Shortly previous to this a flowing well was struck in Kentucky, but the oil was suffered to run to waste.

However, the introduction of oil made from coal and shale paved the way to a recognition of the great value of the petroleum deposits. For many years experiments in making coal and shale oil had been tried, and about 1840 considerable quantities were made in France; but the manufacture did not take rank as an industry until 1850. In this year oil was largely made in Glasgow, Scotland, from coal, and the industry extended rapidly in Scotland and also on the continent. Attention was attracted to the process in the United States; our Coal Measures and oil-bearing shales were found to offer great facilities for the manufacture of oil, and the industry soon spread throughout this country, the factories in 1859 numbering some fifty or sixty.

In 1853 a large firm, engaged in the lumber business on Oil creek, Pennsylvania, took some steps to utilize the oil from an oil spring on their property near Titusville. Some of the oil collected was sent East, and the attention of a number of parties being attracted to its similarity to coal oil, the result was the formation, in New Haven, Connecticut, of the Pennsylvania Rock Oil Company, to which company Prof. B. Silliman, jr., made his famous report on petroleum. The first intention of this company was to collect oil from the springs on their property, but through a fortunate accident the idea of drilling an artesian well for oil occurred to one of the company, and after many delays was put into effect. Col. E. L. Drake was sent out to Titusville as superintendent of the company's operations, and about the middle of August, 1859, the drill was started. The drillers averaged about 3 feet a day, making slight indications all the way down. On Saturday, August 28, at the depth of 69½ feet, work was stopped for the week and the tools were withdrawn. The next day, Sunday, the well was discovered to be full of petroleum. The pump was adjusted on Monday, and the well commenced producing at the rate of 25 barrels per day.

Great excitement ensued. Farms were bought or leased on all sides, and preparations were made for drilling wells in many places, though but little was accomplished until 1860. In 1861 the first flowing well was struck—the "Fountain" well—which produced 300 barrels per day. This upset all calculations; people were willing to believe anything regarding the industry, and great numbers rushed to the oil regions. Other flowing wells were struck, and prices fell to 20 cents a barrel, then to 15, and then to 10. One great difficulty was the scarcity of barrels; much oil went to waste, and in many cases small producers were forced to cease operations.

During the years 1860 and 1861 several hundred wells were drilled along Oil creek, from its mouth to Titusville. Probably not over one-half of these were producers, and but a small proportion were flowing wells, the remainder being small pumpers. However, during the latter part of 1861 and in 1862 the number of flowing wells was greatly increased, and the daily yield rose in the fall of the latter year to 13,000 barrels, and the total production for the year amounted to a little over 3,000,000 barrels. In 1863 the operations were greatly increased in number, and wells were drilling all along the Allegheny river for 80 miles on either side of the mouth of Oil creek, and also along the latter stream and its tributaries. During 1864 operations were still further extended, and wells were drilling and rigs building in nearly every locality in which oil is now produced. The price of oil rose throughout the year, the average rate per barrel being $9.87, and enormous sums of money were invested in oil property. During the year no very important developments were made, but the total production amounted to 22,000,000 barrels, with the price in January, 1865, at $11. In 1865 the famous United States well was struck on Pithole creek, and was soon followed by the Grant well, the two producing 2,500 barrels per day. A rush to the vicinity immediately began. Land was sold at fabulous prices, wells were begun in every direction, and Pithole City sprang up. In May, 1865, there were two houses on the ground. In August a city with a population of 14,000 was in existence. The excitement was at its height in this month, and the daily yield of the section was over 5,000 barrels. With the giving out of the United States well in November, however, the decline commenced; the population of the city rapidly decreased; buildings were deserted; and in 1866 what was left of it was swept away by an oil fire. No further important developments were made for some years. In 1869, the Oil creek field having been pretty well drilled over, the attention of some capitalists was attracted to the indications of oil near Parker's Landing, 80 miles down the Allegheny from Oil City. Wells had been drilled there before without great success, but in the year named promising developments were made, and the "lower oil field" came prominently into view. From Parker City operations extended to Saint Petersburg and Edenburg on the north and Petrolia and Millerstown on the south, and the limits of the field were pretty well defined.

From 1869 until 1875 there were no important developments in the oil trade. In the latter year wells were drilled in McKean county, Pennsylvania, and a production of 150 barrels per day was attained by the close of the year. This district continued to enlarge its output gradually, but with no very sudden advances, and in time took its position at the head of the producing regions, having, on December 31, 1872, a daily production of 34,000 barrels. In 1876 producing began in

Warren county, and in 1877 150,000 barrels were produced, the yield, however, immediately falling off and not again attaining such proportions until 1881. In 1877 the Beaver county field became worthy of consideration as an oil-producing region, and has been steadily rising in importance ever since. The next development was the Allegany county, New York, field, which commenced producing in 1880, and gradually increased its output, until in June, 1882, its daily production was 22,000 barrels. It has fallen off greatly since that time. In April, 1882, the famous "646" well was struck in Cherry Grove township, Warren county. This was the opening of the great Cherry Grove pool of flowing wells. In July seven wells were producing 4,350 barrels per day, and by the close of August the daily production had jumped to almost ten times that amount. Prices dropped from $1 to about 50 cents per barrel, and the excitement was great. The production of the district, however, fell off about as rapidly as it had risen, and in December but 2,200 barrels were being produced, with prices once more at about $1.

Producing localities.—The localities in the United States producing petroleum are in the States of Pennsylvania, New York, California, West Virginia, Ohio, and Kentucky, though the production of the last four States is very small in comparison with that of the first two. In West Virginia but little is doing. The wells which are producing are small and the production is chiefly heavy oil, fit only for lubricating. In Ohio the operations are also of comparatively minor importance, the oil here also being heavy oil. The total production of these two States during the census year which ended May 31, 1880, was reported to be 224,312 barrels, of which 219,253 barrels were produced in West Virginia and in the Washington county district in southeastern Ohio, the remainder being produced at Grafton and at Mecca, in eastern Ohio. In Kentucky, within the past few years, operations have been renewed, but not to any great extent, the production of oil in the census year having been but a little over 5,000 barrels. The third State on the list, California, is attaining some importance as a petroleum producer. The oil district extends over two counties, and is estimated as producing about 500 barrels daily on December 31, 1882, the estimate being possibly rather high. As nearly as can be ascertained, the production for the last five years has been as follows:

Production of petroleum in California.

	Barrels.
1878	15,227
1879	19,858
1880	42,399
1881	50,000
1882	70,000

The barrel is uniformly 42 gallons. The figures for 1881 and 1882 are estimated from returns made for six months of each year. The demands of the western coast at present are sufficient to consume all the oil produced, and in addition about 100,000 barrels of oil from the East.

The Pennsylvania oil region.—The chief producing localities in the United States, then, are found in the States of Pennsylvania and New York. Throughout a broad elliptical belt of country, extending from a point on the western boundary of Pennsylvania across that State in a northeasterly direction, and some distance across the southern boundary of New York, indications of oil are found. This belt is perhaps 160 miles long and 40 miles broad at the center, and comprises all localities where there are surface indications of oil. The oil-producing localities occupy but a limited position on this belt. In Beaver county, at the extreme southwestern end, are two small pools at which oil is produced. In Butler county, next in order, the small field at Baldridge comes first, then comes the large lower oil field, part in Butler and part in Clarion county. The counties then following in order are Venango, containing the large field first developed; Forest, the most recent and least developed field; Warren, containing the Tidioute, Clarendon, Sheffield, and Cherry Grove pools; McKean, the great producer; and Allegany county, New York. The following table shows the relative number of wells and productiveness of the several districts on December 31, 1882:

Condition of the petroleum districts of Pennsylvania and New York, December 31, 1882.

District.	Average daily production.	Number of producing wells.	Number drilling.	Number completed during month.	Number dry.
	Barrels.				
Allegany, N. Y.	12,000	1,300	54	65	3
McKean, Pa.	34,000	9,500	40	35	....
Warren and Forest, Pa	6,000	1,200	26	12	3
Other districts	9,210	6,000	18	10	6
Total	61,210	18,000	138	122	12

This table clearly indicates the prominence gained by the newer districts and the decadence of the old. While the wells of the Titusville and lower districts produce a larger total amount of oil per day than the Warren and Forest county wells, it will be observed that the wells of the former districts are more numerous, and that their average daily production is only 1½ barrels, while that of the wells in the latter counties is 5 barrels. The proportion of wells completed during the month and found to be dry is also large in the other districts as compared with those named. A comparison of California's daily product of at most 500 barrels with this table shows that its production is as yet insignificant.

Abandoned or exhausted localities.—To speak accurately, there are no abandoned localities in the oil region. Wells in large numbers have been abandoned, and many districts may be said to be comparatively deserted and their production fallen off, but no district where oil has been produced in any quantity has yet been abandoned. It is possible that the wells in some districts may so completely give out that the whole district may be abandoned, and, indeed, such an event is not impossible with the whole region; but such is the character of the industry that it is not possible to determine in any way the probability of an occurrence of this nature.

Future producing localities.—The same truth holds good with regard to endeavors to ascertain localities which may be productive in the future. As has been seen was the case with the recent Cherry Grove development, it is probable that at any time the existence of such a deposit may be discovered anywhere within the lines of the oil belt, even where its existence is least suspected. Of course it is safe to say that as the demand for petroleum increases and the present production declines other localities that now afford indications of oil will be developed, and Kentucky, Tennessee, Ohio, Colorado, and Nebraska may become productive in the future; but it is not possible to make any statement of a positive character regarding such future production.

Foreign oil fields.—A brief notice of foreign oil fields is not inappropriate at this juncture. On this continent, outside of the United States, oil is found in Nova Scotia and Canada, in various places in South America, and in many of the West India islands. In Canada oil has been produced since 1857, and the industry has assumed proportions of considerable importance. In South America oil exists in Peru, Ecuador, Bolivia, and Chili, but only in the first-named country is it produced and used for commercial purposes to any extent.

In Europe the most remarkable deposits of petroleum are those of the Caucasus, there being in the vicinity of Baku, on the Caspian, large numbers of wells. The product is quite important in a commercial way. Petroleum is also found in Germany and Italy. In Asia there are large oil fields in China, Japan, India, and Burmah, in all of which countries the petroleum is collected and utilized to a greater or less extent. The petroleum deposits of New Zealand are also of considerable importance.

Origin of petroleum.—It would not be advisable to enter into an extended discussion, in this paper, of the probable origin of petroleum. Many conflicting theories, with more or less arguments in favor of each, have been advanced; but so little is known definitely on the subject that it is conceded to be a doubtful question. The theory most commonly accepted is that of decomposition of carbonaceous material. The evolution of gases from decaying vegetable matter is familiar to all, and liquid hydrocarbons have also been observed as resulting from such decomposition; and the theory is plausible that the same changes in vegetable matter which bring about the formation of coal also have petroleum as a resultant. The theory is further supported by the facts that oil of an essentially similar character to petroleum is distilled from bituminous coal, and that in general petroleum is found in ocalitiesl where bituminous coal or shales are known to exist; and at all events the theory of carbonaceous decomposition may be considered as agreeing more closely than any other to all known circumstances in connection with the existence and production of petroleum.

Geology of petroleum.—The geological formation in which petroleum is found may be spoken of with considerable definiteness. The oil is usually found in beds of porous sandstone and conglomerate, saturating the rock and filling the fissures in it, which are generally extensive. Deposits of petroleum occur in rocks of the Lower Silurian series and upwards. In Canada and Kentucky the Utica shale of the upper part of the Lower Silurian rocks is highly bituminous, and the petroleum found in these districts evidently proceeds from this formation. By far the most productive oil horizon, however, is found in the Upper Devonian rocks, and these are the strata from which the Pennsylvania and New York oil wells draw their supplies. Through the oil regions of the States named the hills and higher ground are formed of Carboniferous rocks and patches of Coal Measures, underlaid by conglomerate and a few hundred feet of Lower Carboniferous shales. Under this, and generally exposed in the valleys, come the Chemung and Upper Portage formations, composed of alternations of clay shale with the bands of sandstone and conglomerate in which the oil exists. Of course it is not probable that the oil derives its existence from any changes in this clay shale; but the formations named are in their turn underlaid by very thick and black bituminous shales of the Marcellus and Genesee series, in which it is eminently possible that the supposed changes may have taken place, the oil then finding its way to the more open or porous rocks above.

Prospecting or locating oil property.—The circumstances which have governed oil operators in locating oil property have been many and various. Early in the history of the trade, oil on the surface meant oil underneath. A location where oil was found on the surface of springs or streams, or oozing through the ground, was accepted as a favorable situation for drilling oil wells. The unreliability of such indications, however, seems to be quite certain. Wells have been drilled in the vicinity of, and in fact on the bottom of, the ancient pits on Oil creek, already mentioned, without success. Wells have also been drilled in the immediate vicinity of oil springs, and have found no oil in any abundance. This would seem to prove that oil on or near the surface of the earth has but little immediate connection with the large deposits of petroleum from which the wells of the present draw their supplies. In the early years of the oil trade, in selecting a site for an oil well, a ravine or hollow was generally considered to offer advantages, possibly from some mistaken impression that the presence of the irregular and cavernous rock formation in which the oil is found was indicated by the irregularity of the surface. Of course there may be in some cases a connection between the two, but as such ravines more frequently owe their origin to the eroding action of water, a well so located would not necessarily be over the oil-producing rock. The same reason may be urged against the idea that locations along the river and creek bottoms were the most favorable to be found. It has even been asserted that the fissures in the rock, hundreds of feet below the surface, followed very closely the course of the streams on the surface; but this is manifestly improbable. An erroneous impression also prevailed that locations in ravines or on the river-bottoms were good because the stratum of earth was thin and the rock could be reached with less difficulty. This is of course absurd, as rock is more frequently in close proximity to the surface of hills than it is to the surface of valleys or ravines. However, facts are against all these theories, were there no other argument to be urged against them, and they have been proved erroneous by experience, the location of a well with regard to surface configuration having been found to have but little to do with its productiveness.

The chief guide that for years has been and is now relied upon in locating oil property is the success or failure of former operations in the locality under consideration. It having been once decided that the reservoir of oil is beneath one well, it is reasonable to conclude that another well, drilled in close proximity, stands a fair chance of tapping the same reservoir. Of course to this rule must be attributed, more than to any other, the development and increase of our oil fields. From the first, men were attracted to the business by the knowledge that others had succeeded, and drilled their wells accordingly; but this was with reference to locating an oil district and not the position of an individual well; and in discussing the subject reference was had to the latter. The rule has held good in a large number of cases. Still there are many instances where a well sunk in very close proximity to a producing well has failed of success. In one instance a well which was quite dry at first became a producer upon having the diameter of its bore increased about an inch, proving that even so slight a distance from the oil vein will be fatal to the productiveness of the well.

Drilling tools.—The site of the well having been selected, a derrick is built. This is a tall, pyramidal structure of framework, and is built immediately over the point selected for the well. Excavation of the earth is then begun, as, of course, drilling cannot commence until the solid rock is reached. Where the rock is only a short distance below the surface, a hole is dug down to it and a narrow box of planks is inserted. Drilling is then commenced on the rock. Where, however, the rock is some distance down, recourse must be had to a somewhat different method of operating. A pit is dug under the derrick for some distance down, usually until the process is interrupted by the influx of water; a conductor or pipe of some kind is then driven into the earth at the bottom of the pit, and forced through to the rock by means of an instrument resembling a pile-driver. The pipe may be of wood or iron; generally an iron pipe is used, called a driving-pipe. It is prepared in joints of a certain length, and the joints are connected as the pipe is driven into the ground. Generally this operation is a success, but frequently the pipe runs upon a large stone or a thin stratum of rock, and in some cases is bent or deflected from a vertical course; and such a deviation is fatal to the well, as it must be perfectly straight and vertical, and it is generally useless to attempt to remedy the difficulty. The pipe, however, having been successfully put down to the solid rock, the earth is removed from its interior and the operation of drilling commences. The chief tools, properly so called, used in the process are four—the center-bit, the auger-stem, the jars, and the sinker-bar. In a drilling well, these tools hang in the order named, the center bit being lowest. This is a bar of iron a few feet long, with a sharp steel cutting edge on the lower end. To this is attached the auger-stem—simply a round bar of iron, from 28 to 40 feet in length, of 4-inch iron. Then come the jars, two peculiarly constructed pieces of metal, so formed that, as indicated by their name, a sudden jar will be imparted to the tools at every upward and downward motion, as the drilling progresses; serving to loosen the bit if by chance it should become wedged in the hard rock. The fourth piece, to which is attached a long cable reaching up to the surface, is the sinker-bar, resembling the auger-stem, but only from 14 to 16 feet long, and used simply to give additional weight to the tools. The cable by which these tools are suspended in the well passes up to the top of the derrick on the surface, over a pulley, and down again to a large kind of drum at the foot of the derrick, called a "bull-wheel," around which it is coiled. By applying power to this wheel the tools may be drawn up from the well and suspended in the derrick, as it is often necessary to do in order to get at the bit to sharpen it. The tools are permitted to run back into the well by their own weight, a brake on the "bull-wheel" controlling the motion. About eight or ten feet above the mouth of the well, the cable is fastened to one end of a large walking-beam, oscillating on a high post, called a "Samson post," connection being made at the other end of the beam with the engine. By this means a rising and falling motion is imparted to the tools, the impact of the center bit on the rock drilling the hole.

Method of drilling.—With an outfit and tools of this character, then, the work of drilling commences. The rate of progress varies of course with the character of the rock, a hard rock requiring longer time to pierce it. In early times, perhaps 10 feet a day was considered fair progress, but at present, with tools weighing usually in the neighborhood of a ton, and dropping a distance of about 2 feet with every vibration of the walking beam, a very heavy blow is struck and rapid progress is made. Wells are now drilled in fifteen, twenty, and thirty days, that ten or fifteen years ago would have required from thirty days to six months to complete. Much progress has also been made with regard to success in drilling a well. Numberless difficulties were formerly encountered in drilling every well; tools were broken in the well or became fast in the rock; thick mud has flowed in and became "set" around the tools; and a large proportion of the wells commenced never were drilled through to the oil rock. However, with the present improved methods and appliances, such accidents are very infrequent, and very few wells are commenced that are not carried through to the sand successfully.

In drilling, the tools are lowered a little with every stroke by means of a "temper screw" attached to the cable in the derrick, and manipulated by the driller. The débris resulting from the operation of the center-bit is held in suspension at the bottom of the hole, water being usually poured into the well for this purpose. When a considerable quantity of broken rock has accumulated, the tools are withdrawn from the well and an instrument called a sand-pump inserted, which removes the liquid mud and sand from the well. The tools are then replaced and a few feet more are drilled. Sometimes a tool called a reamer is inserted in place of the center-bit, which reams out the hole and removes any irregularities; but with the improved bits now in use this tool is but little used. In this manner the work of drilling goes on. As the well increases in depth, small veins of oil are frequently crossed and veins of gas are also encountered, in addition to the streams of salt water. The drill first passes through a stratum of clay shale of varying thickness. Then a stratum of sandstone, called the first sand is reached; then another stratum of shale, another of sand, called the second sand; another of shale, and then the third sand. In some cases a fourth sand has been found. This third sand is the chief oil-producing sand, the wells producing oils from the first and second sands being comparatively few. The strata enumerated above are of varying thickness, and it is difficult to give any statement that will be a fair average; however, it may be said that the third sand has been found in the Pennsylvania oil-fields at a depth of from 400 to 2,000 feet, and that the majority of the wells drilled have reached it between 1,300 and 1,700 feet below the surface. This, of course, must be understood as being only an estimate.

Well records.—It is customary for operators, when drilling a well, to keep a record of the several strata or kinds of rock drilled through, as shown by the débris brought up by the sand-pump. Of course records from different wells are never alike, but the following may be of service as an illustration. It is the record of a successful well drilled in Allegany county, New York, which, however, reached the third sand at a somewhat less depth than the average:

Section traversed by an oil well in Allegany county, New York.

106 feet of surface formation.
30 feet blue shale.
40 feet white rock.
15 feet red rock.
5 feet chocolate shale.
16 feet red rock and sand.
4 feet chocolate shale sand.
8 feet "water" rock.
12 feet gray stone.
6 feet red rock.
30 feet slate rock.
14 feet gray stone.
3 feet white stone.
4 feet gray stone.
4 feet sandstone.
7 feet dark-gray stone.
30 feet slate.
20 feet light-gray stone.
21 feet slate and shells.
79 feet light colored slate.
4 feet shell and fossil remains.
31 feet slate, soft.
22 feet argillaceous sandstone—FIRST SAND.
30 feet shale.
4 feet shell and fossil remains.
1 foot bright copper-colored shell.
52 feet slate.
4 feet shell and fossil.
21 feet slate.
1 foot shell and fossil.
21 feet slate.
1 foot shell and fossil.
47 feet shale, soft.
40 feet sandstone—SECOND SAND.
80 feet shell and slate.
61 feet slate, shell, and fossil.
9 feet shell and fossil.
119 feet shale.
20 feet excellent quality oil sand, salt water.
104 feet shale.
17 feet sandstone—THIRD SAND—soft.
17 feet third sand, not so soft.
10 feet third sand, same as top.
24 feet pocket, in shell and slate.

1,194 feet total depth.

Cost of drilling.—Of the two following estimates of the cost of drilling an oil well, the first was made about 1865, and shows the cost of drilling a 600-foot well in Venango county at that time; the second shows the cost of drilling a well of average depth in McKean county at the present:

Cost of drilling, 1865.

Forty feet of metal pipe at $6	$240 00
One engine, 10-horse power	1,600 00
Band wheel and belting	125 00
Drilling tools	325 00
Derrick, bull-wheel, walking-beam, and Samson post	100 00
Six hundred feet of cable and sand-pump rope	100 00
Drilling 600 feet at $2.50 a foot	1,500 00
600 bushels of coal at 50 cents	300 00
Tubing, 600 feet at 60 cents	360 00
Total	4,650 00

Cost of drilling, 1883.

Carpenter rig with irons, all complete	$400 00
Boiler and engine	775 00
Belting and connections	125 00
Casing, 5-inch, 500 feet, at 75 cents	375 00
Delivering same at well	20 00
Drilling, average depth 1,625 feet, at 60 cents	975 00
Tubing, 1,700 feet, at 22 cents	374 00
Delivering same at well	15 00
Packer	15 00
Tank and house to cover	160 00
Torpedo	200 00
Total	3,434 00

It will be observed that there are several items in the latter estimate which do not appear in the former, and one or two in the former not in the latter. This is accounted for by the fact that one or two of the items in the 1883 estimate each cover more than one of the items in the 1865 estimate, and that the operations in 1865 were quite simple when compared with those of the present day. The two estimates represent fairly the amount of money considered necessary to put down a well at the two periods named. Of course the cost varies, as does the depth of the well; in Allegany county, New York, for instance, where the average depth is not much over 1,300 feet, the cost would be but $3,200 at present.

Manner of producing.—The well having been completed to the first sand or oil-bearing rock, if a good volume of oil is obtained the drill may be stopped and pumping begun; but if neither at the first nor second sands is a good flow of oil obtained, the well is drilled through to the third sand. The result will then be one of three things: the well will be a dry hole, or it will be a small producer, requiring to be pumped, or it will be a flowing well. In the first case the money invested is of course a total loss, except so far as the tools and materials may be utilized in drilling other wells; in the second case, an additional outlay is required for sucker-rods and other pumping apparatus, and a constant expense is incurred for fuel, except in cases where the gas from the well itself may be utilized. In the third case, all that is necessary is to attend to the oil; the well will take care of itself.

Flowing wells.—In connection with the latter class of wells, some interesting circumstances may be mentioned. The first flowing well was struck in the Oil creek region, as a result of very deep drilling on the part of the operator. At the depth of 500 feet a vein of oil was struck which lifted the heavy tools clear out of the well, and poured forth with amazing force, rising to a height of 60 feet above the surface of the ground. Other wells were at once drilled deeper and many other "gushers" were struck, several of which produced from 1,000 to 3,000 barrels per day. The recent Cherry Grove developments produced a number of "gushers" of this character.

Period of productiveness.—The period of productiveness of an oil well is very uncertain, and almost all that the owner can be positive of is that the well is producing; he cannot ascertain the probable duration of its productiveness. As a general thing, a large flowing well is but short lived, while a pumping well of moderate size is more likely to have a long life. The character of other wells in the district and the length of time they have been producing also furnish some assistance in solving the problem; but even with this help a definite solution is impossible. Various causes, and many no doubt of which nothing is known at present, conspire to check the production of oil wells, and the well, whether flowing or pumping, may suddenly cease producing and no reason be perceptible. In the majority of cases, however, the wells fall off gradually until they cease to produce.

Explosives used.—Frequently when a flowing well stops producing very suddenly, the owners have recourse to a process called "torpedoing" or "shooting" the well, which is often efficacious in restoring and sometimes increasing the production. The process is based on the supposition that the stoppage of production is caused by the orifices in the rock which admit the oil to the well becoming clogged up with paraffine or other obstructing matter. In the early days of the business, and up to 1865, blasting powder was used for this purpose, but in the year named nitro-glycerine torpedoes were introduced by the Roberts brothers. These torpedoes were found to give much better service than the old ones, as they were convenient in size and exploded very suddenly. A 60-quart shot, while a somewhat large one to use on a new well, is yet by no means an uncommon one, and the force of the explosion would equal that obtained by exploding 2,600 pounds of gunpowder, an amount which could not be gotten into the deepest wells. The Roberts brothers took out patents on their invention, which are now owned by the Roberts Torpedo Company, and regarding which seemingly endless litigation has sprung up in consequence of alleged infringements, the exact status of the matter being hard to define. The patents will, however, expire very shortly.

Cost of producing.—In view of the facts recounted, and especially those regarding the duration of productiveness, the uselessness of endeavoring to determine the average cost of producing a barrel of oil will be appreciated. This determination in the case of a single well depends, among other things, on the depth to which the well is drilled, and the difficulty attending the process; upon the cost of pumping, if not a flowing well; and upon the amount of oil produced. Accordingly, it would be impossible to decide exactly the cost of a barrel of oil from an individual well until it had ceased producing; while to ascertain the average cost of production, with reference to all the wells, would be a well-nigh impossible task. Of course rough estimates have been made, but these have been generally in regard to pumping wells of small size, and of only local value; and a statement covering all kinds of wells and all the oil produced cannot be made.

Statistics of production.—The following tables give the statistics of petroleum production in the Pennsylvania and New York oil field, for the years 1871–1883, the figures for the latter year of course being only up to date, June 30. The exact figures for former years are not obtainable, various and different estimates existing, but so conflicting that their value is impaired.

Number of drilling wells in the Pennsylvania and New York oil field at the close of each month for the years 1871–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1871	140	173	240	279	356	303	329	330	439	486	477	394	329
1872	363	369	313	302	386	391	359	392	301	311	354	318	347
1873	361	349	227	177	228	395	340	267	197	163	137	60	242
1874	37	55	99	213	225	210	180	128	107	82	57	54	121
1875	40	40	45	64	127	162	118	96	132	170	179	168	112
1876	142	151	230	267	307	340	353	374	511	565	618	493	363
1877	457	463	395	448	512	395	365	417	535	573	565	426	463
1878	334	326	379	409	376	266	188	185	240	282	297	218	292
1879	265	323	406	468	460	384	329	258	270	313	372	440	357
1880	540	535	577	580	460	440	452	515	491	469	475	408	495
1881	383	420	437	446	470	408	379	352	388	445	475	468	423
1882	422	438	408	405	381	226	240	194	177	184	154	138	276
1883	126	151	205	199	216	228	.....	.....	.....	.....	.....	.....	.....

Number of drilling wells completed in the Pennsylvania and New York oil field each month for the years 1871–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1872	37	120	89	121	135	84	128	118	82	100	64	105	1,183
1873	93	94	100	105	102	130	114	120	106	101	100	98	1,263
1874	102	104	110	113	109	101	121	107	104	120	106	120	1,317
1875	190	187	195	186	172	190	200	210	201	220	217	230	2,398
1876	240	231	242	200	202	261	248	270	209	273	272	272	2,920
1877	281	241	291	269	320	403	317	255	322	467	391	382	3,939
1878	274	226	211	409	470	269	203	186	174	229	248	165	3,064
1879	136	132	238	270	402	330	327	283	210	232	227	261	3,048
1880	320	230	367	500	426	310	338	368	356	364	336	302	4,217
1881	222	220	271	316	406	374	336	332	312	322	363	406	3,880
1882	347	340	385	432	469	340	185	253	164	117	150	122	3,304
1883	125	126	142	209	231	228	.....	.....	.....	.....	.....	.....	.....

Number of producing wells in the Pennsylvania and New York oil field at the close of each month for the years 1872–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1872	3, 892	3, 936	3, 943	3, 967	4, 085	4, 144	4, 245	4, 423	4, 475	4, 475	4, 529	4, 553	4, 205
1873	4, 485	4, 490	4, 411	4, 265	4, 317	4, 400	4, 420	4, 163	3, 940	3, 654	3, 413	3, 358	4, 109
1874	3, 311	3, 235	3, 308	3, 301	3, 266	3, 298	3, 293	3, 287	3, 254	3, 270	3, 220	3, 270	3, 276
1875	3, 132	3, 112	3, 060	3, 052	3, 080	3, 084	3, 067	3, 088	3, 112	3, 125	3, 174	3, 088	3, 098
1876	3, 314	3, 638	3, 670	3, 772	3, 930	4, 527	4, 774	6, 047	5, 285	5, 552	5, 809	6, 000	4, 694
1877	6, 283	6, 441	6, 666	6, 846	7, 037	7, 352	7, 567	7, 684	7, 872	8, 061	8, 323	8, 458	7, 383
1878	8, 616	8, 725	8, 848	9, 071	9, 400	9, 605	9, 776	9, 884	10, 012	10, 188	10, 276	10, 337	9, 561
1879	10, 482	10, 582	10, 692	10, 782	11, 045	11, 223	11, 461	11, 585	11, 760	11, 860	11, 960	11, 960	11, 283
1880	12, 000	12, 072	12, 222	12, 572	12, 972	13, 172	13, 275	13, 500	13, 825	14, 100	14, 400	14, 700	13, 234
1881	14, 900	15, 050	15, 500	15, 769	16, 150	16, 700	17, 000	17, 250	17, 562	17, 799	18, 040	18, 300	16, 668
1882	18, 400	18, 600	18, 850	19, 150	19, 350	19, 500	19, 570	19, 600	19, 600	19, 000	18, 700	18, 000	19, 027
1883	17, 600	17, 300	17, 250	17, 100	17, 100	17, 050	....	....	....	....	....	....	....

Average daily production of crude petroleum in the Pennsylvania and New York oil field each month for the years 1872–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1872	18, 825	15, 965	14, 890	15, 403	17, 326	16, 371	16, 702	17, 739	16, 681	4, 272	21, 287	20, 825	17, 194
1873	20, 407	21, 725	21, 461	21, 384	25, 044	26, 449	27, 983	30, 198	31, 809	30, 403	33, 049	34, 980	27, 106
1874	37, 653	29, 839	28, 498	25, 958	28, 895	30, 725	33, 337	30, 049	28, 021	29, 669	28, 702	27, 682	29, 937
1875	27, 489	25, 708	25, 469	22, 502	22, 468	23, 207	25, 431	23, 186	23, 298	23, 583	23, 340	23, 254	24, 075
1876	22, 975	23, 065	23, 167	23, 383	23, 721	24, 120	24, 633	25, 233	26, 020	26, 102	26, 216	25, 390	24, 505
1877	27, 190	27, 979	29, 087	32, 427	36, 374	37, 693	38, 355	41, 089	40, 497	40, 946	39, 114	40, 518	35, 988
1878	38, 816	39, 102	38, 980	39, 863	40, 802	40, 575	41, 415	43, 288	43, 857	44, 187	44, 065	42, 538	41, 544
1879	44, 191	43, 515	48, 365	51, 015	53, 062	55, 855	56, 057	61, 042	61, 890	59, 238	57, 016	57, 076	54, 206
1880	61, 423	64, 552	65, 032	67, 190	71, 901	71, 948	72, 530	75, 517	78, 210	76, 956	75, 814	72, 214	71, 114
1881	72, 390	68, 326	73, 372	73, 526	77, 203	79, 262	76, 538	75, 217	73, 114	74, 941	75, 561	80, 000	75, 004
1882	75, 921	76, 119	80, 070	80, 093	80, 212	94, 198	105, 102	100, 145	87, 346	74, 118	73, 098	61, 210	82, 338
1883	62, 849	62, 721	59, 054	60, 551	63, 292	65, 930	....	....	....	....	....	....	....

Total production of crude petroleum in the Pennsylvania and New York oil field for the years 1871–'83, by years and months.

Years.	Total.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1871	5, 205, 234	418, 407	372, 568	400, 334	385, 980	408, 797	410, 340	456, 475	462, 582	461, 940	485, 243	464, 610	477, 958
1872	6, 293, 194	583, 575	462, 985	461, 590	462, 090	537. 106	491, 130	517, 762	549, 909	500, 430	442, 432	638, 610	645, 575
1873	9, 844, 744	632, 617	608, 300	665, 291	641, 520	776, 364	793, 470	867, 473	936, 138	954, 270	942, 493	991, 470	1, 084, 380
1874	10, 926, 945	1, 167, 243	835, 492	883, 438	778, 740	895, 745	921, 750	1, 033, 447	931, 519	840, 630	919, 739	861, 060	858, 142
1875	8, 787, 506	852, 159	719, 824	789, 539	675, 060	696, 508	696, 210	788, 361	718, 766	698, 940	731, 073	700, 200	720, 874
1876	8, 968, 906	712, 225	668, 885	718, 177	701, 490	735, 351	723, 600	763, 623	782, 223	780, 600	809, 162	786, 480	787, 090
1877	13, 135, 475	842, 890	783, 216	901, 697	972, 810	1, 127, 594	1, 130, 790	1, 189, 005	1, 273, 759	1, 214, 910	1, 269, 326	1, 173, 420	1, 256, 058
1878	15, 163, 462	1, 203, 296	1, 094, 856	1, 208, 380	1, 195, 890	1, 264, 862	1, 217, 250	1, 283, 865	1, 341, 928	1, 315, 710	1, 369, 797	1, 348, 950	1, 318, 678
1879	19, 785, 176	1, 369, 921	1, 261, 935	1, 499, 315	1, 530, 450	1, 644, 922	1, 675, 650	1, 737, 767	1, 892, 302	1, 856, 700	1, 836, 378	1, 710, 480	1, 769, 356
1880	26, 027, 631	1, 904, 113	1, 870, 008	2, 015, 992	2, 015, 700	2, 228, 931	2, 158, 440	2, 248, 430	2, 341, 027	2, 346, 300	2, 385, 636	2, 274, 420	2, 238, 634
1881	27, 376, 509	2, 244, 090	1, 913, 128	2, 274, 532	2, 205, 780	2, 393, 293	2, 377, 860	2, 372, 678	2, 331, 727	2, 193, 420	2, 323, 171	2, 266, 830	2, 480, 000
1882	30, 053, 500	2, 353, 551	2, 131, 332	2, 482, 170	2, 402, 790	2, 486, 572	2, 825, 940	3, 258, 162	3, 104, 495	2, 620, 380	2, 297, 658	2, 192, 940	1, 897, 510
1883	....	1, 948, 319	1, 756, 188	1, 830, 674	1, 816, 530	1, 962, 052	1, 977, 900	....	....	....	....	....	....

Shipments of crude petroleum, and refined petroleum reduced to crude equivalent, out of the Pennsylvania and New York oil field for the years 1871–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1871	437, 691	347, 718	383, 890	389, 147	587, 375	501, 754	541, 137	528, 134	551, 075	505, 071	480, 977	410, 822	5, 664, 791
1872	476, 966	407, 606	276, 220	428, 512	510, 417	529, 228	591, 238	621, 954	541, 607	607, 468	477, 945	430, 786	5, 899, 947
1873	573, 124	527, 440	668, 374	708, 191	768, 176	696, 414	814, 449	864, 768	952, 955	1, 010, 852	959, 589	955, 443	9, 499, 775
1874	843, 663	501, 220	518, 246	803, 409	899, 027	815, 413	940, 281	793, 865	1, 014, 570	513, 341	546, 117	602, 348	8, 821, 500
1875	453, 095	327, 776	693, 918	729, 581	681, 679	745, 986	904, 537	882, 089	1, 109, 392	871, 917	671, 066	871, 902	8, 942, 938
1876	677, 289	519, 193	623, 762	603, 037	646, 150	921, 862	1, 228, 539	1, 203, 402	1, 154, 549	524, 190	871, 496	1, 190, 983	10, 164, 452
1877	743, 461	484, 904	913, 919	903, 526	1, 234, 324	1, 391, 124	1, 096, 951	1, 425, 943	1, 563, 797	1, 268, 971	1, 205, 634	600, 019	12, 832, 573
1878	775, 791	774, 234	741, 512	846, 632	960, 894	1, 135, 119	1, 330, 454	1, 655, 651	1, 434, 225	1, 747, 390	1, 281, 410	992, 688	13, 676, 000
1879	663, 998	702, 729	973, 879	1, 136, 188	1, 331, 469	1, 369, 314	1, 625, 035	1, 808, 239	1, 627, 120	1, 662, 269	1, 453, 645	1, 532, 585	15, 886, 470
1880	1, 650, 409	1, 395, 151	1, 613, 371	842, 268	1, 095, 259	975, 083	1, 231, 611	1, 394, 129	1, 252, 635	1, 665, 933	1, 226, 030	1, 335, 613	15, 677, 492
1881	1, 061, 617	915, 028	1, 276, 746	1, 348, 398	1, 563, 436	1, 729, 697	1, 925, 532	2, 214, 877	2, 131, 950	2, 080, 467	2, 066, 906	1, 969, 581	20, 284, 235
1882	1, 657, 067	1, 787, 909	1, 718, 956	1, 678, 134	1, 827, 356	2, 172, 685	2, 402, 970	2, 047, 545	1, 992, 171	2, 089, 428	1, 404, 640	1, 121, 453	21, 900, 314
1883	1, 357, 815	1, 250, 824	1, 641, 899	1, 908, 379	1, 995, 634	1, 747, 789	....	....	....	....	....	....	....

Total stocks of crude petroleum in the Pennsylvania and New York oil field for the years 1871–'83, by years and months.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Averages.
1871	537 751	587, 021	642, 000	771, 000	605, 000	554, 000	511, 220	530, 146	541, 300	495, 102	502, 960	532, 000	567, 458
1872	532, 971	579, 793	662, 497	877, 832	950, 803	1, 010, 302	990, 229	997, 166	951, 410	914, 423	886, 909	1, 084, 423	869, 896
1873	1, 183, 728	1, 265, 373	1, 244, 657	1, 178, 643	1, 192, 541	1, 324, 493	1, 433, 620	1, 513, 890	1, 521, 185	1, 452, 777	1, 493, 875	1, 625, 157	1, 369, 161
1874	1, 948, 919	2, 283, 032	2, 648, 210	2, 623, 534	2, 594, 286	2, 701, 625	2, 279 479	2, 932, 444	2, 758, 504	3, 134, 902	3, 449, 845	3, 705, 639	2, 755, 035
1875	4, 011, 703	4, 546, 188	4, 592, 364	4, 537, 843	4, 552, 672	4, 502, 896	4, 386, 720	4, 223, 397	3, 812, 945	3, 672, 101	3, 701. 235	3, 550, 207	4, 174, 189
1876	3, 585, 143	3, 734, 835	3, 829, 250	3, 900, 703	3, 989, 904	3, 791, 642	3, 326, 726	3, 304, 405	2, 930, 456	3, 040, 108	2, 955, 092	2, 551, 199	3, 411, 622
1877	2, 604, 128	2, 860, 636	3, 210, 454	3, 279, 731	3, 173, 008	2, 912, 674	3, 004, 728	2, 852, 544	2, 503, 657	2, 504, 012	2, 471, 798	3, 127, 837	2, 875, 434
1878	3, 555, 342	3, 875, 964	4, 342, 832	4, 692, 090	4, 996, 058	5, 078, 189	5, 031, 600	4, 717, 877	4, 599, 362	4,221, 769	4, 289, 309	4, 615, 299	4, 501, 308
1879	5, 321, 222	5, 813, 663	6, 318, 099	6, 689, 111	6, 980, 064	7, 263, 150	7, 353, 382	7, 114, 195	7, 620, 525	7, 794, 634	8, 051, 469	8, 470, 490	7, 065, 834
1880	8, 724, 194	9, 204, 062	9, 606 683	10, 780, 153	11, 916, 577	13, 099, 934	14, 116, 753	15, 063, 651	16, 157, 316	16, 877, 019	18, 025, 409	18, 928, 430	13, 541, 682
1881	20, 110, 903	21, 108, 003	22, 105, 789	22, 963, 171	23, 793, 028	24, 441, 191	24, 888, 337	25, 005, 187	25, 066, 657	25, 309, 361	25, 509, 285	26, 019, 704	23, 860, 051
1882	26, 716, 188	27, 059, 611	27, 822, 825	28, 517, 481	29, 206, 697	29, 859, 952	30, 715, 144	31, 772, 094	32, 400, 303	32, 608, 533	33, 728, 555	34, 596, 612	30, 419, 499
1883	35, 187, 116	35, 692, 480	35, 881, 255	37, 789, 406	35, 755, 824	35, 985, 935	....	....	....	....	....	....	....

Monthly and yearly average price of pipe-line certificates or crude petroleum at well for the years 1860–'83.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly averages.
1860	$19 25	$18 00	$12 62½	$11 00	$10 00	$9 50	$8 62½	$7 50	$6 62½	$5 50	$3 75	$2 75	$9 59
1861	1 00	1 00	1 00	62½	50	50	50	25	20	10	10	10	49
1862	10	15	22½	50	85	1 00	1 25	1 25	1 25	1 75	2 00	2 25	1 05
1863	2 25	2 50	2 62½	2 87½	2 87½	3 00	3 25	3 37½	3 50	3 75	3 85	3 95	3 15
1864	4 00	4 37½	5 50	6 56	6 87½	9 50	12 12½	10 12½	8 87½	7 75	10 00	11 00	8 06
1865	8 25	7 50	6 00	6 00	7 37½	5 62½	5 12½	4 62½	6 75	8 12½	7 25	6 50	6 59
1866	4 50	4 40	3 75	3 95	4 50	3 87½	3 00	3 75	4 50	3 39	3 10	2 12½	3 74
1867	1 87½	1 85	1 75	2 07½	2 35	1 90	2 62½	3 15	3 40	3 55	2 50	1 87½	2 41
1868	1 95	2 00	2 55	2 82½	3 75	4 50	5 12½	4 57½	4 00	4 12½	3 75	4 35	3 62½
1869	5 75	6 95	6 00	5 70	5 35	4 95	5 37½	5 57½	5 50	5 50	5 80	5 12½	5 63¾
1870	4 52½	4 52½	4 45	4 22½	4 40	4 17½	3 77½	3 15	3 25	3 27½	3 22½	3 40	3 86
1871	3 82½	4 38	4 25	4 01	4 60	3 85½	4 79	4 66	4 65	4 82½	4 25	4 00	4 34
1872	4 02½	3 80	3 72½	3 52½	3 80	3 85	3 80	3 58½	3 25	3 15	3 83½	3 32½	3 64
1873	2 60	2 20	2 12½	2 30	2 47½	2 22½	2 00	1 42½	1 15	1 20	1 25	1 00	1 83
1874	1 20	1 40	1 60	1 90	1 62½	1 32½	1 02½	95	95	85	55	61½	1 17
1875	1 03	1 52½	1 75	1 36½	1 40	1 26½	1 09	1 13	1 33	1 32½	1 44	1 55	1 35
1876	1 80	2 60	2 01	2 02½	1 90½	2 01¾	2 24½	2 71⅜	3 81	3 37½	3 11	3 73	2 56¼
1877	3 53¼	2 70	2 67½	2 58	2 24	1 94⅝	2 07½	2 51	2 38	2 56¾	1 91	1 80	2 42
1878	1 43	1 65¼	1 59	1 37½	1 35¼	1 14	98¾	1 01	86⅝	82⅛	89⅜	1 16	1 19
1879	1 03	98	86¼	78½	76	68⅜	69⅞	67⅛	69⅜	88⅛	1 05⅝	1 18⅛	85⅞
1880	1 10¼	1 03⅛	88¾	78	80	1 00	1 06¼	91	96	96⅞	91⅞	91⅝	94½
1881	95½	90⅜	83⅜	86¼	81⅞	81¼	76⅞	78⅛	97$\frac{3}{16}$	91¼	85¼	84⅜	85⅞
1882	83⅛	84½	81⅜	78⅜	71½	54⅜	57$\frac{4}{10}$	58⅝	72⅛	93¾	1 14	96	78⅞
1883	93¾	1 01	97⅝	92⅜	1 00⅛	1 16⅜	......	......	......	......	......	......	......

Labor employed.—The labor employed in the oil regions is an extremely variable element, the number of hands employed depending of course on the number of wells producing and drilling, and this latter number being, as has been seen from the foregoing statistics, one which is constantly changing. The census reports state that on May 31, 1880, there were employed in all the regions of this country, except California, 11,477 men, these figures including all hands employed either in drilling wells or in attending to those producing. It is probable that the total number at present employed is not largely in excess of the number employed then, if at all. Of course during the summer and fall of 1882, at the time of the Cherry Grove excitement, when so many wells were drilling in that locality, the number of men employed must have increased somewhat; but it must necessarily have decreased as rapidly as it increased, and all that must now be added is the number of men employed in the Allegany county, New York, field, discovered since the census year; but as all districts of the Pennsylvania field have been recently falling off steadily, and the number of men employed growing somewhat less, a deduction must be made which will almost neutralize the effect of the addition, and, as stated, the present number employed will not be much changed from that employed during the census year. The class of labor employed consists chiefly of common laborers, the foremen and drillers being the only skilled labor. The wages paid range from $2.50 to $4 per day for skilled labor, and from $1.50 to $2 for common labor. The total amount of wages paid during the census year was $7,561,020.

Transportation.—The question of transportation is one which early engaged the attention of the oil trade. At the outset the methods of carrying the oil were very primitive. Imperfect barrels were hauled in rough wagons from the wells to the streams, where they were loaded sometimes on steamboats, but generally on rough flat boats or rafts, by which means they were transported to other places on the river and reshipped by rail. In some cases a species of boat was used called a "bulk-boat," into which the oil was run in bulk and transported to its destination, there to be transferred to barrels or tanks. These methods of transportation were much interfered with by the low water in the rivers; and frequently on smaller streams, and notably on Oil creek, a "pond freshet" would be caused. A number of dams on the stream named, belonging to abandoned sawmills, were utilized to hold back and accumulate a large amount of water, which at length was suffered to escape from all the dams at once, and thus an artificial rise in the stream was caused. Soon railroads were built to the oil regions, and tank cars were invented; and finally, in 1865, iron pipes began to be laid to bring the oil from the wells. During the ten years following a number of pipe-line companies were organized for running and storing the crude liquid. Each company covered certain territory, and producers availed themselves of the pipe-line facilities, each receiving a certificate or receipt for his oil, redeemable in oil at any time upon payment of storage charges. The certificates of each company, however, were of course available only in the district in which it operated, and could not be negotiated. In 1877 an ostensible consolidation of five of these companies took place, the new corporation being called the United Pipe Lines, with a capital of $3,000,000. This new consolidation, however, was simply a purchase of the rights and property of the companies by the Standard Oil Company, to which reference will be made. During the year 1877 a number of other lines were purchased by the United Pipe Lines, and the capital of the corporation was increased to $5,000,000. Since that time the company have greatly increased their resources, a statement published in 1878 showing that they had in active operation nearly 2,000 miles of pipe, with all necessary apparatus, pumps, etc., for operating the lines; and at present their pipeage capacity is no doubt very much greater, probably over 5,000 miles. About 4,000 miles of this form a network all over the oil region, connecting some 20,000 wells with the market; and the remainder is composed of trunk lines of large 6-inch pipe, connecting the oil regions with the cities of Cleveland, Pittsburgh, Buffalo, New York, Philadelphia, and Baltimore. On December 31, 1882, a published statement showed that their storage tanks, in which they store oil for the convenience of customers, had a united capacity of nearly 37,000,000 barrels, and that they had in stock, in these tanks, nearly 33,000,000 barrels of oil.

When an oil well is struck, the United Pipe Lines run a pipe to the well free of charge and take the oil, dispensing with the necessity for local storage. When oil is thus received into the lines of the company the amount is ascertained and is placed to the credit of the well owner on the books of the company, 3 per cent. being deducted to cover loss in transportation. The oil is then held by the company subject to the order of the owner, precisely like a deposit in bank, and it is transferable from one account to another upon written order. Upon signature by the owner of a proper order for the whole or any part of his credit balance, regardless of the manner in which such balance is acquired, the order is marked "accepted" by the company, and is then called a certificate, and passes from hand to hand like a certified check. Negotiations in these certificates, usually of the amount of 1,000 barrels, are carried on extensively on the various oil exchanges. When an oil owner desires to use his oil he has simply to pay the charge for pipeage of 20 cents a barrel and provide receptacles for the oil, and it is delivered to him out of the lines of the company. When any of the oil in charge of the company is destroyed by fire or accident, an assessment, known to the trade as "general average," is made on all oil in the company's hands. The loss, then, while possibly heavy, is very small on each oil owner, and the plan is generally accepted as a good mode of insurance.

The Tidewater Pipe Company is not unworthy of mention in this connection. As the name indicates, the intention is to transport crude petroleum to the seaboard, and the lines for this purpose are rapidly approaching completion.

Appearance and gravity of petroleum.—The petroleum of Baku, Russia, produced near the center of the oil region, is clear and light like naphtha and nearly as pure as if distilled, resembling in appearance Sauterne wine very closely. That obtained near the sides of the territory ranges from a yellowish green to a reddish brown, and darker. California petroleum is light green when first produced, but changes to brown and black upon exposure to the atmosphere. Canadian petroleum is black, with an extremely offensive odor. The Italian petroleum is of a reddish straw color. The oil of India resembles very much the oil produced in the Pennsylvania oil field, both being of a dark greenish-brown color. The oil found at Mecca, Ohio, is yellow. The specific gravity of the various oils of this country as determined by Baumé's hydrometer are as follows:

	° Baumé.
Allegany county, New York	38 to 41
McKean county, Pennsylvania	46
Warren county, Pennsylvania	43
Venango county, Pennsylvania	46
Clarion county, Pennsylvania	47
West Virginia	42 to 43
Ohio	25
Canada	42 to 43

Method of manufacture.—The process of manufacturing petroleum is usually called refining, and is considered as eliminating from the oil all the lighter and heavier oils, the solid matter, etc., leaving only the pure oil fit for use in lamps. The process more properly might be termed the separation of petroleum into its several components, all of the eliminated substances being utilized as well as the burning oil. The manufacture of petroleum involves three successive operations—fractional distillation, agitation with sulphuric acid, and agitation with hydrate of soda or ammonia. In the first process an iron still is used, connected with a worm, which is usually cooled with water. The still is filled with crude oil and heat is applied; the oil soon begins to boil, the vapors are condensed in the worm, and the lighter oil begins to run into the receiving tank. The first oils obtained have a gravity of about 95° Baumé; as the distillation proceeds the oils grow heavier, the last passing over having a gravity of about 25°, there then remaining in the still nothing but coke. The product of distillation is at first usually divided into three parts, according to gravity, and is stored in different tanks. The product ranging from 95° to 63° is run into one tank, and is known as crude naphtha; this is afterwards redistilled and separated into three kinds of oil—gasoline, well known as an illuminant, being the product coming over between 95° and 80°; naphtha, that coming over between 80° and 65°; and benzine, used in the manufacture of paints, varnishes, etc., that coming over between 65° and

60°. The second part of the original distillation consists of the oil ranging in gravity from 60° to 38°, and is the kerosene or burning fluid. The third part consists of the remaining oils that pass over, and is separated by redistillation into lubricating oil and paraffine.

This is a general description of the process, of which there are numerous variations. By applying a greater degree of cold to the condensing worm a lighter oil than gasolene is obtained. It is called "rhigolene," and is used as an anæsthetic. By the use of a condensing pump a still lighter liquid is obtained, which is called "cymogene," and which has been used in ice machines. When very large stills are used, of a capacity from 1,000 to 3,500 barrels, the distillation is not continued until coke is formed, but is interrupted when there remains in the still a thick, tarry residuum, amounting to from 5 to 10 per cent. of the original oil, which is sold to be distilled by other manufacturers into lubricating oil and paraffine. This is the custom in the large refineries of Cleveland and Pittsburgh, where a simpler method is also pursued with respect to the lighter oils. In most of these refineries the crude naphtha is sold without further distillation, the products obtained from the crude petroleum then being but three—crude naphtha, burning oil, and residuum, the second of which being the only product that is further manipulated at these refineries.

The burning oil having been thus obtained by distillation, it is submitted to the two remaining operations necessary to convert it to pure burning fluid. As it stands after distillation, the offensive odor is still present, and the fact that this odor still remained after distillation was one that greatly puzzled the first experimenters in refining petroleum. It, however, is now gotten rid of entirely by chemical means. About 2 per cent., by measure, of sulphuric acid is poured into the oil, and the mixture is thoroughly agitated; on standing, a dark tarry sediment separates, which is removed, and the oil is again agitated with water and then with alkali, generally caustic soda or ammonia, to neutralize the acid. After this alkali is removed by water the oil is found to be "sweet" and pure. Some careful refiners submit it to another distillation to expel any small proportion of lighter oil which it may contain, but this is not common.

The methods of refining at different refineries vary greatly as to details, and the yield of the several products from the crude is, of course, different at each works. The following is given as a fair average for Pennsylvania oil of about 45° Baumé:

Gasolene	1½
Naphtha	10
Benzine	4
Burning oil	55
Lubricating oil	17½
Paraffine	2
Loss, gas and coke	10
	100

Since this estimate was made, however, the processes have somewhat improved, so that a considerably larger percentage of burning oil is obtained.

The safety of an oil for burning varies inversely as the proportion of it that is light and is readily evolved in the form of inflammable vapor. If this is large, the oil will explode very easily upon becoming heated; if it is small, the oil will be difficult to explode. The test of an oil's safety, then, consists in determining this proportion, and is called the flashing test in distinction from the "burning test," so called, which does not demonstrate the proportion above referred to. The flashing test consists in subjecting the oil to be tested to heat, and observing the temperature of the oil by means of a thermometer at the time when sufficient inflammable vapor is given off to cause a flash when a small flame is passed across the surface of the oil. If the temperature becomes high before the oil will flash, what inflammable vapor there is is evolved only with considerable heat, and the oil is comparatively safe, while if it flashes at a low temperature the oil is unsafe, from apparent reasons. There has been some difference of opinion as to what flashing temperature should be selected as a standard of safety. From investigations made of the temperature of oil in burning lamps it appears that the heat often rises above 100° Fahrenheit, sometimes to 110°. Oil, then, which would flash before reaching this temperature would be unsafe to burn in a lamp, and the flashing point should be placed higher than 110°; 120°, from all the information accessible, would seem to be the proper point.

The Standard Oil Company.—The business of oil refining, as carried on in this country at present, is chiefly under the control of an organization called the Standard Oil Company. There are numerous other refineries of considerable importance, the census reports giving the number of firms and corporations as 86; but very few of these are at all comparable in importance to the Standard organization. It was organized at a time when speculation was at its height in the oil trade. Oil wells were being drilled by the hundreds, and men were sinking fortunes in the business. Nothing was certain about it; the striking of a well was uncertain; when the oil was reached it was uncertain how long it would continue, and when it did continue it was uncertain whether it could be disposed of at all. Refineries were being built with almost as great rapidity as wells were being drilled, and often by irresponsible persons, who neither had the knowledge to refine oil nor the character necessary to carry on an honest business; and producers frequently were compelled to turn their oil over to these irresponsible parties, and often met with losses in this manner. The whole business was in so unsettled a condition that it was looked down upon by those engaged in other lines of trade, and a man's connection with the oil business did not improve his credit. Soon the refineries became very numerous, and the production of refined oil rose to such proportions that it was far greater than the demand warranted, and the evils of overproduction were added to those already existing. In this state of affairs the Standard Oil Company was organized, and brought order out of confusion. The company has time and again baffled investigation, and it is well-nigh impossible to ascertain anything regarding its internal management with precision; it is, however, claimed by its supporters that its organization was simply a uniting of forces of a number of the leading refining interests. After its organization other refineries were acquired by purchase or absorption, many of the more poorly located or equipped were dismantled, and by these means the Standard gradually came to its present position, and has a virtual monopoly of the refining trade. The Standard Oil Company also obtained control of the transportation of oil by the means referred to before under the subject of the United Pipe Lines, and through the intimate relations existing between such transportation and the various railroad companies.

This is one of the chief charges brought against the Standard Oil Company—manipulation of railroad freight rates and discrimination against other would-be transporters; and the bill seems to be a true one. In view of the control over the stocks and the pipe-line transportation of oil, it seems inevitable that the Standard should also meddle in prices to some extent. Investigations without number have been made, and enormous amounts of evidence are on record regarding the acts of the company; and such is the diversity of this testimony that it is not practicable to state how true the assertions of its opposers may be. There seems to be little doubt that the company has done a great work, and that through its instrumentality oil refining has been reduced to a business, and transportation has been greatly simplified; but as to how much evil has been mixed with this good, it is not practicable to make a definite statement.

Other refineries.—At the present day, however, the refining interests outside of the Standard organization are assuming considerable importance. A number of these have been organized recently, and several are now being operated or about to be run by outsiders, which have but recently been managed by the Standard, which company has for some reason not renewed its leases. Several of these refineries are doing a good trade, and enjoy the confidence of the business public to as great an extent as does the Standard. Of course, some of these may be at any time merged in the latter company, as has often been the case before; but this is purely a matter of business policy.

Review of the first six months of 1883.—The six months of this year closing with June 30 have witnessed no sudden or startling changes in the oil situation. They have, however, been marked by two important changes which have gradually taken place in the condition of the trade. These are, first, a continuous increase of consumption and decrease of production, until at present the accumulated stock is being drawn upon to supply the demands of the trade; and, second, a gradual increase in price, of course consequent upon the change in the relations of consumption and production. During the past five years the stock of petroleum in the pipe lines and in tanks has been steadily increasing, the amount of oil produced by the wells being greater than the quantity necessary to supply the demand for consumption. The reports for April of this year, however, showed for the first time since 1875 a decrease of stock, the amount of decrease being nearly 100,000 barrels. This indicates that the amount of oil run into the lines from the wells was 100,000 barrels less than was required by consumers.

This condition of affairs is one which has been long expected. The trade was moving in such a direction the early part of last year, and was not far from realizing its present condition; but with the rise of the Cherry Grove field this condition was set far into the future. The production of that short-lived but prolific pool raised the stock of oil much higher than it was before, and the daily yield was set far in advance of consumption. When Cherry Grove began to fall off, the two conflicting elements in the trade, supply and demand, began to draw nearer, and their progress has been steady until now they have changed positions.

Prices have also been moving steadily, in harmony with the other elements of the trade. Their rise has been checked occasionally during the past six months, but with the conditions existing in the trade it was inevitable that the higher rates should rule, and the chief wonder was that the conditions were not earlier appreciated by the trade and that prices were not advanced more rapidly.

With regard to the future it is difficult to speak. In the case of some of our industries the course of future events may be spoken of with considerable precision; but in the petroleum trade, where chance plays so prominent a part, none may prophesy with exactness. But it is possible, at the same time, to make certain provisional statements with reference to the probable course which the oil trade will take. It seems apparent that, while subject to fluctuations, the number of efforts to increase the production of petroleum by drilling wells is on the decrease. The number of the efforts made that prove successful is also diminishing. These facts would presume a steady decrease in production, if the figures themselves did not show it. It is also evident that the consumption of petroleum is increasing, the demand coming from all quarters of the globe, and the home consumption growing constantly. The production of petroleum is nevertheless still so large, and will remain so for a long time, even at the present rate of decrease, that it must necessarily form an article of commerce for many years. The chief result will be manifest in the price, which must rise until the commodity will be utilized for only those purposes for which it is most valuable.

This seems to be the tendency in the petroleum trade at present. There is one important possibility, however, that must be considered in all cases, and that is, the discovery of some new and prolific field. It is true, the oil-producing districts have been pretty well explored, and the prospects of discovering another Cherry Grove are small; but then Cherry Grove itself was a most unlooked-for development, and there may at any time be another such surprise brought to light as was found in the woods of Warren county in 1882. But with this proviso, the chances seem to be that the trade will take the direction above indicated. Other contingencies may arise, but the one named is the only influence which is at all feared by those desirous of better prices.(*a*)

PETROLEUM IN THE ROCKY MOUNTAIN DIVISION.

Colorado, Wyoming, and New Mexico alike present abundant proofs of the existence of petroleum in many places; but, although small quantities have been obtained from oil and bitumen springs and through boring, no steadily-producing well has yet been discovered. In Colorado oil springs have been found near Morrison; near Bitter Water fork, on Grand river, below the old White River agency; on a tributary of Bear river, in the Middle Park; at Cañon City, and at several other points. On Oil creek, six miles north of Cañon City, considerable oil has been obtained by skimming the surface of the brackish water of the springs.

In the crude state the product is heavy and impure, containing only about 50 per cent. of heavy oil. Some years ago a well was bored near these springs to a depth of 85 feet, which produced a little oil. Another well was sunk on the flat near Cañon City to a depth of 1,200 feet, which showed only indications of oil. Nine miles south of this well a third well has been put down about 1,500 feet, which is said to have yielded small quantities of oil. An important strike has been made April 25, 1883, in a well just east of Cañon City, quite a quantity of oil having been struck at a depth of about 1,300 feet. Active work will be prosecuted upon it in the hope of further developments. This oil is green in color, highly translucent, of good fluidity, and upon microscopical examination shows no grit. Its gravity, crude, filtered, and distilled, is as follows:

	Degrees Baumé.	Specific gravity.
Crude oil	30	.875
Filtered oil	29	.880
Distilled oil	25	.903
175° kerosene	47	.794

It is believed by many that ultimately large reservoirs of oil will be discovered at Cañon, in the Las Animas county bituminous coal field, or at Crested Butte, Gunnison county.

In Wyoming considerable quantities of oil have been obtained from the wells in the Sweetwater valley, Laramie county. These wells are

a Mr. Stowell's contribution ends here.

dug to a depth of from 20 to 50 feet, and into them the petroleum oozes and is then pumped out. It is a heavy crude oil, more suitable for lubricating than illuminating purposes. No large reservoir of oil has yet been discovered.

In New Mexico the existence of petroleum is known at a few points, but the supply has not been investigated, and little is known of its quantity or quality. In April the New Mexico Bitumen and Oil Company, while prospecting within six miles of the eastern border of the Navajo reservation, and in the extreme western portion of New Mexico, discovered a flowing oil spring; but the workmen were driven away by Navajoes before they could determine the quantity of oil obtainable. The quality of the crude petroleum is excellent, and the value of the strike will very shortly be fully investigated.

COPPER.

THE COPPER INDUSTRY OF THE UNITED STATES.

By C. Kirchhoff, Jr.

At no period during the history of the copper trade in the United States have the conditions affecting the production and the consumption of that metal undergone such momentous changes as during the past five years. The interests involved have been much more diversified; they enter as a factor of great importance into the prosperity of widely-separated sections of the country, and have rendered a correct appreciation of the bearing and scope of the different conditions at work in shaping the course of the industry much more difficult. The great Lake Superior works crushing enormous quantities of low-grade rock, the rich oxidized ores of the southern tier of the Rocky Mountain Territories, the argentiferous ores of the Butte district in Montana, and of Utah, the pyrite deposits of the Appalachian range—all of these both have circumstances in their favor and are laboring under drawbacks whose ever-changing relations will demand the closest, untiring scrutiny to permit of a clear insight into the status of the metal. The recent growth of many of the producing sections has left some of the most important points affecting their future undefined. In a number of instances the ore deposits, their peculiarities and their continuity, are insufficiently known. In other cases the methods of metallurgical treatment are still a matter unsolved by tentative experimental work. The development of another class of mineral deposits, capable of yielding large quantities of metal in the aggregate, depends upon teaching sulphuric acid manufacturers to dispense with brimstone and relax their stringent specifications as to the quality of the crude mineral. The future prosperity of the western mines, opened out by the rapid extension of our railroad system in the Rocky mountains, is influenced largely by the cheapening of freights and the accessibility to supplies of suitable fuel. It hinges upon the efforts brought to bear upon cheapening the cost of production at a more rapid rate here than in rival countries possessing great natural advantages, ample backing of capital, and large experience.

The copper producers of the United States have during the past few months ceased to work for the more restricted home trade. They have entered the markets of the world, not as hitherto to place a surplus at occasional intervals of dullness in business, but as regular contributors to its supplies. In thus stepping into the wider field they will be influenced by every movement taking place and will be forced to compete, not alone with one another, but with the widely scattered copper-producing countries of the world. They are hampered in some respects and favored in others. High wages, costly fuel, and heavy transportation charges; comparatively little experience in the treatment of some classes of ores, and a lack of capital and an unfavorable climate in many instances, are against them. On the other hand, they may count as advantages a laboring population possessing a comparatively high order of intelligence and energy, and trained metallurgists and engineers having a ready faculty of adapting themselves to circumstances. The new mines of the west are rich, have ores as yet very easily mined and worked, and yield metal of great purity, comparatively speaking. The producers of one section—Lake Superior—make a copper unrivaled in the world for its purity and its mechanical qualities. The United States possesses a plant of copper and brass manufacturing machinery that has not its equal, and through many years of experience the manufacturers have learned to produce goods with a finish and an adaptability to their uses which will be quickly appreciated as soon as circumstances permit of their being brought into competition abroad. As yet, and possibly for some time to come, we may be exporters chiefly of furnace products and of raw and refined metal; but the aim must be to place our contributions to the world's copper supplies upon it in the form of finished goods.

STATISTICS OF PRODUCTION.

The first mine worked in the United States appears to have been the Simsbury, near Granby, Connecticut, a company having been formed in 1709. Ten years later the Schuyler mine, near Belleville, New Jersey, was discovered, and with a number of others in the same section was worked for a series of years. The first mine opened in Pennsylvania was the Gap mine, in Lancaster county, in 1732. It does not appear, however, that any work of moment was done until near the middle of the present century. Prof. J. D. Whitney, in his work "The Metallic Wealth of the United States," does not record any output of copper previous to 1845, when he places the yield at 100 tons. In that year too appears for the first time copper from Lake Superior, Michigan, which was destined to rush into prominence so quickly and to carry the United States into the ranks of the greatest copper producers. Professor Whitney gives the estimates of production during the period from 1845 to 1853, which we have placed in our table. From 1855 we have followed Mr. Charles E. Wright, until recently Commissioner of Mineral Statistics of Michigan, as to the output of that State, and have accepted estimates put forward from year to year by gentlemen intimately connected with the copper trade. We have no means now of verifying their figures, as many of the producing mines outside of the Lake region have ceased to work, so that there is little chance of collecting stray data, and none whatever of gathering complete returns.

Production of copper in the United States from 1845 to 1882, inclusive.

Years.	Total production.	Lake Superior.	Calumet & Hecla.
	Gross tons.	*Gross tons.*	*Gross tons.*
1845	100	12	
1846	150	26	
1847	300	213	
1848	500	461	
1849	700	672	
1850	650	572	
1851	900	779	
1852	1,100	792	
1853	2,000	1,297	
1854	2,250	1,819	
1855	3,000	2,593	
1856	4,000	3,666	
1857	4,800	4,255	
1858	5,500	4,088	
1859	6,300	3,985	
1860	7,200	5,388	
1861	7,500	6,713	
1862	9,000	6,065	
1863	8,500	5,797	
1864	8,000	5,576	
1865	8,500	6,410	
1866	8,900	6,138	
1867	10,000	7,824	603
1868	11,600	9,346	2,276
1869	12,500	11,886	5,497
1870	12,600	10,992	6,277
1871	13,000	11,942	7,242
1872	12,500	10,961	7,215
1873	15,500	13,433	8,414
1874	17,500	15,327	8,984
1875	18,000	16,089	9,586
1876	19,000	17,085	9,683
1877	21,000	17,422	10,075
1878	21,500	17,719	11,272
1879	23,000	19,129	11,728
1880	27,000	22,204	14,140
1881	32,000	24,363	14,000
1882	40,913	25,439	14,309

The details of the production of copper on Lake Superior are the most complete. The greater number of returns were freely given directly, while others were kindly submitted by the Hon. A. P. Swineford, of Marquette, the present Commissioner of Mineral Statistics for Michigan.

The production of Lake Superior copper mines in 1882.

	Pounds.
Calumet & Hecla	32,053,539
Quincy	5,665,796
Osceola	4,176,782
Franklin	3,264,120
Atlantic	2,631,708
Allouez	1,683,557
Pewabic	1,482,666
Central	1,353,597
Grand Portage	757,080
Conglomerate	734,249
Mass	666,086
Copper Falls	587,500

	Pounds.
Phœnix	560,985
Hancock	540,575
Huron	364,579
Ridge	102,936
Saint Clair	87,126
Cliff	66,053
Wolverine	65,457
Nonesuch	46,454
Isle Royale	29,730
Minong	21,380
National	17,560
Minnesota	10,672
Belt mines	5,720
Shelden-Columbian	3,300
Aztec	3,129
Adventure	429
Total	56,982,765

Considerable trouble was experienced in endeavoring to overcome the indifference or reticence of producers in other parts of the country, and it is impossible to give anything beyond the general totals by States and Territories for the Far West, while in the Eastern States the returns have been meager, so that estimates had to take the place of summaries of direct and detailed returns. For the other sections of the country specific statements as to the product of individual mines cannot be submitted. On the whole the replies to requests for statistics have been numerous and accurate, though not as complete as desired. They have been most unsatisfactory from the Southern States, and the figures given are based principally upon the estimates of refiners to whom the bulk of the product has been consigned.

Total copper production in the United States in 1882.

	Pounds.
Lake Superior	56,982,765
Arizona	17,984,415
Montana	9,058,284
New Mexico	869,498
California	826,695
Colorado	1,494,000
Utah	605,880
Wyoming	100,000
Nevada	350,000
Missouri	294,695
Maine	290,000
Vermont	1,265,000
Southern States	400,000
Imported pyrites	1,000,000
Desilverizers, etc	125,000
Total	91,646,232

The value of the product in 1882, 91,646,232 pounds, at 17½ cents per pound, average New York price, was $16,038,091. It is impossible to compute the average or total spot value at the mines with any degree of accuracy.

The product of Arizona includes the make of the Copper Queen, the Longfellow, the Old Dominion, the Detroit, the Russell, Long Island, Buffalo, Huachuca & Pima, Columbia, Neptune, and Santa Catarina. The Montana product embraces the make of the Montana Copper Company, the Parrott, Bell, and Boston & Montana smelters, and the Hecla. In New Mexico the principal producers were the Santa Rita, Val Verde, and San Pedro; in California, the Spenceville mines, and in in Utah the Crismon-Mammoth. From the returns of the Colorado smelting works is deducted the product of the Montana and Utah mines sending mattes there. Sainte Genevieve furnished all of the Missouri product, while the bulk of the Maine returns must be credited to the Douglass and Rosier mines; and of the Vermont returns, to the Ely mine. Almost all of the imported pyrites came from Canada. Much of the copper produced incidentally at the lead desilverizing works is worked into bluestone, which cannot properly figure as an item in the ingot product. Wherever it was known that it was so directed it has been omitted.

Production in 1883.—A sufficiently long period has elapsed to enable the statement to be made that the product of 1883 will be considerably larger than that of the preceding year. It is now probable that the Lake mines will show a slight increase. Arizona will not fall short of 19,000,000, and may possibly reach 22,000,000 pounds. Montana will show a very heavy increase, and from present indications will probably double its output, including the rich ores shipped abroad. New Mexico is becoming a heavy producer, and Wyoming will occupy a higher rank, the Wyoming Copper Company having made 621,479 pounds in the first six months, while Dakota will for the first time appear in the list. A very considerable increase is also expected from pyrites, domestic and imported. The estimate that the production of copper in 1883 will be greater than that of 1882 by at least 18,000,000 to 20,000,000 pounds is a conservative one. On the other hand the export movement is assuming very heavy proportions, and it is estimated that at least 30,000,000 pounds of copper will go abroad in the form of Lake and Arizona ingot and Montana mattes and ores. There has been some temporary weakness in the London market in consequence of the reports of heavy shipments from this country, but the latest advices show that it has rallied, the market being sustained by speculative buying.

For the first six months of 1883 the production of metallic copper is estimated at 58,000,000 pounds, valued at $8,500,000, at the average wholesale rates in New York city.

Refineries.—The refining of western and eastern copper and mattes has grown to be a great industry, in which the following works are prominent: Messrs. Pope, Cole & Co., of Baltimore, Maryland; the Orford Sulphur and Copper Company, New York; the New Jersey Extraction Works, Elizabeth, New Jersey; the refining works of the Ansonia Brass and Copper Company, Ansonia, Connecticut; the works at Phœnixville, Pennsylvania, and the Chicago Copper Company, Chicago, being the most prominent. There has been some talk of establishing an additional works in one of the large cities on the Atlantic coast, but the movement has not as yet assumed a definite shape.

THE COPPER DISTRICTS OF THE UNITED STATES.

Lake Superior.—The history of copper mining on Lake Superior records many disastrous failures and a few striking successes. Though the existence of copper was known to the Jesuits as early as the middle of the seventeenth century, the mines of that section did not attract attention until after the publication of the results of explorations by Dr. Douglass Houghton, the State Geologist, in 1841. Prospecting work was actively under way in 1844, and the year 1845 witnessed the beginning of a speculative excitement which reached its climax in 1846. The history of the growth of copper mining on the Lake, the vicissitudes of the many enterprises started, have been so fully developed by Messrs. Charles E. Wright and C. D. Lawton in the reports of the Commissioner of Mineral Statistics of Michigan for 1880 and 1881 that those interested in more closely studying the subject must be referred to those documents. It is necessary, however, in order to afford the means of correctly appreciating the circumstances under which the different mines of Lake Superior are working, to state that the native copper is found in veins, in masses, or scattered more or less uniformly in small quantities in two classes of rock. The "mass" mines, in which the native copper is found unequally distributed in bodies weighing from a few pounds to hundreds of tons, were those which in early times established the reputation of the district, the Cliff, Minnesota, and National being the most prominent in their day. They have now ceased to be of much importance, the principal ones of the group as producers at present being the Central and the Phœnix, and even they depend largely upon the crushing of lower grades of rock. The opening out of a vein of fair-grade ore is nowadays of much greater importance to the copper trade than the discovery of a series of masses. The principal deposits from which the bulk of the copper of the Lake is obtained are the so-called "amygdaloid" and "conglomerate" beds, rocks in which the copper is finely distributed in small grains. These are separated by stamping and crushing, yielding a product called "mineral," or copper mixed with a varying proportion of gangue, of iron, and of moisture, yielding from 40 to 90 per cent. of ingot, a lower grade being recently made. The treatment of the ore from these two classes of veins does not differ in details; but there is a wide variation in the cost of treatment, due to the fact that the rock from the conglomerate veins is much harder, so that it is profitable to work much poorer rock from amygdaloid beds. Among the mines working conglomerate beds, the Calumet & Hecla is most widely known as the greatest producer and by far the most profitable undertaking. Working as it does a wide bed of exceptionally rich rock carrying from 4 to 5 per cent. of copper, it stands unrivaled. With a splendid plant, paid for out of current earnings, it is in a position to produce copper and place it on the markets of the world at a rate lower than any known mine. In the absence of detailed reports from its management, it is impossible to state the figure at which the Calumet & Hecla can lay down copper at the seaboard, but it is inferred from the known cost of other mines that it is probably not above, if not considerable below, 7 cents per pound. The brilliant results of this mine have frequently led to erroneous conclusions as to the prosperity of the other producers of the Lake. How exceptional this mine is as to its capacity to turn out large quantities of copper at a low cost may be gathered from the following statement of the cost of production, including smelting, marketing, and current improvements, in the other leading mines in the district. The following exhibit shows the average tenor of the ore in ingot copper, and the total production in 1882:

Cost of production of Lake Superior copper, per pound.

Mines.	Production 1882.	Cost of production.			Yield from—		
		1882.	1881.	1875.	1882.	1881.	1875.
	Pounds.	*Cts. per lb.*	*Cts. per lb.*	*Cts. per lb.*	*Per cent.*	*Per cent.*	*Per cent.*
Quincy	5,665,796	9.50	10.03	15.79	3.21	2.62	
Osceola	4,176,782	12.97				1.29	
Atlantic	2,631,708	13.80	13.68	22.12	0.69	0.72	0.78
Central	1,353,597	14.76	14.24	15.81	2.20	1.58	2.67
Allouez	1,683,557	15.04	19.32		0.87	0.95	
Franklin	3,264,120	13.00			1.10		
Pewabic	1,482,666	17.00	16.36		1.00	1.38	

These figures, so far as they represent averages, clearly show the reduction in cost due to the introduction of modern improvements in Lake Superior mines, and at the same time serve to indicate how large a proportion of the mines of that district are capable of being worked without a loss at the low prices for the metal now ruling. The typical mines of the two extremes are the Quincy, which works a high-grade conglomerate, and the Atlantic, which treats a low-grade amygdaloid. It will be of interest to quote here a statement of cost given on the authority of Mr. William Petherick by Mr. Whitney in his work already quoted. It refers to the Northwest mine, the date being 1853. The rock crushed averaged 1.34 per cent., and the cost was estimated exclusive of dead work:

Cost of handling copper ore in 1853 *at the Northwest mine, Lake Superior.*

	Per ton.
Stoping	$2 00
Filling, landing, and wheeling	26
Tramming to kiln	06½
Burning, including wood and labor	35

	Per ton.
Dressing	$0 68½
Steam engine, labor of stamps	76
Miscellaneous charges, carpenter, smith, etc	30
Total	4 42

The cost of mining at the present time of course varies within wide limits, the fluctuations being due to the nature of the ground, and, above all, to the outlay for prospecting and dead work, growing, as it does, at a rapid rate when large blocks of non-productive ground are traversed. The introduction of high explosives and power-drilling machinery has not alone cheapened the cost of dead work and ore extraction, but has also rendered it possible to do more rapid work. Thus the managers of the Atlantic estimate that with drills six men can stope 60 fathoms per month at a cost of $10, while with the same number of men by hand work only 25 to 27 fathoms can be stoped, at a cost of $17. At the Copper Falls the cost for drifting with power drills per foot was $9.08 against $10.33 by hand; for sinking, $10.86 and $11.65, respectively, and for stoping, per fathom, $13.99 and $14 respectively. According to a statement made by officers of the Conglomerate Mining Company, the total cost of drifting by hand is $11.43 per foot, while it is $11.17 per foot by drills, drifts opened by the latter, however, being carried along in larger dimensions, so that when passing through copper-bearing ground there is an additional advantage of $1.80 per foot, not counting the fact that in power drilling the advance is more than twice as fast as in hand drilling.

The cost of hoisting the rock, breaking, selecting, and carrying it to the stamp mill has been decreased by the handling of large quantities, and this has also contributed to reducing the cost of crushing and dressing. The following figures of the cost of treatment of the rock (exclusive of mining and surface expenses) in different mines at various periods will aid in forming an estimate of the capacity of Lake Superior mines to produce copper cheaply:

Cost of crushing and dressing Lake Superior copper ore, at various dates.

Mines.	Years.	Quantity of ore treated.	Cost of breaking, tramming, stamping, washing, etc.
		Tons.	*Per ton.*
Copper Falls	1862	19,752	$1 12
Allonez	1881	63,362	1 07
... Do	1882	97,232	98
Atlantic	1875	100,000	93
....Do	1881	176,055	48
....Do	1882	189,800	42
Quincy	1870	55,027	2 15
...Do	1880	84,426	79
Osceola	1881	160,880	92
Central	1881	20,549	72
....Do	1882	18,639	88

The metallic copper produced by the mines, either in the form of masses or small pieces called "barrel-work," or as "mineral," ranges in purity from 40 to 96 per cent. of copper. The cost of transportation to the smelting works, situated at Hancock and at Detroit, varies according to the locality of the mine. The Lake freight to Detroit ranges between $3.50 and $4 per ton. The refining process has been described in detail by Prof. T. Egleston, of the Columbia School of Mines, in Volume IX., pages 678 to 730, of the Transactions of the American Institute of Mining Engineers. The charge for refining is approximately $11 per ton. The bulk of the copper is shipped by water to Buffalo, and thence by rail to the Eastern markets, at a cost of $6 to $8 per 2,000 pounds. All-rail transportation is much more expensive, being approximately one cent per pound. The result is that under ordinary circumstances the supplies for the markets are shipped during the period when navigation is open, a stock being thus accumulated during the fall to meet consumption during the winter and early spring. It has repeatedly happened during the history of the copper trade that an exceptional speculative or trade activity has made it profitable to incur the greater expense of this overland transportation, in some instances checking an undue rise in values.

For many years the history of the copper trade has practically been a record of the movements of the consumers and producers of Lake copper. The fact that, as the tables show, by far the greatest portion of the product of the country has been drawn from that region has, until a very recent period, given it the controlling influence in our markets. The output of the other sections has, with few exceptions, been subject to such variations, from marked prosperity to entire abandonment, that it is a difficult matter, in the absence of full records, to trace the local history of copper mining in the different States.

Arizona.—During the past few years public attention has been directed with much interest to the development of the undoubtedly great copper resources of this Territory, and enterprises of this character are still regarded with much favor, although the markets for the metal have an unfavorable turn. During the years 1866 to 1869 considerable work was done at Williams's Fork, but the inaccessibility of the mines, Indian troubles, and other causes, forced a suspension, and copper mining in the Territory was at a standstill until 1873, when the Longfellow mines, in the Clifton district, were located and production was begun in a small way, gradually expanding in spite of adverse circumstances until the remarkable success of the Copper Queen mine at Bisbee stimulated an activity which still continues. The product of Arizona during the period from 1874 to 1880 is not known. There are good reasons for believing that from about 800,000 pounds, in 1874, it gradually rose till it reached 2,000,000 pounds in 1880. In September of that year the Copper Queen Company started work, and the following year witnessed a series of developments in the Globe district, at Pinal, and in other sections of Arizona. Many of these enterprises did not reach their full development until late in 1882, while others after a brief period of activity in that year closed down temporarily or for good. Profitable as copper mining on the whole has been in Arizona, it has in a number of instances been disastrous. It has been a repetition of the experience in almost all the western mining districts. Inefficient management, lack of metallurgical skill, undue haste in providing reduction works before the mines were fully developed, and the absence of the necessary working capital, have singly or combined led to failure. It is impossible to speak in general terms of the conditions affecting the copper mining industry of Arizona ; they vary so much according to locality and they are not concentrated in well-defined districts. Until now the Indian troubles have repeatedly affected the working in some sections, while in others the want of water has hampered operations. The principal factor, outside of the quantity and quality of the ores and fluxes furnished by the mines, has been the supply of fuel. In close proximity to lines of railroad, English coke, or coke from Trinidad, Colorado, can be obtained at $20 to $30 per ton, while smelters at a distance from them must pay $50 to $75 per ton for their fuel. As the quantities of ore smelted per ton of coke vary from five to seven tons, according to the quality of the coke and the character of the ore, mines whose fuel is dear, and who, of course, must also pay high figures for freight on their product, cannot afford to smelt anything but high-grade ores. This again means an increased cost for mining and selecting the mineral, so that the works at a distance from lines of transportation are dependent upon the discovery of high-grade ores and are liable to more frequent stoppages, not alone on that account, but also because they can be forced to stop in consequence of any troubles along the long lines of travel over which their supplies are brought. The Globe district, in which the Old Dominion, Long Island, Takoma, Carrie, and other works are situated, furnishes ample proof of the potency of these influences. The managers of Arizona copper enterprises fully feel the weight of these facts, and those in the Clifton district have nearly completed a line connecting them with Lordsburg on the Southern Pacific. The Copper Queen is fairly well located and has spent considerable sums for good roads, while other mines (like the Peabody) are on the line of a railway itself.

The ores of Arizona are almost exclusively carbonates and oxides, not carrying enough silver to make its extraction profitable, though in some of the lately explored portions of the Territory ores richer in silver are reported. As yet in most of the mines a sufficient depth has not been reached to develop notable quantities of sulphurets, and until that point is arrived at a notable falling off in the production need not be looked for in the more favorably located mines. Some of the ores are very easily smelted and furnish a copper of exceptional purity. It should be noted, however, that, contrary to the opinion generally held, it is by no means an invariable rule that oxidized ores must produce a pure metal. The general practice in Arizona is to smelt these ores in cupola furnaces, with coke as a fuel wherever available. The ores are usually basic in character and require siliceous fluxes. The tendency in the smelting practice in Arizona appears to be in the direction of fast driving by using high pressure of blast and chambers for gathering flue dust, thus running up the capacity of the furnaces and diminishing general expenses and labor account.

The three principal centers of the copper production in Arizona are the Clifton district, in which the Arizona and the Detroit companies are at work; Bisbee, where the Copper Queen has been the only successful enterprise, the Neptune having collapsed; and the Globe district, where the Old Dominion is the leading producer.

The Clifton mines are near the New Mexico line, in the southeastern part of the Territory, the ores running in zones in beds of felsite in enormous bodies. They are manganiferous and ferruginous carbonates and oxides, running on an average, as mined, 15 per cent., and after picking carrying as charged into the furnaces 20 to 30 per cent. of copper. The leading interest in the district is held by the Arizona Copper Company, controlled by Scotch capitalists, who have endeavored to make extensive improvements. The caving in of one of the mines furnishing basic ores has of late restricted operations and made the work more expensive. The cost of production has not been made public, but the low cost of fuel, the abundance and high grade of the ores, and the large scale upon which operations are conducted justify the belief that the district is capable of holding its own, if carefully and prudently managed, even if prices should further decline materially. There are other promising properties in the district and it is likely that the present rate of output will rather be materially added to instead of showing a decline, after the leading mine has been restored to its usual productiveness.

The Copper Queen mine, the largest single producer in Arizona, is as yet the only one that has done any work in the Warren district, in which it is located, few of the many other claims in the district having as yet proved the existence of any ore bodies of magnitude. The mine has worked an exceptionally large body of carbonates and oxides, metallic copper and glance making their appearance in the lower levels of the mine. The ore is high in grade, very pure, and needs little flux to carry it up to a black copper containing from 96½ to 97 per cent. of pure metal. The company has thus far paid $975,000 in dividends, and the cost of production is placed at 9 to 9.25 cents per pound. The mine is said to have ample reserves of good ore.

The third district of promise is the Globe, which, while producing largely, is hampered by its position at a distance from the railroad. As yet no trustworthy account of the character of the deposits has been published, nor are figures accessible upon which to base any opinion as to the capacity of all of the mines to produce at low figures. Even closely adjacent works exhibit the extremes of success and failure. A number of smaller enterprises have not proved profitable, and are temporarily abandoned.

Outside of the districts mentioned are a number of mines provided with smelting works, among which the Peabody, now worked by the Cochise Copper Company, formerly in the hands of the Russell Gold and Silver Mining Company, deserves mention as a promising enterprise. The Pima Copper Company has closed down, and the furnace has been leased by other parties. In various sections of the Territory furnaces are built and building. So far as known, and judging alone from the progress made by the leading concerns, Arizona will considerably increase its output this year in spite of low prices.

Montana.—Though not equal to Arizona as a producer, Montana can boast of the most important district in the country outside of Lake Superior. With the exception of a small quantity of copper obtained in smelting argentiferous lead ores, the whole output of Montana comes from a small number of mines in the immediate vicinity of Butte City. For years rich copper ores were shipped from Butte to Colorado and the East, before the railroads reached it; but it was not until better transportation facilities had been afforded that the district began to figure as a heavy producer of the metal. The completion of the Utah and Northern railroad in 1880, by reducing the cost of fuel and the cost of shipment of product, made the establishment of local smelting works possible and stimulated the opening of the mines and the working of the ores in a degree which has carried the district into the foremost rank, which its peculiar advantages will enable it to maintain even under present conditions. The copper producers will also during the next few months enjoy the benefits of a competing road, the Northern Pacific, which besides will afford them an outlet to the Atlantic coast direct, to Lake navigation via Duluth, and in time to a number of points on the Pacific coast.

The copper deposits of Butte are a series of wide veins carrying argentiferous copper, sulphuret ores frequently high in grade so far as the base metal is concerned, and sufficiently large amounts of silver to bear the cost of separation and leave a profit. The mines yield notable quantities of ores ranging from 30 to 50 per cent., in copper, which are generally shipped abroad; one mine, the Anaconda, which has just begun the work of extraction after a long period of thorough development, having contracted for the sale of several thousand tons in Great Britain. The bulk of the ore is however, of course, lower in grade, ranging between 8 and 14 per cent. It is now quite generally concentrated, though at quite a heavy loss, in order to get rid of a large excess of silica, and is then chiefly smelted to matte in reverberatory furnaces, cupola furnaces being used for certain classes of lump ores. The character of the ores varies in the different mines. The ore from the Gagnon, from which the supplies of the smelter of the Boston & Montana Company are principally drawn, is high in silver, but also carries considerable zinc and some arsenic. The product of the smelting works, a matte running about 80 ounces of silver, goes for further treatment to the works of the Boston & Colorado Smelting Company at Argo, Colorado. The ore of the Colusa mine, worked by the Montana Copper Company, is purer; but until recently, when mineral higher in silver was struck in greater depth, contained less of the precious metal. The matte produced, containing from 60 to 70 per cent. of copper and 50 to 60 ounces of silver, has been until this year sold to refiners on the Atlantic seaboard. The bulk of it now goes to Swansea, where the higher price for the silver more than compensates for the lower returns on copper. The third large producer is the Parrott Company, working similar ores, and the fourth, the latest addition to the list, the Bell Company, both possessing mines and smelting works of their own. The Bell Company works ores more suitable for blast-furnace smelting and containing about one and one-half ounces of silver to the per cent. of copper, against two ounces for the Gagnon ores. The question of carrying up the silver contents in the furnace products made, is one of supreme importance to the Butte smelters. When it falls below a certain limit, 35 ounces per ton of matte, it does not pay to extract it; and every important addition to the quantity it holds, above that limit, enables the refiners to make better returns per ounce. For matte running from 60 to 70 per cent. of copper and from 50 to 80 ounces of silver, the silver contents, making due allowance for loss, represents an addition to the returns, per pound of copper, of from 3 to 4 cents. Even though Butte copper ores do carry some arsenic, which need not be so much feared in humid processes of extraction, the producers of the district have the advantage over their competitors as soon as they can bring up their grade of silver to the limits mentioned, of probably fully 3 cents per pound. When it is considered that with their comparatively cheap fuel and good railroad facilities, they could make copper at a profit, even at present prices, putting it down at the Atlantic seaboard at from 12 to 13 cents per pound exclusive of silver, it will be conceded that Montana copper will hold its own in any emergencies likely to arise. The existing works are now turning out metal at a rate which, barring accidents, promises to bring the make up to at least 20,000,000 pounds this year. The works are skillfully managed by metallurgists of experience and controlled by men of capital, and it seems probable that before the year has closed the work of erecting an additional large smelting plant will be planned to treat the ores of the Anaconda mine.

New Mexico.—The copper mines of New Mexico have been worked for centuries by the Spaniards, and later in a desultory way by Americans, Prof. J. S. Newberry, of the Columbia School of Mines, calling attention to the deposits in the Nacimiento mountains as early as 1860. The wealth in copper of the Territory is great, and a number of enterprises had fairly begun work during the latter part of the year 1882, and others have since been started. The first company to begin work was the Cañon del Agua at San Pedro, but at the outset trouble was experienced in working the ores, which it is reported is now overcome. The Santa Rita Copper and Iron Company started towards the end of the year, and the San Jose Smelting Company, adjacent to the Hanover district, a few miles from Silver City, was nearly ready for work. In the Sandia mountains east of Albuquerque Mr. C. L. Hubbs has mines and a smelter, large deposits are being developed near Shakespeare, and good prospects are reported from the Gila valley near Clifton, across the Arizona line. The Andreas mountains, which are also rich in copper, have been little developed; and the same may be said of the neighborhood of Tulerosa in the White mountains, in the southern part of the Territory, and of the country about Animas, near Lake Valley. A great deal of activity is being displayed in New Mexico which, from all accounts, has certainly much favorable ground, and is destined to figure more prominently in the returns during the present year.

California.—During the era of high prices and scarcity of labor in the mines of the East, the work was begun on the Pacific coast and a period of speculative excitement followed, which led to much misdirected outlay of capital, so that after a few years of growing productiveness a combination of circumstances suddenly brought the industry to an end. Without a local market and working mines containing very large bodies of low-grade ores, but only limited quantities of shipping ores, the limit of profitable exporting grade being 12 per cent., an increase in the freight rates killed the shortlived industry of which Copperopolis was the principal seat. The following figures for the exports during the years from 1862 to 1867 show the magnitude of the business and illustrate the tendency developed of transferring it to English smelters:

Exports of copper ores from California.

Years.	To New York.	To Boston.	To Swansea.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1862	86	3,574	....	3,660
1863	1,337	4,208	7	5,552
1864	4,905	5,064	264	10,233
1865	4,146	9,050	2,591	15,787
1866	7,676	3,415	10,384	21,475

After the collapse of this early effort, copper mining languished, and it was only by the most persistent work on the part of the managers of the San Francisco Copper Company, working mines at Spenceville, Nevada county, that the fact was demonstrated that low-grade ores may be profitably worked in California. With some slight modifications, the plan is the same followed where poor pyrites are treated. The ore is roasted in large piles, leached and precipitated with scrap iron, a cement being produced which contains about 84 to 86 per cent. of metal. The Spenceville ore carries only a low percentage of copper on an average, and the yield of this and the Newton mines is placed at about 600 tons of cement. A considerable proportion of this is used in the manufacture of bluestone, for which the silver mills of the Far West offer a fair market. A small quantity is shipped to be refined.

As in the Rocky mountain States and Territories, copper mining is attracting considerable attention now. Mr. C. G. Yale, of San Francisco, furnishes the following data in regard to recent developments: "Smelting works of a capacity of 25 tons per day have been put up at Campo Seco, Calaveras county, and it is expected that a considerable amount of metal will be run out during the current year. Mr. H. D. Ranlett has also arranged for putting up leaching works at the same place for treating the ores of the old Lancha Plana mine, now called the Satellite. From this mine 2,000 tons of ore were extracted last summer, 500 tons of which were shipped to Baltimore, Maryland, the balance being retained for treatment at the mine. This is one of the few mines in California which have yielded native copper in considerable quantity."

Whatever the developments of the future may bring—and there is no doubt that there are numerous copper deposits along the foothills of the Sierra Nevada—at present California plays an unimportant part. Some of the pyrites mines, though of great magnitude, cannot for some time look to aid through the creation of a market for sulphuric acid, though at Spenceville the utilization of the sulphurous acid obtained in roasting, as well as the production of iron sponge from the residues after leaching, has been considered.

In 1882 shipments of copper ore from San Francisco to England by sea amounted to 864,700 pounds. During the same period the railroads carried eastward the following amounts:

Eastward shipments of copper from California by rail in 1882.

	From—	By Central Pacific railroad.	By Southern Pacific railroad.
		Pounds.	*Pounds.*
Copper	Sacramento	126,541	
Cement copper	....do	1,510,070	
Do	San Francisco	150,880	134,290
Copper ore	Stockton	100,000	

Colorado.—Mr. F. F. Chisolm, of Denver, has kindly prepared the following data relating to the production of Colorado. Copper is found in many sections, but the production of copper bullion from any single locality is limited. The mines at the towns of Central, Black Hawk, and Nevada, in Gilpin county, are the largest producers, the ores being a sulphide of copper and iron carrying gold and silver. The ore from this locality is shipped to the Boston & Colorado smelter at Argo, and to the smelters at Golden. Considerable quantities of copper ores are shipped from the San Juan mountains to the Pueblo Smelting and Refining Works at Pueblo, while a small proportion is treated at the Crooke Mining and Smelting Company's works at Lake City.

Quite recently the deposits of copper ore north of Cañon City have received considerable attention, and the mines in that locality are now regularly shipping oxidized copper ores to the Pueblo Smelting and Mining Company at Pueblo. Nowhere in Colorado are copper ores treated for their copper contents alone. The product of Colorado to January 1, 1883, is as follows:

Value of the copper product of Colorado.

Previous to 1870		$40,000
1870		20,000
1871		30,000
1872		45,000
1873		65,000
1874		90,197
1875		90,000
1876		70,000
1877		93,796
1878		89,000
1879		131,000
1880		184,000
1881		161,000
1882. Boston and Colorado smelter	$127,000	
Pueblo Smelting Company	63,720	
Miners' Smelting Works, Golden	45,632	
Moore Mining and Smelting Company, Golden	24,210	
Crooke Mining and Smelting Company, Lake City	8,000	
		268,562

The tonnage of copper bullion produced in 1882 was as follows:

Copper production of Colorado in 1882.

	Tons.
Boston and Colorado Smelting Company, Argo	354
Pueblo Smelting and Refining Company, Pueblo	177
Miners' Smelting Works, Golden	127
Moore Mining and Smelting Company, Golden	67
Crooke Mining and Smelting Company, Lake City	22
	747

The copper produced from Colorado ores is more or less injured in quality by small quantities of tellurium, arsenic, antimony, bismuth, etc., which render it "red short," and materially reduce its value.

Utah.—During the past few years this Territory has also come forward as a producer of copper, the output in 1882, according to estimates by Messrs. Wells, Fargo & Co., having been 605,880 pounds, the bulk shipped probably in the form of auriferous and argentiferous mattes to the works of the Boston & Colorado Smelting Company at Argo, Colorado. The principal work done thus far is in the Tintic district, in the Crismon-Mammoth property, where thirteen matting furnaces have been put up to concentrate the ore into matte. The works are now idle. It is proposed to separate the precious metals from the copper by the electrolytic process, and the machinery for that purpose has been already provided. But as little more than working tests have been made, except in a few localities where the results of experience are strictly guarded as a secret, competent metallurgists express doubts that success will be reached without a protracted period of experimental work. The process is by many regarded as the most promising means of solving the question of separating gold and silver from copper ores, and it holds out the advantage of producing a pure copper from the impure ores generally associated with the precious metals. It has been held that the copper could be deposited in a form fit for immediate use in the rolling-mill, but experience abroad has dispelled that idea, and copper produced by electrolytic means is now often remelted.

Among the other districts which have attracted attention in Utah, during the past few years, are the Ewing in northwestern Utah, and the Beaver district. The rapid development of the railroads in the Territory and the opening out of its coal mines will tend materially to aid the copper industry.

Idaho.—As yet comparatively little attention has been paid to the copper deposits of Idaho, though their existence on a promising scale is well known in Ada, Alturas, Custer, and Lemhi counties, and on the divide between the Weiser and Salmon rivers. The mines in the Heath district, Ada county, have been prospected slightly, but until now only very small quantities of matte have been made in smelting silver ores. The completion of the Oregon Short Line, which will reach the mining districts, gives promise of leading to more extensive development.

Wyoming.—The latest Territory to assume a rank in the list of copper producers has been Wyoming. The first discovery of copper ore, according to an account by Mr. F. J. Stanton, kindly transmitted through Mr. F. F. Chisholm, was made in March, 1881, by Mr. H. T. Miller, one and a half miles north of the Platte river, 90 miles north of Cheyenne and 15 miles from Laramie, the ores being chiefly oxides and carbonates. Small shipments of rich ores were made during that year and the following year to the Miners' Smelting and Reduction Works at Golden, Colorado; and to the Northwestern Reduction Works, now the Chicago Copper Company. According to assays upon which the sales were made the ore carries from one-third to one-half of an ounce of silver for each per cent. of copper. During 1881 the copper contents of the ore shipments were only 75,000 pounds; while in 1882 they were 107,000 pounds. In addition to this the smelter started in the beginning of this year at Fairbanks has turned out 330,000 pounds of bars, carrying the total product to nearly 400,000 pounds. The refined Wyoming copper has now made its appearance upon the Eastern markets, and is reported to be good metal.

Nevada.—Though copper deposits of magnitude are known to exist in Nevada, they have as yet added only insignificant quantities of metal to the output of the country. Small amounts of ore have been extracted for the manufacture of bluestone, and from the Battle Mountain district ore shipments to England have been made for a series of years. The only smelting works are those of the Esmeralda Copper Company at Soda Springs. The crude metal as offered in the markets of the Atlantic seaboard has, however, proved to be very arsenical, and it will be necessary that some modifications be made in the metallurgical treatment before favorable financial returns can be made. The ores (oxides and carbonates) are reported to be high in grade, and the character of the black copper received may be due only to local causes. The Santa Fé and Soda Springs mining districts have good railroad facilities, and are therefore in this respect exceptionally well placed.

Missouri.—The copper mining industry of Missouri is one of recent growth and is confined to the deposits in Sainte Genevieve county, which according to Mr. Frank Nicholson occur in the second of the lower limestone series of the Lower Silurian system, the copper occurring in two nearly horizontal sheets. The Cornwall mines are the only ones in which much work has been done, and which possess smelting and refining works, the latter also occasionally doing work for outside parties. Prof. M. B. Potter, of Washington University, Saint Louis, Missouri, estimates the cost of making copper at Sainte Genevieve, when producing 150 tons of dressed 20 per cent. ore per month, to be 8.56 cents per pound of refined copper delivered at Saint Louis.

The Eastern States.—From Maine to Georgia there is hardly a State which has not during the past twenty years at some time furnished smaller or greater quantities of copper, but a permanent supply has come only from a few points. The movement to replace brimstone by pyrites in the manufacture of sulphuric acid has revived the interest in the development of a number of properties; and it is believed that some of them will be found capable of meeting the stringent specifications of buyers of pyrites and build up a business which, largely independent of the copper trade as it is, will add to the output of that metal in spite of low prices.

Maine.—The deposits of Maine attracted little attention until in 1879 and 1880 the general revival of interest in mining led to the investment of capital in Maine copper mines. On the whole the results attained were disappointing; and though a goodly share of the failures was due to mismanagement, the resources of the State in this respect, however interesting they may be locally, do not appear to be on a scale likely to materially affect the general copper trade of the country.

New Hampshire.—In New Hampshire the only deposit of magnitude is the pyrites mine of Milan, which recently has been steadily worked.

Vermont.—This State has been the steadiest copper producer in the East, the Ely mine having, though poorly managed, for many years contributed annually from one to two and a half millions of pounds of copper from a low grade of pyrites. Recent efforts to introduce modern methods of smelting and concentration have not as yet been carried to a successful issue, chiefly because of dissensions among the parties interested, and the mine is now idle. Smaller quantities of copper have been produced at the Elizabeth mines. The Vermont copper has always been refined at Ansonia, Connecticut, and going directly into consumption there, the magnitude of the production has not been suspected except by a few and has been generally underrated by statisticians.

Massachusetts.—Massachusetts has from time to time furnished ores in small quantity. Now an effort is being made, successfully, to introduce the pyrites of the Davis mine near Charlemont, the ore being burned at the rate of 1,000 tons per month.

Pennsylvania and New Jersey.—These States have repeatedly had their copper excitements, but very little is being done at present. The same is true of Maryland.

Virginia.—In Virginia cupriferous pyrites have been discovered and opened out in a number of places, large bodies in some instances of very good quality having been proved. With fair facilities for shipment to tidewater, and as the basis of a great local manufacture of sulphuric acid in connection with the making of phosphate fertilizers, they are considered capable of important development. During the past month, active work in the pyrites mines at Tolersville shows that a good start has at last been made.

Tennessee.—This State was at one time the seat of an important copper industry, with Ducktown as its center, producing for years upwards of a million and a half pounds of copper. But for some time the mines have been practically abandoned, and it is not likely that they will assume a prominent position, notwithstanding the magnitude of the deposits, until they have been made more accessible by railroad connections.

North Carolina.—In North Carolina the principal producing mines are those of Ore Knob, which have, however, of late lost much of their former importance.

Georgia.—In Georgia the Tallapoosa mines furnish cupriferous pyrites to the acid works at Augusta.

Alabama.—At one time copper was produced at the Stone Hill mines.

REVIEW OF THE COPPER MARKET.

A brief résumé of the leading features of the copper market in New York from year to year since 1875 will best serve to show the causes which have in the past affected values, and will afford an opportunity to gauge their strength as affecting the situation at the present time and in the early future. It should be stated that, unlike the case of other metals, which are now distributed from a number of seaboard and interior markets, occasionally so influenced as to be almost independent of one another, New York and Boston are still almost the only markets of any consequence for copper. The principal consumers, the great copper rolling and brass manufacturing interests, are still centered in the East, and there has not as yet been the strong tendency to a shifting of the center of manufacturing westward which has so strikingly developed in other industries.

1875.—In 1875 the markets for copper were very quiet, the business of the consumers being moderate, while the metal was strongly maintained by producers, there being none of the speculative interest of the previous year. The export sales of Lake aggregated 6,000,000 pounds, the rise after the end of April being due to the supplying of consumers with 5,000,000 pounds of copper at 20 cents, followed in August by additional sales of 3,000,000 to 4,000,000 pounds. The foreign markets were steadied by armament purchases. The figures given for Chili bars are the quotations on the first of each month. It is impossible to attempt to give with sufficient accuracy the average for each month, and though the figures quoted do not reflect the movement of prices in detail, they give a fair estimate of their course in general.

Price of copper in 1875.

Months.	Lake Superior ingot, in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	23½	21⅛	£84 00
February	22¾	21¾	82 10
March	21½	21⅛	82 00
April	21¾ (21E*a*, 20C*b*)	22⅛	80 00
May	22⅝	23¼	82 10
June	23	23	83 00
July	23	22⅝	81 10
August	23⅜ (23C*b*)	23	79 00
September	23⅞	23⅛	82 10
October	33¼	23	82 10
November	28¼	23	82 00
December	23⅜	23⅜	81 00

*a*E signifies for export, *b*C for home consumption.

1876.—The following was the range of prices of Lake copper in 1876 and of Chili bars in London. The prices at which leading sales for export and to manufacturers were made are added in parentheses:

Price of copper in 1876.

Months.	Lake copper in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	23¼	23	£81 10
February	22⅞ (21 E.)	22½	81 00
March	22¼ (21 C.)	22	76 00
April	22⅝	22	77 00
May	22⅛ (19 E.)	21	79 10
June	21	19¼	77 10
July	20	19½	74 00
August	19½ (19 C.)	18¾	72 00
September	21 (19 E.)	18¾	71 10
October	21¼	20½	72 00
November	20½	20	76 10
December	20	19⅝	76 10

Throughout the year the demand for consumption was not up to the requirements of a growing production. The price weakened through offerings of outside lots during February, and the market dragged along, with occasional short-lived spasms of activity, until about 8,000,000 pounds of Lake were sold for export at 21 cents, and a little later manufacturers contracted for the delivery of 5,000,000 pounds at 21 cents. The metal for a while fairly held its own, receding slowly in consequence of a slack business, until the companies cleared away 4,000,000 pounds to foreign buyers at 19 cents, approximately. In August consumers again took 3,000,000 pounds at 19 cents, but prices did not stiffen until an additional lot of 4,000,000 pounds was sold for export at 19 cents. With a moderate business doing, except in one week in October, copper gradually fell off to the close of the year.

1877.—In spite of all efforts to maintain values, 1877 proved a year of almost uninterrupted decline, as the following table shows:

Price of copper in 1877.

Months.	Lake Superior in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	19½	19	£76 00
February	20½ (19 E.)	19½	73 00
March	19½	19	71 10
April	19½	19¼	70 10
May	19¼ (19¼ C., 19¼ E.)	19	68 10
June	19⅜	19	69 00
July	19¼	19	69 00
August	19 (18½ C.)	17⅞	69 00
September	18½ (17½ E., 18 C.)	17⅞	67 10
October	18	17¾	65 10
November	17¾	17⅝	65 10
December	17¾	17½	63 10

The feature of the year was the continuance of heavy export sales, aggregating 11,505,032 pounds, and distributed roughly as follows:

February, 5,000,000 pounds, at 19 cents; May, 3,500,000 pounds, at 19¼ cents; September, 3,000,000 pounds, at 17½ cents.

In addition to this, the sales for cartridges at private terms are supposed to have footed up 2,000,000 pounds. Weakness on the part of speculative holders contributed to demoralizing the market in February and October, and this element remained inactive until November, when a moderate lot was taken above the ruling market price. Manufacturers contracted for 4,000,000 pounds in May at 19¼ to 19½ cents, for 2,500,000 pounds in August at 18½ cents, and for an additional 1,000,000 pounds at 18 cents in September. The course of the London market was throughout unfavorable, and under the circumstances operated steadily to press our own.

1878.—The average of prices during the year was:

Price of copper in 1878.

Months.	Lake copper in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	17⅝	17¼	£66 00
February	17½	17⅛	65 10
March	17⅛	16⅞	65 00
April	17 (16 E.)	16⅞	63 10
May	16¾ (16¼ E., 16½ C.)	16¼	62 00
June	16⅜	16¼	65 00
July	16¼	16	64 00
August	16	16	61 10
September	16¼	16	61 00
October	16 (15½ C.)	15½	60 00
November	15⅞	15½	57 10
December	16	15⅞	59 00

A variety of causes contributed to make the year one of uniform and almost uninterrupted decline of values to a point never before witnessed in the American copper trade. The business of domestic manufacturers was not brisk, and the stagnation in Europe (repeatedly turned to a sharp downward movement by the failure or death of large holders of copper there and in Chili) did not afford the Lake companies a fair opportunity to market their surplus abroad. The export was heavy, 13,000,000 pounds, chiefly contracted for at the beginning of the year, in April and May, at 16 and 16¼ cents. Pool sales to consumers were made twice, 6,000,000 going off in May at 16½ cents, and 9,000,000 in October at 15½ cents. Besides this, approximately 4,000,000 pounds were sold to cartridge manufacturers for export, so that except other brands of copper competing a little more this year, the quantities at any time available in the open market from producers direct were small. Small consumers were, as usual, supplied chiefly by the dealers, who, as a rule, entered into the pool sales, probably with the understanding that during the time of delivering first hands should not offer below the price at which their purchases were effected.

The decline in October on both sides of the Atlantic was principally due to the panic created in commercial circles in England by the collapse of the City of Glasgow Bank, causing a feeling of great uneasiness here.

1879.—The range of prices was as follows:

Price of copper in 1879.

Months.	Lake copper in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	16 (15½ E.)	15⅛	£58 00
February	15½	15⅛	56 00
March	15¾	15½	55 00
April	15¾ (14 E.)	16	56 00
May	16½ (16 C.)	16	56 00
June	16¼	16⅛	55 00
July	16⅛	16	56 00
August	16⅜ (16 C.)	16	53 00
September	17	16¼	54 10
October	21½	18	61 00
November	21¾ (22 C.)	21	66 00
December	21½	21	66 10

Opening with a dull feeling in all the markets of the world, Lake copper declined gradually, in spite of the fact that 13,000,000 pounds were contracted for during the first four months for export; the first and smaller lot, presumably 5,000,000, going off at 15½ cents, while the later, larger lot, closely upon 8,000,000, was taken at 14 cents. The depression in England became so great that it was decided in Australia to close down the Wallaroo mines, though highly favored through high grade of ore and exceptional purity of copper produced. The Wallaroo is, in fact, with the exception of electrolytic copper, one of the very few brands that can compete with Lake in quality, Burra Burra and Cape standing lower, followed by Best Selected. In May, manufacturers realizing that supplies might be inadequate under a gradually improving demand, bought 3,000,000 to 4,000,000 pounds at 16 to 16⅛ cents in May, and took 6,000,000 pounds at 16 cents in August. The market gradually stiffened in September, a small lot besides going abroad for export. In October copper was carried upward by the sudden tide of speculation that swept over the country, a movement facilitated in the case of this metal by the fact that previous pool sales had been exclusively to manufacturers, so that dealers had short supplies only; speculators, who had become disgusted by years of adverse trading, had none, and the stock was, therefore, concentrated in strong hands. The upward movement, which was chiefly engineered by outside elements, received a check, however, by the reimports of Lake copper previously shipped abroad, notwithstanding the fact that the foreign purchasers were supposed to be bound not to allow copper once sent from here to return, an agreement which they practically could not carry out, even if they so desired. In November, manufacturers again came forward to secure supplies for delivery during the first months of 1880 at 22 cents. Abroad, the effect of the Chili-Peru war did not prove, as was expected, a cause of scarcity, ample supplies coming forward from other quarters.

1880.—As the following summary of the range in values for 1880 will show, the first half of the year was characterized by a period of reaction, after the culmination of the speculative movement:

Price of copper in 1880.

Months.	Lake copper in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	25	21⅜	£65 10
February	24½	24	72 00
March	24	22¾	70 10
April	22½	21	65 10
May	21	18	60 00
June	18½	17⅞	56 00
July	18⅞	18½	60 00
August	19⅛ (19 C.)	19	61 00
September	18⅞	18¾	61 00
October	18⅞	18¾	60 00
November	18⅞	18¾	61 00
December	19⅛	18⅞	61 00

The year opened with a speculative buying on an extended scale, which in a short time ran up prices from 21⅜ to 25 cents, the latter figure, however, being paid only for smaller lots. The conviction had gained ground among the trade, as well as among outsiders, that supplies would be inadequate to meet the current demand for manufacturing purposes; but when February and March passed away, a disappointment to holders, values gradually gave way under offerings by weaker speculators, until the reaction had carried them to their natural level. Consumers, as usual on a falling market, were hard to move, and were aided by the heavy amounts of reimports of Lake copper, making the bulk of the 4,540,671 pounds of copper imported during the year. It was only late in the season, in August, that a pool sale of six to eight million pounds of Lake was effected at 19 cents. Months of dullness, as is generally the case, followed the supplying of the manufacturers and dealers, but prices were well held till the close of the year, when a slight improvement set in. The shipments abroad were light, and the foreign markets, therefore, exerted comparatively little influence upon our own.

1881.—The year 1881 was in many respects an extraordinary one, as a glance at the following summary of the fluctuations of prices will show:

Price of copper in 1881.

Months.	Lake copper in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	
	Cents per pound.	*Cents per pound.*	*Per ton.*
January	$19\frac{3}{8}$	$19\frac{1}{8}$	£62 00
February	$19\frac{3}{8}$	$19\frac{1}{8}$	62 00
March	$19\frac{3}{8}$	19	61 00
April	19	$18\frac{3}{4}$	61 00
May	$18\frac{7}{8}$	$18\frac{1}{4}$	58 10
June	$18\frac{1}{4}$	$16\frac{3}{4}$	59 00
July	$16\frac{1}{2}$ (16 C.)	16	58 10
August	$16\frac{5}{8}$	$16\frac{3}{8}$	59 00
September	$18\frac{1}{8}$	$16\frac{3}{4}$	59 05
October	$18\frac{3}{8}$	18	62 10
November	19	$18\frac{1}{8}$	63 00
December	$20\frac{3}{8}$ (20 C.)	$19\frac{1}{4}$	67 00

The year opened quietly, with a firmness on the part of producers which, in spite of the small volume of business, kept prices fairly well maintained, until in May it was found necessary to market nearly 8,000,000 pounds of Lake copper abroad. Meanwhile, the stories of extensive developments of new deposits of copper in the southwestern Territories, backed by the appearance in the market of growing quantities of other brands of copper, had strengthened the position of buyers and had given them hitherto unheard-of opportunities of keeping out of the market for Lake copper. There is no doubt now that the immediate effect of the developments referred to was largely overrated then, not alone by consumers, but also by producers. The latter, seeing their metal accumulating on their hands and noting a steady decline in spite of their export sale, became alarmed, and in June offered the Lake copper freely at 17 cents. In July about 2,000,000 pounds were taken by consumers at the range of 16 to $16\frac{1}{2}$ cents; and later, in September, further large sales were made at 17 cents, the price being immediately carried to 18 cents. It became more and more apparent that the scare of the summer months was not warranted by the actual state of affairs at the time, and the market again passed into the firm control of the Lake companies, who by their unshaken attitude carried values upward gradually, until at the close of the year five to six millions of pounds at 20 cents were taken by manufacturers to cover winter requirements.

It will be noted that in the year 1881 copper from other sources than the Lake Superior district for the first time played an important part in shaping the course of the markets. The future was heavily discounted, and a natural reaction placed the control of the metal back into the strong hands which had for so many years wielded an exceptional power. In the earlier days of the decade which has now passed a speculative element had occasionally sought to take advantage of possible future contingencies. Repeated failures of such efforts had thoroughly discouraged outsiders, and the trade drifted into such a position that the Lake companies from time to time made contracts for delivery to the manufacturers and the principal dealers, usually with the understanding that first hands would not supply the trade direct during that period, except at a price which would allow the latter to distribute the purchases made to fill the requirements of smaller buyers. The result has been a period of dullness following a sale, until the pending end of deliveries on the contracts led to renewed negotiations, often prolonged by either the firm attitude of producers or of consumers. The latter have repeatedly held off for a long time to depress values, while the former, closely watching the foreign market and the home trade in manufactures, have relieved thomselves of an estimated surplus by export sales. These have generally been possible by concessions which made the returns lower than the prices which it was possible to maintain here by such a course. The best markets for our Lake copper have been England and France, though other countries have at times taken large blocks for armament purposes. It will be noted that for years a considerable proportion of the exports were made in the form of cartridges, the Lake companies placing the manufacturers here in a position to undersell their foreign competitors. This, however, ceased after foreign governments had purchased full complements of our cartridge-making machinery in this country, a course which, however, made them dependent, at least for some years, upon our raw material, as its use presupposes copper of the very highest mechanical properties.

The year 1881 witnessed the beginning of a heavy production in other districts, but its influence, as already stated, was only temporary, and was counterbalanced by an extraordinary demand for machinery brass and similar alloys, and particularly for electric-lighting plant, thus coming to the rescue of a market that threatened to sink under the burden of a heavy overproduction.

1882.—These contending influences were at work during the year 1882 and kept the market fairly steady, as the following summary of the fluctuations during that period will clearly show:

Price of copper in 1882.

Months.	Lake copper in New York.		Other brands in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	Highest.	Lowest.	
	Cts. per lb.	*Cts. per lb.*	*Cts. per lb.*	*Cts. per lb.*	*Per ton.*
January	20⅜	20¼	20	19¾	£71 00
February	20	19	19½	18¾	64 15
March	19¼	18⅞	19	18½	64 00
April	18½ (18 C.)	17⅞	18¼	17⅝	64 00
May	18¼ (16 E.)	18	17¾	17½	63 10
June	18¼	18	17¾	17⅝	68 10
July	18¼	18⅛	17¾	17⅝	67 00
August	18¼	18⅛	17¾	17⅝	68 10
September	18¼ (18 C.)	18	17¾	17⅜	67 10
October	18¼	18	17½	17¼	71 00
November	18⅛	18	17½	17¼	69 10
December	18	17⅞	17⅜	17⅛	66 10

Manufacturers being well supplied and the demand for speculative purposes very small, the price of Lake gradually receded under slight offerings. It was evident that the supplies contracted for would amply meet all the needs. Consumers were firm and only bought a little more freely towards the close of February. Meanwhile the pressure of outside brands began to get heavy, and as the best of them were easily obtainable for half a cent less than Lake, though equal to it for many purposes, consumers found it possible to hold off. March passed away quietly, with these influences steadily shaping to lower figures until in the middle of April the companies came forward contracting for the sale of 20,000,000 pounds at 18 cents, thus supplying all the principal consumers for a number of months. This of course had the result of making the market for Lake copper uninteresting for a long period, the only transaction worthy of note being an export sale of about 3,000,000 pounds at 16 cents in the middle of May, which for a time caused a flurry and a temporary upward turn of prices, notably of outside brands, of which considerable quantities were simultaneously purchased by consumers here, probably with the intention of guarding against any possible scarcity. June, July, and August were dull, business being restricted to the marketing of outside brands at a pretty steady decline. The table given above will serve to illustrate this movement. It is only necessary to add that the figures represent the prices of the better brands, less well-known grades of copper being generally placed at a sacrifice. There are other circumstances which made it a difficult matter to follow closely the marketing of this copper. More than one-third of the copper other than Lake is refined by one concern, which is at the same time closely associated with a leading manufacturing company and one of the greatest firms of dealers in the country. Very little of this copper reaches the open market, being either used in manufacturing or distributed to the small trade in minor quantities. In the beginning of September the Lake companies again sold ten to twelve millions of pounds of copper at a price reported to be 18 cents. The fact, however, that the reports of the majority of the copper mines for the year indicate a lower figure would warrant the inference that it was probably less. This seems probable, because the export sales during the year were comparatively unimportant, so that the average receipts per pound could not have carried the figure down considerably. Round lots of other brands were sold simultaneously at prices a little more than half a cent less, and the market again relapsed into inactivity. The small quantities of Lake copper offered were disposed of at fair figures, and it was only toward the close of the year that the pressure to sell other brands, causing a steady decline in their values, began to affect Lake copper. That the heavy production of the year did not more promptly and more seriously affect the values must be attributed to a number of causes. The fact that its effect had been overrated a year before had led to more conservative views, both on the part of consumers and producers, and the manner in which much of the increase in Arizona and Montana copper was marketed was such as to disguise its magnitude. The consumption, too, was very heavy, except towards the end of the year, when the tariff agitation began to press upon business.

1883.—The first six months of the year 1883, by removing all doubt as to the magnitude of the supplies, brought about the decline for which the way had been paved during the whole of the year 1882. The fall was precipitated by the unusual and prolonged dullness in business. In detail the fluctuations in values were as follows:

Price of copper during the first six months of 1883.

Months.	Lake copper in New York.		Fair western in New York.		Chili bars in London. Opening quotations.
	Highest.	Lowest.	Highest.	Lowest.	
	Cts. per lb.	*Cts. per lb.*	*Cts. per lb.*	*Cts. per lb.*	*Per ton.*
January	18⅛	18	17	16½	£66 15
February	17⅞	17¾	16⅛	15¾	64 15
March	17⅝ (16 E.)	17⅛	15¾	15⅛	65 10
April	16	15¾	15	14½	62 00
May	16	15⅞	15	14½	64 00
June	15⅞ (15 C.)	15	14⅞	14	64 00

In the early part of January manufacturers contracted with Lake companies for the purchase of ten to eleven million pounds of copper, approximately two to three months' demand, at 18 cents. The result was that sellers of other brands began to show much anxiety in disposing of their product, and a decline was precipitated, which more and more widened the gap between the quotations of Lake and of other brands. This brought out from week to week small lots of Lake to be resold by those manufacturers who desired to realize a profit by using Western copper. Under the pressure thus brought to bear, Lake copper slowly receded, and in turn forced down the price of competing brands. This decline was rendered more rapid still by the efforts of sellers of unknown brands to obtain a foothold, and by the throwing upon the market of Western copper by bankers who had made advances upon it. The eagerness of holders to place their metal naturally increased the reluctance of buyers, who were confirmed in their position by the fact that the demand for manufactured goods was slack and had been made worse by the competition for trade by makers, of whom each believed himself to be capable of outbidding others because of low purchases of raw material. The demoralization in the latter spread to the manufacturing trade, which only aggravated the evil. In the middle of March the Lake companies sold about 7,000,000 pounds of copper for export, and when this movement did not seem to check the decline or shake the position of buyers, they suddenly, in the beginning of April, began to be free sellers at 16 cents. A considerable quantity of copper was placed, but there was not, it appears, a pool of sellers negotiating with the principal buyers. The first effect of this sudden turn was to force a few small holders to realize at lower figures. Since then Lake was pretty firmly held at 15⅞ cents, and has slightly recovered, the quantities offered being slight in April and May. In June the Lake companies again came forward, contracting for the delivery of 20,000,000 pounds to consumers at 15 cents. Meanwhile other brands dropped off, particularly those not having a recognized standing or marketed under special circumstances. The quotations given above are for fair brands; they are higher, in some cases as much as one-quarter to three-eighths of a cent, than the figures which have formed the basis of actual transactions. They are lower, on the other hand, than the prices readily obtained for certain special brands made of black copper produced from the pure oxidized ores, notably of Arizona, and which range only one-half of a cent lower than Lake copper. It is striking that the differences should be so great, being in some cases as much as 1½ cents per pound. There can be no doubt that, intrinsically, copper refined carefully and having no grave quantities of impurities is worth more than the difference in quotations would indicate. Chili bars containing only 96 per cent. of copper have been occasionally sold in this market during the past ten years, and generally the difference was not more than 1½ cents per pound.

As yet the low price of copper has not had the effect of stimulating consumption, though it is likely that the use of the metal will be on a more liberal scale in the future. The development of the many applications of electricity for lighting, and the transmission of speech and of power, is going on at a rate which promises much for the copper interests. The quantities absorbed for the construction and renewal of machinery and railroad rolling stock are steadily on the increase, and brass is rapidly gaining in favor as a material for decorative purposes. Notwithstanding all these elements in its favor, there is little prospect of a permanent rise in value in this country independent of a simultaneous upward movement abroad. The principal reason for this view must be sought in the fact that we are now very heavy exporters of raw material. The engagements thus far and the prospective further shipments abroad, made reasonably certain by special circumstances, foot up to at least 30,000,000 pounds of copper, diverted from our own markets. The Lake companies have contracted for the shipment of at least 7,000,000 pounds, and 3,000,000 pounds of Arizona black copper have also been sold abroad. The greater part of the copper exported will, however, be argentiferous ores and furnace material, principally mattes, aside from the ingot copper and matte from treating pyrites, re-exported with a drawback. So long as the price of copper here is near the parity of copper in London, argentiferous material will seek that market. Favored by low prices of labor and fuel, and working with a modern process, which, it is said, permits close work, the details of which are not yet known, one firm of Swansea smelters can outbid our own refiners. The lower price obtained for copper abroad is more than balanced by the lower cost of working and the higher price paid for silver. In consequence, the bulk of the matte produced by independent works in Butte, Montana, goes to Swansea, the quantity being close upon 18,000,000 pounds. In addition to this, the Anaconda, a thoroughly developed Butte mine in the hands of very strong parties, has contracted for the delivery of 6,000 tons of very high-grade ore, pending the building of smelting works. This furnace material would promptly seek a market in this country should any important rise take place here not coinciding with a corresponding advance in England. It would not of course at once check an upward movement, because it would take some time before appearing on the market. It would, however, aid in carrying values back to a figure more closely harmonizing with those ruling in the markets of the world. It is, too, a factor which from all the indications of the present is destined to exert even a more powerful influence in the future. On the other hand, it must not be forgotten that in all estimates of the production and the available supplies, for the present at least, it relieves the market. How long American metallurgical skill will allow this movement to continue remains to be seen.

EXPORTS.

The following tables show the exports of domestic copper in the form of bars and ingots, of domestic production, and as copper ore. The third table, giving the quantities of foreign ores and metal exported, throws light upon a movement which, since the change in the law in 1869, which checked the growth of the smelting industry of the Atlantic coast, has not had much significance.

Copper pigs, bars, sheets, and old copper of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Quantity.	Value.
	Pounds.	
1872	267, 868	$64, 844
1873	38, 958	10, 423
1874	503, 160	123, 457
1875	5, 123, 470	1, 042, 536
1876	14, 304, 160	3, 098, 395
1877	13, 461. 553	2, 718, 213
1878	11, 297, 876	2, 102, 455
1879	17, 200, 739	2, 751, 153
1880	4, 206, 258	667, 242
1881	4, 865, 407	786, 860
1882	3, 340, 531	565, 295
Calendar year 1882	2, 999, 671	534, 449

Copper ore of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Quantity.	Value.
	Cwts.	
1872	35,564	$101,752
1873	45,252	170,365
1874	13,326	110,450
1875	51,305	729,578
1876	15,304	84,471
1877	21,432	109,451
1878	32,947	169,020
1879	23,070	102,152
1880	21,623	55,763
1881	9,958	51,499
1882	25,936	89,515
Calendar year 1882	44,100	179,837

Copper ore, pigs, bars, ingots, etc., of foreign production exported from the United States during the fiscal years specified.

Years.	Ore.		Pigs, bars, ingots, old, and other unmanufactured copper.		Manufactured copper.
	Quantity.	Value.	Quantity.	Value.	Value.
	Cwts.		*Pounds.*		
1872	317	$2,023			$5,383
1873			435,837	$101,810	13,949
1874			584,959	108,123	14,784
1875	5,110	20,318	23,670	3,691	79,432
1876	971	10,513	34,884	3,718	207,119
1877			98,178	13,023	254,838
1878	1,200	1,400	126,847	13,388	122,845
1879	1,938	16,478	120	30	8,496
1880	2,268	9,810	233,457	42,532	14,357
1881	2,094	6,545	664,564	103,286	13,304
1882	9,049	28,814	108,504	18,636	13,575
Calendar year 1882	19,635	61,585	2,312	204	13,779

The exports of manufactured copper of domestic production at times, as will be seen, assumed considerable importance, due entirely, however, to arrangements between producers and manufacturers in relation to the shipment of cartridges to foreign governments. The business in manufactured goods for export is regarded by many as one which is destined to be of great promise, and the latest developments give encouragement to that view.

Manufactured copper of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

	Value.
1872	$121,139
1873	78,288
1874	233,301
1875	43,152
1876	343,554
1877	195,730
1878	217,446

	Value.
1879	$79,900
1880	126,213
1881	38,036
1882	93,646
Calendar year 1882	112,246

IMPORTS.

The imports of copper, of ores, and of manufactured goods have varied widely during the past ten years, as is proved by the following tables. The figures for ingot copper, however, include reimports of domestic copper, and a considerable quantity of the metal in the ores, notably during the past few years, is re-exported under the drawback system.

Copper pigs, bars, ingots, old copper, and other unmanufactured copper imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

Years.	Quantity.	Value.
	Pounds.	
1872	5,106,330	$1,040,458
1873	13,156,456	2,635,604
1874	1,544,600	287,978
1875	930,103	144,448
1876	1,741,128	271,266
1877	1,680,183	254,696
1878	370,596	49,100
1879	154,955	17,961
1880	5,262,086	821,329
1881	718,616	86,433
1882	744,566	90,945
Calendar year 1882	477,764	55,414

Copper ore imported into the United States during the fiscal years specified (specie values)

[Dutiable.]

Years.	Quantity.	Value.
	Cwts.	
1872	27,110	$85,622
1873	15,900	57,950
1874	5,461	71,111
1875	46,231	179,239
1876	18,397	71,180
1877	318	2,475
1878	7,838	84,359
1879	2,152	20,689
1880	40,743	185,080
1881	88,436	165,806
1882	163,819	157,708
Calendar year 1882	433,378	172,161

Manufactured copper imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

	Value.
1872	$800,478
1873	1,051,492
1874	163,656
1875	203,623

	Value.
1876	$243,962
1877	330,016
1878	322,418
1879	276,746
1880	409,803
1881	387,076
1882	315,475
Calendar year 1882	299,874

OUR FOREIGN COMPETITORS.

At no time have the foreign markets had so great an influence upon the prosperity and future development of the copper industry of the United States as at the present, and it becomes the duty of all engaged in it to watch closely the sources of foreign supplies to the markets of the world. A review of the industry of the most prominent competitors of the mines of this country has therefore attained a significance it never possessed before.

Great Britain.—The production of the mines of Great Britain has steadily declined under the pressure of heavy receipts of foreign ores, furnace products, precipitates, and bars from foreign countries. Cornwall has always been the heaviest producer, its share being on an average more than one-half, while Devonshire is credited with about one-fifth of the entire yield. Below is given the output in recent years:

Production of copper in Great Britain.

Years.	Ore.	Copper.
	Gross tons.	*Gross tons.*
1860	....	15,968
1865	....	11,888
1870	....	7,175
1871	....	6,280
1872	....	5,703
1873	....	5,240
1874	....	4,981
1875	....	4,322
1876	....	4,694
1877	73,141	4,486
1878	56,094	3,952
1879	51,032	3,462
1880	52,128	3,662
1881	52,556	3,875

The influence of Great Britain as the leading copper market of the world is not, however, due to the yield of its own mines, but to the enormous quantities of crude metal, furnace products, and ores which it handles, and which flow to it from almost all quarters of the globe. The great metallurgical, chemical, and manufacturing industries of Great Britain place it in a position to work black copper, regulus, mattes, and ores for pure metal, and redistribute a large portion of it in the shape of manufactured copper cheaper than the countries in which the raw material originates, and to which it partially returns. The following table showing the movement since 1860 will fully illustrate it and show its growth:

British imports and exports of copper from 1860 *to* 1877, *inclusive.*

Years.	Imports of— Bars, cakes, and ingots.	Copper in ores and furnace products.	Total imports.	Exports.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*
1860	13,142	13,715	26,857	26,117
1865	23,137	23,922	47,059	41,398
1870	30,724	27,025	57,749	53,006
1871	33,228	23,671	56,899	56,633
1872	49,000	21,702	70,702	53,195
1873	35,840	26,756	62,596	55,716
1874	39,906	27,894	67,800	59,742
1875	41,931	29,483	71,414	51,870
1876	39,145	36,191	75,336	52,468
1877	39,743	53,582	93,325	54,088

The following figures from the Board of Trade returns for the five years since 1878 show in detail the form in which the copper is brought into Great Britain and in what form it is exported:

Imports of copper into Great Britain from 1878 *to* 1882, *inclusive.*

	1878.	1879.	1880.	1881.	1882.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*
Pure in pyrites	14,443	12,040	16,446	13,551	15,672
Pure in precipitate	13,173	18,159	18,205	18,619	17,935
Pure in ore	15,441	13,173	14,976	15,396	15,489
Pure in regulus	5,155	7,049	6,598	6,491	9,270
Bars, cakes, etc	39,360	46,670	36,509	32,170	35,509
Total	87,572	97,091	92,734	86,227	93,875

Exports of copper from Great Britain from 1878 *to* 1882, *inclusive.*

	1878.	1879.	1880.	1881.	1882.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*
Raw English	17,319	16,370	15,202	18,737	12,776
Sheets	12,769	15,402	16,580	15,960	15,698
Yellow metal, at 60 per cent	8,744	10,042	10,128	9,939	10,892
Brass, at 70 per cent	3,450	2,761	2,677	3,263	3,499
	42,282	44,575	44,587	47,899	42,865
Fine foreign	12,719	17,837	14,895	13,790	12,818
Total	55,001	62,412	59,482	61,689	55,683

Turning first to the imports of pyrites, we find the following table of the imports and their source since 1873 in the volume of the Mineral Statistics of Great Britain:

Imports of pyrites into Great Britain.

Years.	Norway.	Portugal.	Spain.	Germany.	Other countries.	Total.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*
1873.	67, 462	199, 559	246, 692	....	6, 634	520, 347
1874.	41, 044	162, 569	294, 117	....	907	498, 637
1875.	21, 820	165, 433	344, 019	....	6, 283	537, 555
1876.	7, 688	56, 579	419, 068	....	21, 417	504, 752
1877.	8, 564	149, 562	498, 977	....	22, 209	679, 312
1878	5, 773	136, 705	419, 561	....	12, 318	474, 357
1879	8, 485	82, 529	374, 505	....	15, 783	481, 302
1880	10, 952	166, 519	463, 199	8, 695	8, 684	658, 049
1881.	....	....	....	....	....	542, 378
1882	....	....	....	....	....	626, 902

It will be noted that the demand in England for pyrites has been subject to considerable fluctuations. The business is one which has during the past year been agitating copper producers in this country considerably. For some years Canadian pyrites has been coming in, chiefly from Capelton, and more recently pyrites from Newfoundland and Spain, and it has been feared that the copper extracted from them would seriously affect our markets. Such pyrites are now beginning to be used by our sulphuric-acid makers as a substitute for imported brimstone, which is consumed by them at the rate of, approximately, 100,000 tons per annum. Should it be possible to supplant the latter entirely, the quantity of pyrites required would be 200,000 tons per annum. The average contents of the pyrites imported into England is a fraction higher than 2.5 per cent., and the extreme limit for the copper contents admissible for good working in pyrites kilns is placed at 5 per cent. Assuming that the average of pyrites imported into this country would be 3.5 per cent., a general change of the present method of producing sulphuric acid from brimstone to the burning of pyrites would carry into this country 7,000 tons of copper, assuming that there were no losses in treatment. It is not likely that any others but the acid works on the coast would avail themselves of the cupriferous mineral, so that only a portion of the total demand could be covered in this way. There are now six works actually using pyrites, and with their present plant and the ores they are working they do not probably produce at a rate greater than two to three millions of pounds of copper. One of them has adopted the European plan of leaching, and in fact is regarded as a plant built to afford one of the Spanish mines an outlet for a portion of its product. The others have followed a practice built up very successfully in this country of smelting the cinders (after burning off the sulphur in kilns) in water-jacket furnaces, at a cost which under favorable conditions for the supply of coke is said to be below $1.75 per ton. The handling of large bodies of cinders is thus avoided, a small quantity only of concentrated matte being shipped to the copper works where the metal is extracted. Until now, under the provisions of the old tariff, it has been more profitable to re-export this copper under the drawback clause. The tariff as now in force specially provides for pyrites as follows: "Sulphur ore, as pyrites, or sulphuret of iron in its natural state, containing not more than three and one-half per centum of copper, seventy-five cents per ton: *Provided*, That ore containing more than two per centum of copper shall pay, in addition thereto, two and one-half cents per pound for the copper contained therein." Under these provisions the duty on pyrites of different grades per pound of copper contained in them is as follows:

For 2 per cent. pyrites, 1⅞ cents duty per pound of copper.
For 3 per cent. pyrites, 3¾ cents duty per pound of copper.
For 4 per cent. pyrites, 2½ cents duty per pound of copper.

Assuming that the reduction in cost of manufacturing sulphuric acid from pyrites instead of from brimstone would enable the chemical manufacturers to pay the duty on low grade, two per cent. ore, the cinder would contain copper enough to make the value of its copper contents $5.60, placing the price of the metal at 14 cents per pound. Deducting the cost of smelting into matte, $1.50 per ton, there would remain only $4.10 to cover cost of shipment of matte to refining works and cost of treatment, marketing, etc., the losses of metal being very small. It will be seen that the margin on such low-grade ore is necessarily slight, and that any copper made from it would have to be exported, either in the form of matte or as refined copper, and the comparatively high duty on the metal in pyrites higher in copper would be a strong inducement to pursue the same policy.

The developments in the soda industry abroad during the past few years foreshadow its course in this country, where circumstances have led to its halting at a point long passed in Europe. The greater part of the sulphuric acid made abroad is used for the manufacture of soda by the Leblanc process, which has held undoubted sway until a few years ago, when the Solvay ammonia process, in which the use of sulphuric acid is done away with, was introduced. The total quantity of soda, equivalent to the pure carbonate, made in the world is a little more than 700,000 tons, which would call for a consumption of pyrites of about 425,000 tons. The retention of a market of such importance is of course of vital interest to the Spanish and Portuguese mines, and they have therefore decided to stem the tide by building Leblanc soda works in France and in Belgium, and sulphuric acid works in this country, where one of the principal outlets for the sale of the acid is to the petroleum refiners. It is likely, therefore, that they will seek relief for the pressure from this quarter by increased exertions in the direction indicated, and by a further development of the manufacture of copper at the mines.

This brings us to another point, which deserves particular attention as affecting the copper supply of the world, and therefore influencing our market correspondingly. It is the steady increase in the quantity of precipitate shipped from the same mines which produce the pyrites in Spain and Portugal. At these mines, among which the Rio Tinto, Tharsis, and San Domingo are the most prominent, a small proportion of high-grade ore is smelted into regulus direct; the medium grade, running about 3.5 to 4 per cent. of copper (wet assay) is shipped as such, while all the low grade is treated on the spot by roasting enormous quantities in heaps, leaching, and precipitating the copper with scrap iron. The resulting copper, called precipitate, is an impure metal running from 50 to 70 per cent. Efforts have been made during the past few years to replace this crude process, with its drawback of the injurious effect of the sulphurous acid fumes upon vegetation, and its enormous consumption of scrap iron, by another method—that of Doetsch and Déby—which extracts the copper from the crude ore direct. This promises to solve the question which threatens the life of the pyrites mines, and to which allusion has already been made. It dispels the hopes entertained by some of the rivals of the Spanish and Portuguese miners that by a gradual decline of their market with sulphuric acid manufacturers they would be checked in their steady advance as copper producers. We have no means of arriving at the exact quantity of precipitate brought into the English markets, as the Board of Trade returns do not separate this material from regulus, of which a small quantity is also made in Spain and Portugal. It may, however, for all practical purposes, be assumed that the figures in the following table, in which the British imports are classified according to their source, are for precipitate alone, so far as those two countries are concerned:

Imports of precipitate and regulus into Great Britain.

Countries.	1880.	1881.	1882.
	Gross tons.	*Gross tons.*	*Gross tons.*
Portugal	5,358	8,144	7,301
Spain	20,482	21,647	21,398
Chili	14,659	8,116	10,882
Other countries	4,502	6,309	9,716
Total	45,001	44,216	49,297
Pure copper	24,772	25,110	27,205

The material coming from Chili, Canada, Australia, the Cape of Good Hope, and other countries is chiefly regulus. This year our own country will take a prominent place among the regulus figures, a sufficient quantity of matte to represent 7,000 tons of pure copper being forced to seek a market in England, chiefly because the higher price for silver paid there than in this country balances the lower price received for the copper, owing, it is said, to a modern extraction process introduced in Swansea.

The third great source of supplies of the metallurgical industry of Great Britain is ores which are shipped from many quarters. They vary in grade and in character, and it will be necessary to add columns giving values in order to afford some insight into the nature of the ores which compete in the markets of the world:

Imports of copper ores into Great Britain.

Countries.	Quantities.		Values.		Average value per ton.	
	1881.	1882.	1881.	1882.	1881.	1882.
	Gross tons.	*Gross tons.*				
Italy	12,382	12,690	£81,733	£82,822	£6.60	£6.53
Venezuela	18,890	25,630	125,698	190,387	6.66	7.43
Bolivia	4,128	3,714	50,931	46,794	12.33	12.60
Chili	385	362	5,935	5,902	15.41	16.33
Cape of Good Hope	11,556	19,052	210,851	381,019	18.25	20.00
British North America	25,540	15,163	110,901	90,218	4.34	5 95
Other countries	29,759	26,652	215,525	238,162	7.24	8.93
Total ore	102,640	103,263	801,574	1,035,304	7.81	10.02
Total pure copper	15,396	15,489				
Average percentage	15.00	15.00				

It will be noticed that the bulk of the rich ores comes from the Cape of Good Hope, where the mines of the Cape Copper Company have for many years yielded increasing supplies of rich mineral. Recent shipments have been light, however, and some doubts are expressed as to capacity of the mines to maintain the high grade. The lowest grades of ores in any quantity come from Canada, while Italy and Venezuela supply a medium grade. Cuba, which at one time sent so much raw material to this country, and in 1860 shipped 16,605 tons of ore to England, has dropped off entirely, while Australia has developed a smelting industry of her own and is exporting chiefly refined copper. From this country small quantities of ore have at times been forwarded to England from California and Nevada, and it is only this year that really important shipments will be made. The owners of the Anaconda, at Butte City, Montana, as already stated, have contracted for the shipment of 6,000 tons of very high grade copper ore, containing important quantities of silver, and it is understood that negotiations for additional ore from other sources are pending. It is not expected, however, that the sales of raw material will continue very long, as smelting works will be built at the mine at no distant date.

The chief sources of supply of black copper, averaging 96 per cent., and refined copper, are Chili and Australia. The following figures will show how largely these two countries participate in furnishing the manufacturers of Great Britain with raw material:

Imports of copper, wrought and unwrought, into Great Britain.

Countries.	1880.	1881.	1882.
	Gross tons.	*Gross tons.*	*Gross tons.*
Chili	24,258	21,019	22,585
Australia	9,406	9,150	8,152
Other countries	2,845	2,001	4,772
Total	36,509	32,170	35,509

The Australian copper is generally a high grade of refined, including such brands as Wallaroo and Burra Burra, while the bulk of the Chili product is bars averaging about 96 per cent. fine. We shall more particularly refer to both in speaking of the copper industry of the countries alluded to. England, of course, takes a considerable quantity of the Lake copper shipped from this country, and this year will receive in addition thereto notable quantities of Arizona black copper, 2,000 tons having been already contracted for, with the possibility of further shipments following.

Turning now to the exports of copper and its manufactures, it is of interest to note, aside from the volume of this movement, its direction, as revealing who the principal customers of Great Britain are:

Exports of copper (ingot, bars, and slabs) from Great Britain.

To—	1881.	1882.
	Gross tons.	Gross tons.
Germany	3, 667	2, 407
Holland	2, 714	1, 363
Belgium	1, 869	2, 128
France	7, 172	5, 902
British India	1, 069	20
Other countries	2, 211	9, 957
Total	18, 702	21, 777

Exports of wrought or manufactured copper from Great Britain.

To—	1881.	1882.
	Gross tons.	Gross tons.
Russia	1, 315	463
Germany	702	327
Holland	509	300
France	612	1, 121
Italy	436	429
Turkey	1, 337	1, 404
Egypt	1, 332	560
British India	4, 950	6, 570
Other countries	4, 687	4, 024
Total	15, 880	15, 198

Exports of manufactures of brass from Great Britain.

To—	1881.	1882.
	Gross tons.	Gross tons.
All countries	4, 657	4, 999

Exports of yellow metal from Great Britain.

To—	1881.	1882.
	Gross tons.	Gross tons.
British India	7, 127	8, 849
Other countries	9, 521	9, 304
Total	16, 648	18, 153

British India is therefore the best purchaser of English copper and its manufactures, while France takes the greatest quantity of crude metal, closely followed by Germany. It should be noted in this connection that probably the bulk of the shipments from Great Britain to Holland are in reality only goods in transit to Germany.

Chili.—For many decades the copper producers of this favored country have practically ruled the markets of the world, for which they have contributed more metal annually than the whole of Europe, until the last ten years, when the rapid increase of the producing power of the Spanish peninsula, and of Germany in a less degree, began to cast it in the shade. No statistics of the actual product of Chili have been published, but as the local consumption is comparatively insignificant, it will be safe to assume the total shipments from the coast to be equivalent to the production. Speculation and variations in the freights cause these figures to vary within a greater range than the actual production, the price of exchange, too, having an important influence. The following figures, giving the exports from Chili since 1855, will show the development of the copper industry in that country:

Exports of copper from Chili.

	Tons.
1855	20,250
1856	21,938
1857	25,498
1858	30,470
1859	28,250
1860	36,289
1861	38,371
1862	43,109
1863	32,540
1864	47,500
1865	48,327
1866	44,820
1867	44,654
1868	43,669
1869	54,867
1870	49,130
1871	41,200
1872	46,337
1873	42,165
1874	48,240
1875	45,430
1876	50,740
1877	45,400
1878	46,770
1879	49,390
1880	42,990
1881	38,030
1882	42,960

These figures represent fine copper, and therefore include the metal in ore and regulus. The following instructive table proves how the relative proportion of the different descriptions of copper produce exported from Chili during the last ten years has changed in favor of the native industry:

Relative quantities of copper, and copper contained in regulus and ore, as exported from Chili from 1873 *to* 1882, *inclusive.*

	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Bar and ingot copper	64½	68	71½	80	75¼	82½	80	80¾	82¼	84½
Fine copper in regulus	27½	26	22	16¾	18¾	15½	17¼	16¼	15¾	13¾
Fine copper in ore	8	6	6½	3¼	6	2	2¾	3	2	1¾

The bulk of the regulus and ore goes to English smelting works, while a considerable quantity of the bars is sent to France.

A glance at the tables of shipments proves that the war with Peru and Bolivia, which began in February, 1880, was not without a marked influence upon the output of the Chilian mines, which dropped off to 42,990 tons in 1880, to 38,030 tons in 1881, and then recovered to 42,960 tons in 1882. As for the future of the mines of Chili and Bolivia, it must not be forgotten that they are located in a narrow strip of coast land that has been thoroughly prospected, so that a series of new finds is not among the probabilities. Work will therefore be restricted to the old districts, in which the disadvantages of greater depth and of poorer ores will call for strong efforts to maintain the present rate of output. Important though Chili is as a copper producer, comparatively little is known in this country or in England of the capacity of its mines to meet low prices. They are worked by wealthy native families and by English capitalists, whose returns are not given to the public. The only two enterprises in the hands of public companies which publish reports are the Copiapo, which in 1882 paid a profit of £26,152 on a capital of £166,425, and the Panulcillo, which netted £25,000 on a £200,000 capital on 5 per cent. ore. It is not believed by those well informed that Chili will become a much heavier producer of copper, while there are those who claim that the increased cost of mining and the decline in the yield of the ores will force it to fall back a little below the average of 45,000 tons annually.

Spain.—The important influence which the development of the mineral resources of Spain has had upon the markets of the world has been repeatedly dwelt upon. The following are the official returns of exports in metric tons since 1878, when the production of precipitate was added to the shipments of cupriferous pyrites. The returns give the exports of copper as "bars, slabs, etc."; but there is little doubt that they do not represent pure copper, but the impure cement copper. Due allowance should be made for this fact, which is apparently neglected by some statisticians:

Exports of precipitate and pyrites from Spain.

Years.	Precipitate.	Pyrites.
	Metric tons.	*Metric tons.*
1878	1,377	427,259
1879	20,834	459,576
1880	20,940	501,425
1881	17,710	452,475
1882	21,708	571,442

The addition to the world's supply of such a vast quantity of copper, principally coming from two mines splendidly equipped for the mining, treatment, and handling of vast quantities of mineral, has naturally had an important influence. Whatever falling off there may be in the quantities of pyrites shipped (and, as the above figures show, there is no serious indication of it as yet) will probably be fully compensated by increased production of precipitates. The business of the Rio Tinto and the Tharsis companies has been an exceedingly profitable one. According to the report of the Tharsis Sulphur and Copper Company for 1882, a profit of £335,676 was made during the year on shipments amounting to 212,218 tons of pyrites, 5,534 tons of precipitate, and 184,059 tons of iron ore; a dividend of £314,479, or 27½ per cent. on the paid up capital, being paid to the shareholders. During the same year the Rio Tinto exported 272,826 tons of pyrites and 9,651 tons of precipitate, and realized a gross profit of £738,308 on ore averaging 2.805 per cent. of copper by wet assay.

Portugal.—In the same general range in which the famous Spanish mines are worked are those of Portugal, prominent among which is the San Domingo, now worked by the Mason & Barry Company, at one time far more important than its younger rivals. In 1870 the exports of pyrites from Portugal were 274,363 metric tons, but they fell off to 61,773 tons in 1876. Since then the San Domingo mines have come into the hands of a stock company, the Mason & Barry Company, of London, which with a capital of £1,200,000 worked the mines at a net profit of £276,719 for the year 1882.

Australia.—The copper industry of the Australian colonies is of long standing, copper having been discovered in South Australia in 1844, in New South Wales in 1858, and in Queensland in 1860. Among the mines are some of the most famous of the world, including the Burra Burra, the Wallaroo, and the Moonta in South Australia, and the Great Cobar in New South Wales. As the first named mines are near the coast, and are well equipped, and yield from rich ores a metal rivaling Lake in purity, they may be said to be in a certain sense among the competitors of our own copper. Some of them have yielded and still produce very large profits, so that it is not likely that the supplies from this source will be seriously affected by any possible lowering of prices. The statistics available are not complete, but the following figures, compiled from various sources, may serve to show the magnitude of the industry of the colonies. A very disturbing element in the production appears to be periods of drought.

Exports of copper and furnace products from the Australian colonies.

Years.	South Australia.		New South Wales.		Queensland.
	Ingots.	Ores.	Ingots.	Ore and regulus.	Ingots.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*	*Gross tons.*
1870	5, 471	20, 886	994	6	1, 523
1871	6, 396	20, 127	1, 350	94	2, 490
1872	7, 452	26, 964	1, 035	417	2, 448
1873	7, 087	27, 382	2, 795	51	(?)
1874	6, 629	22, 854	3, 638	522	(?)
1875	6, 842	26, 436	3, 520	157	(?)
1876	5, 463	22, 682	3, 106	169	2, 105
1877	5, 143	18, 532	4, 153	360	544
1878	3, 594	17, 007	4, 983	236	642
1879	....	....	4, 107	36	....
1880	....	....	5, 262	132	....

Germany.—The German Empire, while largely dependent upon foreign countries for the supply of copper, has during the past decade made great progress in developing its own copper industry, as the following figures of the production of that metal since 1875 in Prussia, the principal producing State, will show:

Production of copper in Prussia and in the Mansfeld district.

Years.	Prussia.	Mansfeld district.
	Metric tons.	*Metric tons.*
1875	7, 212	6, 283
1876	8, 235	6, 908
1877	8, 661	7, 971
1878	9, 096	8, 546
1879	10, 165	9, 813
1880	14, 593	10, 999
1881	15, 702	....
1882	20, 011	....

Outside of Prussia, Brunswick is the only producing state worthy of mention, making on an average 500 tons of copper annually. There are large works besides in the vicinity of Hamburg which treat foreign ores. Their output, however, is not known, though the metal is made by the electrolytic process, and is highly esteemed for its exceptional purity. We have in the above table given specially the production of the Mansfeld district, where enormous quantities of ore from narrow beds of bituminous slate, running about 2.85 per cent. of copper and 0.015 per cent. of silver, are worked at a very good profit. The bulk of the remainder of the copper made in Prussia comes from pyrites, some of which is imported.

The German legation at Washington has kindly furnished the following figures of the imports and exports of copper and manufactures of copper:

Imports of copper and copper manufactures into Germany.

	1879.	1880.	1881.	1882.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Ingot copper and brass	13,378	12,719	11,372	10,579
Copper rods, sheet, and wire	608	770	437	230
Manufactured copper	1,201	1,015	1,119	1,015
Total	15,187	14,504	12,928	11,824

Exports of copper and copper manufactures from Germany.

	1879.	1880.	1881.	1882.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Ingot copper and brass	9,387	7,204	7,704	6,097
Copper rods, sheet, and wire	3,200	3,928	5,130	1,997
Manufactured copper	2,972	4,195	4,737	3,854
Total	15,559	15,327	17,571	11,948

It will be seen, therefore, that in a general way Germany has slightly gained as an exporter, particularly as an exporter of manufactured copper, though the year 1882 shows a marked falling off. Production in Germany has, however, gained much more rapidly, indicating an increase in home consumption.

France.—M. Paul Trasenter, of Liége, after a careful study of the strangely muddled statistics of France, has compiled the following figures as an approximate estimate of the production:

Production of copper in France.

	Metric tons.
1870	2,100
1871	2,720
1872	2,600
1873	2,140
1874	2,000
1875	2,300
1876	2,230
1877	2,330
1878	3,500
1879	3,350
1880	3,300
1881	3,395

Belgium.—No copper mines are worked in Belgium, and there is only one establishment, the Hemixem works, near Anvers, which treats by the humid method ores from the Vigsnaes mine in Norway, carrying 3 to 4 per cent. of copper. The works produced, according to M. Trasenter, the following quantities:

Production of the Hemixem works, Belgium.

	Metric tons.
1873–1874	613
1874–1875	660
1875–1876	715
1876–1877	789
1877–1878	910
1878–1879	1,008
1879–1880	1,029
1880–1881	1,063
1881–1882	1,089

Russia.—The latest statistics available for the production of copper in Russia are for the year 1879, the yield in that year having been 190,680 poods, or 3,122 metric tons, of copper, distributed as follows:

	Poods.
Elizabethpolsk	47,035
Perm	39,112
Ufa	35,612
Akmollinsk	31,000
Tomsk	28,690

Canada.—The most important mines of the colony are those of Newfoundland, among which the famous Tilt Cove and Betts Cove mines take a leading position. The product is almost exclusively shipped to England. The mines in the vicinity of Capelton, on the other hand, send large quantities of low-grade pyrites to New York to be used in the manufacture of sulphuric acid. Until now they have been the main source of the pyrites imported.

THE METALLURGY OF COPPER.

BY JAMES DOUGLAS, JR.

COPPER SMELTING AS PRACTICED IN THE UNITED STATES.

Adaptation of method to class of ores.—Copper is found on this continent in the rocks of every geological age; it has been worked in nearly every State and Territory, and occurs in every variety of ore. In the metallic state it is frequently met with as the result of the decomposition of sulphurets; but as the only product of the mines it is found in but two notable regions, both in this hemisphere, one the south and north shores of Lake Superior, the other at Coro-Coro, in Bolivia. On Lake Superior it is found in veins, as masses sometimes of great size, and also disseminated in grains or large lumps and sheets in beds of so-called amygdaloid trap and conglomerate. Although the ore from these beds yields a very low average—as low in the case of the South Atlantic mine as 0.72 per cent., or 14.4 pounds of copper to the ton—yet, owing to the cheapness with which it can be concentrated by mechanical means to over 70 per cent., and the slight cost of refining the concentrates, a profit can be made. But three-quarters of the world's supply is derived from sulphureted compounds of copper and iron, which form a series of ores of definite composition. The three typical examples of the series are:

Composition of sulphureted copper ores.

	Copper.	Iron.	Sulphur.
	Per cent.	*Per cent.*	*Per cent.*
Copper pyrites (chalcopyrite), containing	34.6	30.5	34.9
Variegated copper ore (bornite), containing	60.8	13.67	24.46
Copper glance (chalcocite), containing	77.2	1.5	20.6

The ore of most frequent occurrence is copper pyrites, which is, however, seldom unassociated with iron pyrites or with lower compounds of iron and copper. Bornite and a number of ores of variable composition—intermediate between chalcopyrite and chalcocite—are generally products of decomposition of chalcopyrite, and seldom form the exclusive product of any mine. But besides the transformation of sulphurets low in copper into others higher in copper under atmospheric agency, further transformation of the copper constituents of the ore into a great variety of oxidized compounds takes place—into blue and red oxides, green and blue carbonates, silicates, and even into chlorine compounds. Wherever the iron sulphuret is oxidized into hydrous and anhydrous peroxide and magnetite, as might be expected, considering the agents (air and moisture) which have effected the decomposition in these oxidized ores, they occur from the surface to but a limited depth. In the Southern States, where iron pyrites constitutes the bulk of the vein matter, it is common to find the following successive layers: First, a so-called iron cap of red hematite, almost barren of copper or carrying a few crystals of copper carbonate, rich enough in iron and poor enough in copper to be used as an iron ore; then follows a layer of variable thickness, either of what is called black oxide, but is in reality an oxysulphuret, or of an ore with the appearance of bornite; and beneath this are reached the unaltered sulphurets of iron and copper, always of lower grade than the overlying ore. In the Rocky mountains iron pyrites is seldom the preponderating mineral, and therefore the surface ores are usually in the Northwest, as in Montana, rich oxysulphurets, merging in some mines into purple ore; in the Southwest, as in Arizona and New Mexico, carbonates and oxides, associated with more or less oxide of iron and manganese.

These differences in the composition of ores necessarily involve a difference in treatment. If we run down in a cupola furnace a sulphureted ore of iron and copper, carrying more or less quartz, lime, and earthy matter, there will result (1) a slag carrying all of the silica, lime, alumina, and perhaps some of the iron of the sulphurets, and (2) a matte carrying all or nearly all the sulphur, combined with the copper, and most of the iron. The results will be little better than would have been obtained by a careful concentration of the ore, which would have removed the light gangue from the heavy mineral. But if, before smelting the ore, it be thoroughly roasted, there is eliminated (we will suppose for argument's sake, perfectly) the sulphur as sulphurous acid gas, and the iron and copper are converted into oxides. If now this roasted ore be fed into a cupola furnace, the siliceous and calcareous gangue is slagged off as before, and if enough silica be present all the iron which existed in the pyrites will be similarly disposed of, while the copper oxide will be reduced by the action of the carbon of the fuel, and can be tapped out as metal. As nature has in the prominent mines of the Southwest oxidized the copper, and has done it in many cases most perfectly, the treatment is there simplified to a single reducing fusion in a cupola furnace, whereas the sulphureted ores of the Atlantic coast and of Montana, and also those occurring in the Northwest, must be first oxidized artificially.

Copper smelting in this country is therefore practised—

I. On the concentrates from the native ores of Lake Superior, which are subjected to a single fusion, whereby the copper is separated from associated iron oxide and silica, preparatory to a refining operation in the same furnace.

II. On the carbonate ores of the Southwest, which are worked exclusively in cupola furnaces, and which yield to a single fusion a coarse copper, which is shipped eastward for refining.

III. On sulphureted ores both at certain mines and at central establishments in the East. When the ores are basic the cupola furnace is used; when siliceous, the reverberatory. At some mines and at one of the coast works both cupolas and reverberatories are used.

I.—THE SMELTING OF NATIVE ORES.

The product of the Lake Superior copper mines reaches the Lake smelting works as—

1. *Masses* attaining sometimes 10 tons in weight, extracted only from the veins.

2. *Barrelwork:* The larger lumps from the copper-bearing beds, which do not enter the stamp battery or collect in the mortar.

3. *Concentrates:* The coarser grade running over 90 per cent., the slimes as low as 40 per cent., the smelting average being between 70 and 75 per cent.

4. There has of late been made a still poorer concentrate of under 20 per cent., which is sold to the smelting works on the coast and is run down with sulphureted ore and matte.

Grades 1, 2, and 3 are smelted at three works only, namely, those of the Detroit & Lake Superior Smelting Company at Hancock and Detroit, Michigan, and the works of C. G. Hussey & Co., Pittsburgh.

As the mineral is free from sulphur, arsenic, and antimony, and is mixed only with a small percentage of iron oxide derived from the ore, of metallic iron from the crushing machinery, and a small percentage of siliceous gangue, it is only necessary to smelt it with from 6 to 8 per cent. of limestone and 10 per cent. of rich refinery slag, skim off the slags, and refine the metal. These operations occupy from twenty-two to twenty-three hours—

1. The *charging* of about 12 tons of mineral and fusion lasts about twelve hours.

2. *Skimming* slags (the first of which, containing only from 3 to 5 per cent. of copper, go to the cupola; the richer are returned to the next charge in the refinery) lasts about five hours.

3. *Refining* lasts about two hours.

4. *Ladling* lasts about three hours.

The mass copper furnaces are provided with a removable roof, which is lifted by an overhead crane; the mass or masses are then lowered, the furnace bed being suitably protected, and the roof is replaced. The charges of barrel and stamp work are thrown in with the necessary fluxes through the side door. About 75 per cent. of the copper contents of the charge is ladled out in ingots; about 25 per cent. passes into the slags. The refinery slags, as stated, are at the Lake works returned to the furnace with the next charge; the poorer slags are run down in a cupola.

The cupola charge consists of 20 tons of slags, containing about 4 per cent. of copper, 8 to 9 tons of limestone, and 6 to 7 tons of anthracite coal. The yield of the cupola is slags poor enough to be thrown away and cake copper fit for refining. The cupola used is a modified McKenzie, with an annular tuyere five-eighths of an inch wide encircling the furnace below, and a slightly conical water-breast 22 inches high and 24 inches above the hearth. Upon the water-breast rests the brick body of the furnace, 5 feet 8 inches high to the charging door, elliptical in shape, being 7 feet 9 inches by 5 feet 8 inches. The brick lining immediately above the bosh supplies the iron of the slag with silica, and is so rapidly consumed that a ten to twelve hours' run is almost the limit of its life. During these short campaigns 20 tons of slag are put through. Greater durability is rendered the less necessary inasmuch as the slags from the mineral of each mine are kept apart and smelted separately, and the cupola must therefore be frequently blown in and out. At the same time it would seem that silica could be added in some more economical shape. At the Pittsburgh works, where coal is very cheap, the richer slags are subjected to reverberatory treatment before being passed with the poorer slags to the cupola.

The construction of the Lake Superior refineries, if we except the movable roof of those adapted to the mass copper, does not differ materially from that of the ordinary Swansea furnace; but special valves and deflecting plates are employed to throw the air through vents in the bridge on to the charge; the ash-pits are provided with doors, and a low pressure blast is used beneath the fire-bars, so as to control the admission of air and the character of the atmosphere within the furnace.

Every possible care is taken during the ladling to maintain the charge at perfect pitch, as determined by mechanical tests made from time to time; and by carefully regulating the heat, both of the bath of metal and of the water in the boshes, a beautiful surface color of the ingot is invariably and uniformly obtained. As at the two works of the company about 25,000 tons are refined annually, of which the Hancock works turn out about three-fourths, and as no other operation but refining is practised, the whole attention of the superintending staff is directed to but one object, and the corps of workmen attains the utmost skill in the performance of its several duties. As a consequence, the excellence of the manipulation, coupled with the absolute freedom of the mineral from all injurious elements, has won for the Lake ingot a world-wide reputation for purity and uniformity of quality, which enables it to command in the markets of Europe a higher price than any brand of copper manufactured there. (*a*)

II.—THE SMELTING OF CARBONATE ORES.

Copper, hardly if at all inferior to Lake, is made from some of the carbonate ores of Arizona.

The Longfellow smelting works.—The first successful attempt to smelt ores in Arizona within recent times was made at Clifton by Messrs. Lazinski. In 1873 they opened the Longfellow mine, whose ores consisted of carbonates and oxides of copper, associated with peroxide of iron and manganese. The first furnaces used were small Mexican adobe cupolas, the capacity of which is little over one ton daily, the blast being derived from large bellows worked by hand. Reverberatory furnaces were next tried; but the ores being basic, and firebrick worth a dollar apiece—for the railway was then over 700 miles distant—the cupola was again resorted to, but this time it was supplied with an iron water-back and tuyeres. The water-back once burning out, an attempt was made to cast one in copper as a substitute; but the casting turned out to be a mere plate with a hole in it. For lack of better, this was built into the furnace, and was found to stand so well that the cupolas within the area of fusion were constructed entirely of copper slabs, cooled at first by a spray of water, afterwards by the air alone. Such copper-plate furnaces lasted in good order for about sixty days, as long as charcoal was used, but the intense heat produced by coke twisted the plates out of shape so rapidly that they were replaced by copper water-jackets—clumsy deep copper troughs, open at the top, which were cast in close moulds from the coarse alloy of copper and iron made by the furnace. There have now been supplanted by the ordinary iron water-jacketed furnace.

The old copper-plate furnaces were 37 inches by 35 inches at the tuy-

a For fuller details, see Professor Egleston's paper on Copper Refining in the United States; Transactions of the American Institute of Mining Engineers, August, 1880.

eres, provided with three tuyeres in the back plate and supplied with blast by a 4½ Baker blower. The fire-door was 7 feet above the tuyeres. The slag-tap was 8 inches below the tuyeres. The copper-tap was 16 inches below the slag-tap. They smelted from 15 to 17 tons daily of selected ore when running with charcoal, producing 7,500 pounds of cake copper of about 90 per cent.

The later copper water-jacketed furnace was 50 inches by 35 inches and had 4 tuyeres in the back, and smelted with coke as much as 50 tons of ore daily. The blast was supplied by a 5½ Baker blower.

The ore smelted was taken exclusively from the Longfellow mine, and contained rather an excess of base oxides of iron and manganese. It was found that when the charge contained an excess of manganese over iron, the slag was thick and the copper separated imperfectly; but the ferruginous slags usually made with about 50 per cent. of protoxide of iron and 10 per cent. of manganese did not retain over 1 per cent. of copper. The ores carrying on an average only about 14 per cent. silica and the slags less than 30 per cent. silica, the resulting cake copper was impure, nearly 10 per cent. of iron entering it.(a)

At present, another smelting establishment on the San Francisco river, five miles below Clifton, works ores from some adjoining mines owned by the Detroit Copper Company. There the opposite error was for a time committed of running with a far too acid charge, the resulting slag from which has carried as high as 53 per cent. of silica. As a consequence, all the iron, manganese, and other valuable bases entered the slags, leaving the copper cake almost absolutely pure; but the silica had in addition to draw upon the copper, of which 3 per cent. and over entered the slags. When charcoal was used by the Longfellow smelters the consumption was 1 to 4½ of ore. With three-quarters coke and one-quarter charcoal the consumption of fuel dropped to 1 to 7. With coke the Detroit company is now smelting over 9 of charge with 1 of Welsh coke.

The old Longfellow furnaces were manipulated in an altogether novel manner. The slag was tapped into a sand bed, and at intervals of three hours the copper was tapped, like iron from a foundry cupola, into a large ladle swung from a crane, and poured thence into heavy copper molds holding from 150 pounds to 200 pounds of coarse copper.

At present the Arizona Copper Company (a Scotch organization), which purchased the Longfellow and some other valuable mines in the same vicinity, has erected two water-jacketed furnaces of the ordinary type, and is running them as is done elsewhere.

Copper Queen smelting works.—At the smelting establishment of the Copper Queen mine, at Bisbee, Arizona, the production of a very pure cake, and at the same time a tolerably clean slag, has been obtained by a judicious furnace mixture. The furnace is supplied from a large body

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a For analyses I am indebted to a report by Mr. A. W. Wendt.

of oxidized ore in limestone. At the surface the ore consisted of remarkably beautiful crystalline masses of carbonate of copper and calcite, in which concretions of copper carbonate, calcite, oxide of iron, and manganese were imbedded. As depth has been obtained crystalline carbonates have ceased to be the principal product of the mine, but they still occur in a soft, somewhat argillaceous ore carrying a high percentage of copper as carbonate and oxide. This constitutes the bulk of the deposit, and carries nearly enough silica to satisfy the lime, iron, and manganese of the ore itself, which is thus almost self-fluxing when mixed in proper proportions.

Two furnaces are kept steadily in blast, and smelt 50 tons each per day. The furnaces are water-jackets, such as were designed originally by the present superintendent, Mr. Lewis Williams, and are, with unessential modifications, manufactured by the Pacific Iron Works, Prescott, Scott & Co., of San Francisco; by Fraser & Chalmers, of Chicago; and by other makers. They stand on four pillars, and are provided with drop bottoms. They are round, and the space between the inner and outer shells is 9 inches at bottom and 4½ inches at top. The dimensions are as follows: Diameter at tuyeres, 36 inches; diameter at feed-door, 54 inches; distance from feed-door to tuyeres, 6 feet; distance from tuyeres to slag-tap at side of furnace, 7½ inches; distance from slag-tap to copper-tap on level of the hearth, 20 inches. The water-jackets extend from 4½ inches below the tuyeres to the feed-door; the iron shell below the water-jackets being lined with firebrick and tamped with brasque. In some other furnaces the water-jackets extend down to the hearth. The superstructure from the feed-door upward is of brick in an iron shell, which enters a horizontal dust-flue 36 inches in diameter and 96 feet long, provided with hoppers in which the dust (about 5 per cent. of the whole) collects. The dust is mixed with the more clayey ore and moulded into bricks, which are sun-dried and re-fed to the furnace. The furnace is fed alternately with Trinidad coke and ore, the coke being to the ore as 1 to 6. When Cardiff coke was used, its consumption was only 1 to 7½ of ore. No matte is made, though the mine has attained a depth of 250 feet vertical and 50 feet below the water-level. Throughout the mine traces of sulphur exist, which enter the cake, but no copper sulphide is found, nor is the lime a sulphate, as might be expected were the ore derived from a sulphide oxidized in place. The slag is tapped frequently into a long iron pot, through which it flows into the ordinary slag buggy. In the long pot, whose contents remain fluid for about two hours, a small amount of metallic copper settles. The metallic copper is tapped from the front of the furnace every half hour into pigs of from 250 to 300 pounds in weight. The cake runs from 97.5 to 98 per cent.

The total production from 1882 to 1883 was 4,202 tons of cake copper, equal to 4,052 tons of refined ingot. The furnace yield of the ore treated was 12.72 per cent., and the cost of refined copper sold in New York was 9.75 cents per pound.

The operations at the Copper Queen have thus been dwelt on at length, as they may be accepted as typical of the manner of smelting the carbonate ores of the Southwest.

In Globe there are three establishments, though the furnaces of the Old Dominion are alone running. At the Peabody mine and the Omega, copper cake and some matte are made, the latter unquestionably cleansing the slag. In a number of other localities furnaces have been put up, which run intermittently. The total production of copper from this class of ores in Arizona was last year about 12,000 tons, and it may rise during the present year to from 15,000 to 20,000 tons.

Carbonate ores are, however, not confined to the Southern Territories. For several years cake copper has been made from the ores of the Blue Bell mine, near Elko, Nevada, and more or less smelting has been done at other localities in the same State; but comparatively little copper, obtained by a single fusion from oxidized ores, comes from elsewhere than Arizona.

III.—THE SMELTING OF SULPHURETED ORES.

This is carried on east of the Rocky mountains at five different works on the Atlantic coast, all of which purchase ores and furnace products for refining. They are owned by—

1. The Baltimore Copper Company, Messrs. Pope, Cole & Co. Their works are and always have been the most important on the coast. They follow the Swansea practice in reverberatory furnaces for copper ores, and treat their copper-silver materials with sulphuric acid. The works cover five acres of ground, are situated on the harbor of Baltimore, and included in 1881 three large refineries, about thirty reverberatories for ore and matte smelting, and three cupolas for rehandling slags, besides a bluestone department.

2. The Revere Copper Company, of Boston, conduct their operations less actively than formerly, when they used cupolas of the German type.

3. The Orford Copper and Sulphur Company, of Boston (works at Bergenport, New Jersey), have introduced notable improvements in cupola construction and methods. They use very large matting cupolas, smaller black copper cupolas, and reverberatory, blister, and refining furnaces.

4. The New Jersey Extraction Company, of Elizabethport, New Jersey, is an English corporation, whose operations include the extraction of copper from pyrites residues, smelting and refining ores and matte by the Welch method, and the extraction of silver from argentiferous mattes prior to their conversion into copper.

5. Messrs. Crocker Bros., of Taunton, Massachusetts, use small cupolas for concentrating to coarse copper.

There are also cupola smelting works of large capacity connected with the Ely mine, Vermont, and the Ore Knob copper mine, North Carolina. Small works in Portland and Boston have run intermittently on Maine ore; and at Sainte Genevieve, Missouri, a small establishment smelts sulphureted ores from mines in the neighborhood, and refines in addition some Arizona cake.

The operations of the Boston & Colorado Smelting Company at Argo, near Denver, and at the branch works in Butte, Montana, though conducted on a very large scale, do not come within the scope of this discussion, as the copper is used as a medium for recovering gold and silver, and has not heretofore been generally converted into ingot copper, but into bluestone.

In Butte, Montana, in addition to the furnaces making matte for the Argo Works, are three smelting works in connection with the mines of the Montana, the Parrott, and the Bell companies. The first named smelts its siliceous ores in reverberatories and the basic ores in a cupola. The Parrott Company uses reverberatories only; the Bell only cupolas. The combined plants contain a concentrating capacity of nearly 200 tons daily, three cupola furnaces, and 20 reverberatory, calcining, and matting furnaces. The copper production, chiefly as 65 per cent. matte, is equal to about 800 tons a month of metallic copper.

It will thus be perceived that both the Swansea method in open furnaces and the so-called German method in cupolas are practiced side by side in this country, and a better opportunity is afforded of deciding the vexed question of their relative advantages than often occurs. But before stating the argument on both sides it will be well to briefly describe the main features of the two systems.

The former Swansea method of smelting in reverberatories.—As formerly practiced, the Swansea system was conducted entirely in reverberatory smelting furnaces. A mixture of sulphureted and naturally or artificially oxidized ore, containing sulphur enough to concentrate all the copper into a matte of 20 to 30 per cent., and sufficient silica to combine with all the iron that did not enter the matte, and with all other bases, so as to make a clean fusible slag, was run down in a reverberatory furnace. The resulting matte was recharged, roasted, and smelted again at a low heat, whereby some of the sulphur was oxidized and passed off as sulphurous acid, and the oxidized iron combined with the silica of the furnace lining, unless siliceous ore or slag was added. This operation was repeated till all the iron was eliminated, and a pure sulphide of copper, known as white metal, was obtained. These repeated roastings and fusions produced a good copper, but required an inordinate quantity of fuel and labor. Mr. Napier was mainly instrumental in introducing the modified Swansea method now employed, the steps of which are as follows:

1. The ores and slags from subsequent operations are mixed so as to produce a matte of 30 to 33 per cent.; this grade being preferred, be-

cause if it be lower in copper an extra fusion would be required, if higher the cost of subsequent operations would not be materially reduced, while the slags would be enriched by the higher tenor of the shots of matte which are unavoidably drawn out of the furnace when skimming. If the ore is fusible, four charges of 8,000 pounds each can be smelted in a large furnace in 24 hours. When the fusion is complete the slags are skimmed off and the matte, if sufficient in quantity, is tapped. But the English practice of limiting the tenor of the first matte to 33 per cent. is not followed everywhere. In the Guayaquil smelting works of Messrs. Urmeneta & Errasuriz, Chili, one of the largest in the world, the mixture is made up to 15 per cent. of copper, from sulphureted and naturally oxidized ores, and a matte of 50 to 55 per cent. is made at the first smelting. At the Butte works, Montana, also, where a roasted concentrate of about 20 per cent. is matted in reverberatories, the product runs from 60 to 65 per cent.

2. Napier recommended the 30 to 35 per cent. matte to be tapped into water and thus granulated; but most works crush it between rolls previous to calcining it in some suitable furnace. At works in England, where the law is stringent against polluting the atmosphere with noxious gases, the most highly sulphureted ores and mattes are calcined in furnaces which yield a gas of sufficient density for acid making. Mr. Vivian (see his "Lecture on Copper Smelting," Scientific Publishing Company, New York) states that by the use of the Gerstenhöffer in his Hafod works he utilizes 47 per cent. of all the sulphur that enters in any combination, and there makes from what was formerly a nuisance 3,666 tons of oil of vitriol. The matte is roasted so as to leave in the roast about 12 per cent. of the 23 per cent. of the sulphur which it contained before roasting, but a still higher proportion of the iron is oxidized.

3. When, therefore, this roasted matte is again fused, either with a siliceous desulphureted ore or a siliceous slag, there is produced what is technically known as white metal, containing 72 to 75 per cent. of copper, about 20 to 18 per cent. of sulphur, and the balance iron.

4. The product of the last operation, if it be properly performed and has yielded a regulus of over 70 per cent., is now reduced to the metallic state in the blister furnace. It is melted down very slowly, so as to oxidize as much as possible of the sulphur. The slag formed is skimmed off and air is blown upon the melted mass, the result being the formation of oxide of copper and sulphurous acid—the oxide of copper, coming as is supposed into contact with unreduced sulphide yields metallic copper and sulphurous acid, which latter being evolved in the body of the mass causes it to swell to much above its normal bulk—

$$2CuO + CuS = 3Cu + SO_2;$$
$$CuO + SO_2 = Cu + SO_3.$$

From the extreme density of the fumes evolved they would seem to carry some sulphuric acid, which may be derived from the sulphurous acid, when rising through the mass, reducing an equivalent of copper to the metallic state. The chilled charge when again fused should be ready to be tapped as blister of about 98 per cent. copper.

The cost of the preceding operations may be estimated, under the conditions stated, as follows:

Ore to be treated, 48 tons of 10 per cent. matte, yielding 9,600 pounds of copper.

MATTING, OCCUPYING THREE DAYS (SIX SHIFTS).		
6 days' labor for smelter, at $2.25	$13 50	
6 days' labor for helper, at $1.50	9 00	
4 tons of coal per day=12 tons, at $4	48 00	
Production, say, 16 tons of 30 per cent. matte		$70 50
CRUSHING.		
16 tons of matte, at 50 cents		8 00
CALCINING, OCCUPYING TWO DAYS (FOUR SHIFTS).		
8 men, at $1.50	12 00	
2 tons of coal, at $4	8 00	
		20 00
CONCENTRATION OF MATTE.		
1¼ days, at same cost per shift as for matting		35 25
(This is not strictly correct, as less fuel is used per day in concentrating than in matting.)		
MAKING BLISTER.		
1 day, at the same cost per shift as for matting		23 50
Total		157 25

The above estimate and that which will follow, under the head of cupola smelting, allow nothing for superintendence, repairs, furnace tools, and for the innumerable accidents which disturb all calculations, but which certainly do not occur more frequently with the reverberatory than with the cupola. They are also made under the most favorable conditions of ore mixture. A very siliceous or aluminous ore would cost twice as much as the above estimate allows for matting; but such ore cannot usually be smelted at all in a cupola.

Cupola smelting of sulphureted ores.—Till recently the German cupola practice was invariably followed. The German furnace consists of a brick shaft 3 by 4 feet or 4 by 5 feet at the tuyeres, which are generally inserted at the back. The crucible is either closed, as in crucible furnaces, or is a sump or basin in which the matte collects. It extends in front beyond the shaft and is divided by a wall dipping below the surface of the slag, as in the sump furnace, or the crucible is provided with two tap-holes which discharge both metal and slag into basins outside the furnace, in which the separation is effected.

The channel furnace with two eyes, a German brick furnace, smelts about 10 tons daily, and the length of a campaign seldom exceeds a fortnight, when the shaft must be relined and the sump, or basin, retamped with brasque. The following statement of furnace work at Ore Knob, in 1876, illustrates the operations of the German furnaces used there and in Vermont:

MATTING IN CUPOLA.

30 pounds charcoal (2 bushels)	200 charges per day = 21,000 pounds per day.
105 pounds ore	
35 pounds flux	

Yielding matte 35 per cent.

CONCENTRATION IN SPECTACLE FURNACE.

25 pounds charcoal	140 charges per day = 11,700 pounds matte and slag per day.
28 pounds slag	
56 pounds roasted	

Produce, two-thirds black copper; one-third matte.

Slag retreated in ore and matte charges; matte reroasted three times and added to matte charges.

Fourteen or fifteen years ago Piltz introduced much larger cupolas, with a circle of tuyeres; and the Rachette furnace, an oblong furnace with tuyeres on the opposite long sides, was applied to copper smelting. The Piltz furnaces built at the Panulcillo mines, Chili, in 1871, smelted as much as 60 tons of ore each, daily. But American metallurgists, untrammeled by precedent, have certainly made great improvements in cupola construction and practice. Cupolas with circular tuyeres like the Mackenzie used at the Lake works, or with six tuyeres surrounding a high-jacketed furnace, or magnified Rachette furnaces, such as the Orford Company have built at Bergenport and as those which have supplanted the small German furnaces at Ely, are now the only forms of furnace in general use in this country. The sump of the old German furnace has grown into a well, detached from the furnace, into which the products of fusion flow continuously. Neither the water-jacket nor the well can lay claim to be American inventions. Mr. John Williams, since so well known in this country, built in 1852 near Drontheim, Norway, sectional water-jacketed furnaces, consisting of a circle of long narrow water-backs, perforated by tuyere holes. In these furnaces he also used the germ of the modern outer well, by flowing the entire charge continuously from the furnace through an aperture two inches below the tuyeres into an outer sump inclosed in iron plates, in which the separation of slag and matte took place. Water furnaces were long used at the lead works of Pont-Gibaud, France, and were introduced thence by Mr. Rickard into the Richmond Company's works at Eureka, Nevada. Smelting in water-jackets received a great impulse when, in 1873, Messrs. Daggett, at the Winnamuck, and Williams, at the Flagstaff, on lead, and at the Copperopolis mine, on copper carbonate, erected water-jackets; but the present familiar type of water-jacket was planned and first erected at the Blue Bell mine by Mr. Lewis Williams. An outer well was, I believe, used at Vivian's works before being employed on this side of the Atlantic. But to the Orford Company is due the credit of designing and using most successfully a well with a partition extending from side to side, and reaching from the top to some distance beneath the surface of the slag. The slag is drawn off in a steady stream from the compartment nearest the furnace, and the matte from the compartment beyond. As the company has built the furnace of a capacity of 100 tons per 12 hours, the flow of both matte and slag is so rapid as to meet the difficulties which would otherwise beset such a mode of procedure. A notable advantage of the well is that it relieves the smelter almost entirely of iron sows, the constant flow of material being unfavorable to their formation. Reduced iron sometimes settles in the well, but the removal of the well and its replacement by another is a short operation and does not necessitate a blow-out.

The data are not yet available for determining the consumption of fuel in water-jackets and brick furnaces respectively—nor whether, for instance, the heat absorbed by the water in the one class of furnace is greater or less than the loss by radiation from the other; but, on whichever side the balance stands on that score, there can be no question that the water-jacket reduces the cost of repairs most notably. The Copper Queen furnaces have run for 1,520 days and produced 17,000,000 pounds of copper; and yet less than 2,000 bricks have been used in repairs, while the cost of repairs and renewal of the jackets averages $250 on each furnace per annum. In matte-smelting the cost of replacement of a chilled well is so trifling compared with that of tamping in the old-fashioned sump as to eliminate that serious item of repairs from modern cupola works.

The cost of making black copper in a cupola of average size, from suitable ore under the same conditions of labor and fuel as regulated the estimate for reverberatory smelting, would be about as follows:

MATTING, 48 TONS, BEING ONE DAY'S RUN.

2 furnace men, at $2.25	$4 50	
4 feeders, at $1.50	6 00	
4 slag-wheelers, at $1.50	6 00	
7 tons of coke, at $5.50	38 50	
2 engineers, at $2	4 00	
1 ton of coal for engine, at $4	4 00	
		$63 00
Producing, say, 16 tons of matte. [A much richer matte is, however, made at some works, and that with great advantage and economy.]		
Breaking for stalls or heaps 16 tons, at 25 cents		4 00
Breaking or heap-roasting five times, 16 tons, at $1.50		24 00
Concentrating in black-copper furnace 13 tons of roast, at $1.50		19 50
Roasting and concentrating 2 tons of white metal, at $3		6 00
Total		116 50
As against reverberatory treatment		157 25

If, instead of a 10 per cent. mixture, both furnaces ran on an inferior grade, the difference would be more marked in favor of the cupola.

Conclusions.—To sum up the comparisons:

1. The cost of smelting a suitable ore in a cupola is less than in a reverberatory, but the range of ore suitable for cupolas is less than for reverberatories, and therefore at general works, such as those of Baltimore, the reverberatory is more applicable than the cupola, more especially now when so little ore and so much furnace produce is coming to the Atlantic coast.

2. If the ore is arsenical, the elimination of the arsenic and certain other impurities is better effected in the reverberatory than in the cupola.

3. In certain localities where wood and coal are cheap and charcoal inferior, or coke dear, reverberatory smelting is the more economical. For instance, in Butte, Montana, wood can be had for $5 a cord, and Wyoming coal at $8 per ton, while Pennsylvania coke costs $30. Under these circumstances, even with dear labor, the cupola has little or no advantage over the reverberatory. At the Montana Company's works, where the reverberatory is used on the siliceous ores and the cupola on the more basic, the comparison is rather in favor of the reverberatory under the above exceptional circumstances.

4. Where refractory building material is scarce, but the ore is suitable, water available, and other conditions favorable, there should be no hesitation in adopting the water-jacketed cupola.

5. If a sulphureted ore is brought to the metallic state in a black-copper cupola, the product of 90 to 95 per cent. is below that of the blister furnace. The cost of refining is thereby increased, the yield of the refinery diminished, and in some cases an inferior copper produced. However, in some works cupolas are used for matting and reverberatories for subsequent concentration.

6. The slag will under equal conditions be invariably cleaner in cupola than in reverberatory smelting—a point admitted by the most strenuous supporters of the Swansea method.

7. The repair account under the old cupola system was much heavier than it is with reverberatories; but as cupola smelting is now conducted the balance is probably on the other side. Moreover, the serious expense and delay occasioned by iron sows in the old cupola furnace have almost disappeared.

8. For the production of cake copper from carbonate ores, which depends entirely on a reducing action, the cupola is in every way preferable to the reverberatory.

9. A reverberatory-furnace bottom soaks in a large amount of copper, which lies there as dead capital, a loss not incurred in cupola smelting to the same extent.

10. It is evident that no arbitrary rule can be laid down. Local as well as general considerations must in each case regulate the decision.

It is unnecessary to describe in detail the final refining operations, which are seldom performed at the mines (the Ore Knob and Sainte Genevieve mines alone refining their own copper), and which are essentially the same whether applied to the product of the cupola or of the reverberatory, provided the grade of the cake be sufficiently high. Some Arizona cake has been so low as to require preliminary concentration in a blister furnace, and some brands contain impurities which impair their value. Certain brands, on the other hand, have been found to possess exceptional excellence for special purposes, and therefore command a better price than ordinary grades. It is a mistake to suppose that all carbonate ores yield a copper of equal quality.

In addition to the general smelting works enumerated above, and all of which of course refine, the Ansonia Brass and Copper Company, the New Haven Copper Company, and other rolling-mills, which refine their own scrap, are purchasers of so-called copper bullion.

THE HUMID METALLURGY OF COPPER.

Applicability of the wet methods.—Humid methods are adopted for extracting copper from its ores—

I. When the quantity of copper present is too small to admit of the application of a furnace method. The reagents consumed in dissolving copper from its associated minerals are generally in proportion to the absolute quantity of copper present; and, consequently, when the copper contents are low, the quantity and cost of the necessary solvents are proportionally reduced, in case the non-cupriferous ingredients are inert and unacted on; whereas the fuel, which is the principal reagent in all smelting methods, has to dispose of and alter the constituents of not only the copper but likewise the gangue.

II. When the ore contains injurious elements which cannot be eliminated in the smelting furnace, as, for instance, arsenic and antimony.

III. When the copper is associated with other metals, economically valuable, which, if all were smelted together, would pass into valueless combinations. For instance, the pyritous ores of Spain, after their sulphur has been roasted off, might be smelted, but by so doing the silver would enter the copper and be lost, and the iron would enter the slag and become valueless.

Local conditions at any given locality, such as the value of fuel, which is always sparingly consumed in humid methods, compared with the value of the dissolving or precipitating reagents, which in some places are very cheap and in others unobtainable at economical figures, as well as the character of the ore and its contents, must determine whether a dry or a wet method shall be selected, and if the latter, which one of the many proposed shall be chosen.

Among the deterring conditions in any case is the presence of a considerable quantity of lime, magnesia, or other constituent in the ore, which by consuming the solvent occasions its waste.

Every wet method consists of two principal operations: (1) The separation of the copper by solution from the other ingredients of the ore or mixture; (2) the separation of the copper in the solution from any other substance held in solution, by precipitating it as metal, as oxide, or otherwise.

All wet methods may be grouped into two principal classes:

I. Those in which the fresh solvent has to be used for the extraction of the copper from each successive charge.

II. Those in which the solvent is renewed or regenerated in one of the later stages of the operation.

I.—NON-REGENERATING METHODS.

Natural cementation.—Heavily sulphureted ores of iron and copper readily undergo decomposition, the sulphur being oxidized into sulphuric acid, which attacks the simultaneously oxidized iron and copper, forming soluble sulphates of these two metals. Under the combined action of heat and moisture the sulphatization takes place actively in certain mines, the water flowing from which carries a notable amount of copper. To save this it is conveyed through tanks filled with iron, whereby the copper is recovered as metallic precipitate (cement copper). When the Tennessee mines were actively worked, a great deal of copper was saved in this way that would otherwise have run to waste. In Europe many hundreds of tons of copper are precipitated annually from the water flowing from the Spanish mines, the Mona mine, Anglesea, and others. The Salienthal mine waters yield 0.264 pound of iron and 0.032 pound of copper per cubic foot, or 0.5 per cent. of copper. As there is always a large amount of free sulphuric acid in these waters, the consumption of iron is largely in excess of what is required to merely precipitate the copper. From a neutral solution 87 parts of iron will precipitate 100 parts of copper, but from the acid liquors of Salienthal it required, in 1859, 5,598 cwts. of iron to precipitate 2,153 cwts. of copper, or 260 parts of iron to 100 parts of copper.

This same reaction, by which the sulphurets in mines are being deprived of their copper, is taken advantage of to extract the copper from iron pyrites low in copper. For instance, at the Barry & Mason mines and elsewhere in Spain and Portugal large heaps of fine ore accumulate, carrying about two per cent. of copper. These are simply wetted, preferably by water thrown with violence from a hose, which carries mechanically some air into the heaps. As a result in that warm climate, disintegration and decomposition proceed so rapidly that the copper is virtually leached out from the heaps in about two years and recovered by precipitation on iron. In this country a very old industry has been the manufacture of copperas from the crude pyritous ores of the Copperas Hill mine, Vermont, which are decomposed slowly even in that cold climate by atmospheric agency.

Heap and furnace roasting to sulphatize copper.—The sulphatization of the copper may, however, be accelerated by roasting the ore slowly. When roasting mixed sulphurets of iron and copper, sulphate of iron is produced at a low heat. This at a somewhat higher heat is decomposed, and the liberated sulphuric acid attacks the copper. If the temperature favorable to this reaction could be maintained, all the copper would be converted into and remain as sulphate. But the operation is too delicate to be perfectly and invariably effected, and therefore, although this direct sulphatization has been the aim of a great deal of patient and intelligent study and experiment, no furnace in which or method by which to effect it economically and thoroughly has been devised.

Away back in the sixteenth century, Joachim Gans, according to Vivian, proposed to wash out the sulphate from roasted ore. Bankart, working in the same direction in this century, gave an impetus to hydrometallurgy by roasting ground sulphureted ore in a reverberatory furnace, leaching out the sulphates, and reroasting the leached ore with some raw sulphurets till the oxide which escaped sulphatization was finally rendered soluble. He thus effected a very thorough extraction of the copper, but the handling and rehandling of the ore so frequently counterbalanced the advantage, and the method fell into disuse. But the essential features of this method are practiced at Agordo, Italy; in Spain, elsewhere in Europe, and at Spenceville, California. At all these mines sulphurets of iron carrying a low percentage of copper are built into piles of 250 or 300 tons upon a foundation of wood. Lumps of about two inches cube form the core of the piles, being built around a perforated chimney. The fine ore is spread over the surface. The rapidity of combustion is regulated by the admission of air into channels built into the base, and by varying the thickness of the covering. A well-constructed pile will burn for nine months. The lumps after roasting contain a rich kernel of sulphide of copper and iron inclosed in a friable shell of oxide of iron, in which the copper exists almost wholly as sulphate.

At Agordo, in Italy, these kernels are separated and smelted, while the shell is leached for the extraction of the copper. At Spenceville, in California, where alone in this country this method is practiced, the roasted ore—without the rejection of the kernels, which are there (owing to haste in roasting) but imperfectly formed—is passed directly to the leach tanks, where it is twice drenched with water, and a solution of 7° Baumé obtained. The leached stuff, still carrying nearly one-half of its copper as sulphide and oxide, is thrown into large piles, where oxidation continues to go on, and whence the copper is slowly extracted by water made to percolate through the mass. At Spenceville the richer copper liquors are freed of their copper in large rotating barrels charged with iron scrap. The exclusion of air reduces the formation of basic salts of iron, and thus enables a cement of exceptional purity, running over 80 per cent., to be produced. The record of work at Spenceville last year shows 492 tons of 84 per cent. cement copper recovered from 13,715 tons of ore.

At Agordo, where the leach liquors are run from the vats directly into open precipitating vats, the consumption of iron was 3.27 to 1 of copper, and the cement contained so much basic sulphate as to be unfit for refining. To prevent this, Zoppi, in 1876, treated his leach liquors with sulphurous acid in a suitable tower before precipitating the copper, and as a result reduced the consumption of iron to 2.55 parts to 1 of copper, and obtained a cement fit for the refining furnace.

To effect a more perfect sulphatization, sulphate of iron has been mixed with the ore to be roasted, but Monnier at several works in this country employed a better reagent in sulphate of soda; inasmuch as sulphate of iron gives off its acid at very low red heat, whereas sulphate of soda in contact with roasting ore absorbs an additional equivalent of acid, stores it up as bisulphate, and only relinquishes it to sulphatize the oxide of copper when the heat is highest near the fireplace of the muffle. By evaporating down the liquors after precipitation of the copper, the sulphate of iron or of iron and soda can be recovered, and the two last methods then become regenerative.

Solution by means of sulphuric acid.—In several European works the sulphurous acid from roasting pyrites and blende is introduced with steam beneath the false bottoms of the leach-tanks, and is allowed to permeate the moistened mass of oxidized ore. These conditions are very favorable to the production of sulphuric acid, which attacks the copper oxide. Dilute sulphuric acid is also in many places in Europe used as a solvent of oxide of copper from ores. The bluestone of commerce is made by attacking pure copper oxide with sulphuric acid, the sulphate formed in roasting ore or matte seldom being free enough from iron oxide to yield pure crystals. Formerly old sheet-copper was the source of most of the blue vitriol; but of late, both in Europe and in this country, silver-bearing copper matte, concentrated until almost all the iron has been eliminated, and then roasted at a temperature which renders insoluble what iron remains, and treated with sulphuric acid, has supplied more than the demand. The copper oxide made at Hill's works, Argo, Colorado, enters the market in this form; the Baltimore Copper Works treat their silver-bearing ores and mattes in this manner; and several of the lead-smelting works which produce copper swell the production of bluestone. The supply in Europe is so far in excess of the demand that the sulphate of copper in some works is heated in close vessels, the acid distilled off and collected for use again, and the resulting pure oxide of copper smelted. In Nevada an impure bluestone is made from a carbonate ore of copper and from copper cement, for use in the silver mills. Though in some European works sulphuric acid, alone or in connection with other reagents, is used as a solvent of copper, to be afterward precipitated, in this country it is too costly to be so employed unless it be made in the metallurgical operation itself. It is, if anything, a more active solvent than dilute hydrochloric acid at the same temperature, but if suboxide of copper be present in the roast it breaks it up into protoxide yielding sulphate and metallic copper, which at a low temperature it does not attack, and which therefore escapes solution.

Solution of copper as chloride.—Hydrochloric acid being a waste product at the chemical manufacturing centers of Europe, is there largely used as a solvent of copper oxide, and to assist in the decomposition of sulphurets; but far more copper is rendered soluble by the action of salt on sulphureted ore in the roasting furnace than by the direct action of the acid. Longmaid, in 1844, patented a method for extracting copper in this way, but it was not carried out on a large scale till the production of cupriferous residues from Spanish pyrites, after their desulphatization at the acid works, called for a method by which the copper could be saved economically, without sacrificing the associated iron and silver. Henderson, whose name has been given to the process, repatented the essential points of Longmaid's method, adding, however, to the roasting furnace a Gossage tower, in which to condense the gases evolved in the calciner, and thus acidulate the leach liquors. As practiced at present in England, where about 20,000 tons of metallic copper are made annually by it, the following are the steps of the process:

The pyrites cinder, as it comes from the acid works, contains on an average:

	Per cent.
Copper as sulphide	1.65
Copper as sulphate and oxide	2.10
Iron as sulphide	3.64
Iron as peroxide	77.40
Silver	0.0037
Small quantities of zinc, lead, lime, arsenic, etc.	

There must at least be as much sulphur present as there is copper. The cinder is ground and sized through screens with eight holes to the linear inch, 8 to 17 per cent. of salt being added, according to the furnace used. Gibbs claims that his mechanical furnace chloridizes with 8 per cent.; whereas the Widnes gas-furnaces are said to require the addition of 17 per cent. The quantity which can be chloridized per day also varies with the furnace used, but the rate of calcination may be set down at 9 to 10 tons per day per furnace, fed usually in three charges. The heat is never raised above a dull red, the limit within which the copper is most effectually chloridized without being volatilized. Where gas-furnaces are used, as at Widnes, extraneous heat is applied for about three hours. By that time the reaction between the sulphur and salt is proceeding vigorously, and the gas is turned almost off; for the heat evolved in the roasting mass, which is repeatedly rabbled, maintains a sufficient temperature. The chloridation is completed in six and one-half hours, when the charge should contain:

71 per cent. of the copper as chloride.
4 per cent. (or not over) of the copper as subchloride.
20 per cent. of the copper as oxide.
5 per cent. (or not over) of the copper as sulphide.

Muffles, or combined muffles and reverberatories, as well as mechanical furnaces, are used; but in all cases the gases, consisting of hydrochloric, chloric, sulphurous, and sulphuric acids, are carried from the furnace through Gossage towers, where an acid leach-liquor is obtained. But generally the acid thus condensed is insufficient to dissolve the oxide of copper in the roast, and free hydrochloric acid has to be used as a final bath.

The chloridized ore is thrown hot upon the false bottoms of large wooden leach-tanks holding 10 tons, and is washed first with weak liquors from a previous operation, then with water, and finally with the tower, and if necessary additional acid liquors. The filling, leaching, and emptying occupy 48 hours. The liquors passed to the precipitating vats contain from 5 to 6 per cent. of copper. The residues generally contain:

Copper ....0.15 per cent.
Iron as peroxide.............90.61 per cent. =63.42 per cent. of metallic iron.

The precipitation is always effected by iron, and the chlorides of iron and sodium and sulphate of soda in the resulting liquors are run to waste. The consumption of iron is from 100 to 120 parts to 100 parts of copper.

No other humid method is carried on anywhere so extensively and successfully as is this by the twenty-five pyrites companies of Great Britain, as well as by works in Belgium and Germany. Recently it has been put into operation in this country by the New Jersey Extraction Company on the Spanish ores of the Rio Tinto Company. Roasted cupriferous pyrites is undoubtedly the ore best suited for it, for the peroxide of iron, as shown by Macfarlane, plays an important part in bringing about such exact results. When the method was applied to very siliceous ores, as at the Bruce mines in Canada, the extraction was not as perfect. An ore of much above 4 per cent. cannot be advantageously treated, the chloridation being imperfect and a larger amount of subchloride of copper being formed than there is alkaline chloride in the liquor to dissolve. The large consumption of salt precludes the use of the method where that reagent is expensive. Hence various plans have been proposed, and to a certain extent adopted, to use the waste liquors or their saline contents as solvents, in what are known as—

II.—REGENERATIVE METHODS.

The various plans.—In 1862 Gossage obtained letters patent for a plan to economize the waste Henderson liquors by evaporating them to dryness, by which an insoluble peroxide of iron and soluble perchloride are obtained—a most powerful solvent of not only copper oxides but copper sulphides. The waste by formation of basic persalts and the cost of evaporation forbade the general adoption of the method. Were the waste liquors evaporated to dryness in a reducing atmosphere, and the protosalts of iron, as well as the chloride and sulphate of sodium, recovered for mixture with fresh ore in the furnace, the result would be more economical, but neither method is applicable where the cost of concentration exceeds the value of the product. Chloride of iron in solution sprinkled over roasted pyrites, even crude, becomes perchloridized in the air and in time converts the insoluble copper into soluble chloride. The result is hastened by the addition of salt and free hydrochloric or sulphuric acid, as proposed by Kipp. Instead of obtaining a persalt of iron by evaporation to dryness in an oxidizing atmosphere, Henderson and others have proposed to obtain perchlorides and persulphates by forcing air through the solution of protosalts; but all these plans are open to the objection that a large proportion of the solvent is thereby lost and must be replaced.

The protochloride itself is a good, though not as powerful or as rapid, a reagent as the persalt of iron. Its action on oxide of copper was pointed out by H. Meyer in 1862 as producing a mixture of perchloride and subchloride of copper.

The conversion of two-thirds of the copper into insoluble subchloride ($4\ FeCl + 3\ Cu_2O_2 = 2\ Cu_2Cl + 2\ CuCl + 2\ Fe_2O_3$) necessitated the addition to the chloride of iron of a solvent of the subchloride of copper, such as common salt. Used thus in conjunction, a bath of chloride of iron and chloride of sodium, as in the Hunt & Douglas method, has given good results when applied to naturally or to suitably oxidized ores. In carrying it out in practice it is found necessary to grind the ore to greater fineness than for a chloridizing roast, and that the addition of a small percentage of salt in the roasting furnace accelerates the oxidization. The roasting, as in the Henderson process, should be conducted at a very low heat and with abundant access of air; a high heat and deficiency of oxygen converting the copper into insoluble compounds and the iron into magnetic oxide, the production of which in any roast is an unfavorable indication. The leaching is effected in the usual way. The solution of the copper is generally somewhat slower than in the Henderson process, and the extraction of the copper is not quite as perfect; but much less salt and iron are consumed, the saving in the latter reagents being due to the presence of so much subchloride. If the ore contains arsenic, in the presence of the neutral salt of iron none enters the solution. The resulting precipitate is therefore free from any deleterious contamination and can be smelted and refined into good copper at one operation. The regeneration of the chloride of iron is not complete, owing to the formation of basic oxichloride in the leaching and precipitating vats; but, if a sulphureted ore is under treatment, enough sulphates can be formed in the roast to replace the loss of iron, and the addition of salt to replace the chlorine—if due care be taken to work with closed vats—need not exceed 25 per cent. of the weight of copper produced.

At Oker, in the Hartz mountains, a combination of different methods is resorted to in the treatment of copper mattes. The ground matte is salt-roasted, but owing to its richness the chloridation is, of necessity, imperfect. The oxides formed are, however, extracted:

1st. With the protochloride of iron liquor from a previous operation;

2d. With dilute tower acid;

3d. With dilute sulphuric acid, 2½ cwt. of chamber acid diluted to 12° Baumé and heated to boiling, being left for two days on a 5-ton tank charge of partially exhausted ore. The precipitate resulting from the first leach liquors is pure; that from the second and third unfit for the direct production of ingot.

At Alderley Edge, England, an ore occurring in a bed of sandstone carrying a small percentage of copper as oxide and carbonate, mixed with phosphate and arseniate of copper, has long been treated with dilute hydrochloric acid. The copper solutions, being arsenical, are purified by the addition of protochloride of iron, which is said to precipitate the arsenic as an arseniate of iron, with the production of some free hydrochloric acid. After precipitation of the copper the solution, containing chloride with some perchloride of iron, is concentrated to a specific gravity of 1.4 per cent., and sprinkled over a reverberatory furnace-sole covered with red-hot sand, whereby free hydrochloric acid is generated, to be condensed in a tower and used for leach liquors.

The action of sulphurous acid as a solvent, when oxidized into sulphuric acid, has already been referred to. Its indirect action as a reducing and acidulating agent has also been noted when describing Zoppi's treatment of the Agordo solutions. This reaction has been taken advantage of by other copper workers and is made the basis of several regenerative methods. McTear proposes to pass the Henderson solutions before precipitation through a stream of sulphurous acid gas, with a view to reducing the perchloride of iron present and liberating free acid; as expressed by the equation

$$Fe_2Cl_3 + So_2 + HO = Fe_2Cl_2 + HCl + SO_3.$$

Acidulated liquor would then enter the precipitating vats, but by watching the progress of the precipitation and drawing off the solution before it is quite effected iron would not be wasted and the free acid would be available as a solvent.

Déby has more recently patented a method in which he claims that the protosulphate of iron after the precipitation of copper sulphate is oxidized into persulphate in its passage through a tower where it meets an ascending current of sulphurous acid gas. Were the sulphurous acid unmixed with air the result would be the reverse; but in practice the acid is no doubt diluted with excess of air, the oxygen of which persulphatizes the solution, while the sulphurous acid simultaneously tends to reduce the persalt, and in doing so generates free sulphuric acid. The resulting liquor is a powerful solvent, carrying free sulphuric acid and persulphate of iron. This solution (as does sulphuric acid alone) separates sulphide of copper from sulphide of iron, dissolving the copper slowly and obviating the necessity of a preliminary roasting. Déby is applying this method very successfully to the waste pyrites of the Rio Tinto mines, Spain, and has obtained a patent in this country.

An ingenious method was patented in 1866 by Messrs. Whelpley and Storer, in which also sulphurous acid is the efficient agent. It was never successfully carried out on a manufacturing scale, though the reaction, if effected by the aid of simpler apparatus than the inventors recommended, might be made use of. They employed a bath of chloride of calcium and sodium, and into it threw oxidized copper ore and sulphurous acid from a shaft furnace—the result being the production of sulphate of lime and subchloride of copper, which, when precipitated as suboxide by milk of lime restored to the bath its chloride of calcium:

$$2\,CuO + Ca\,Cl + So_2 = Cu_2Cl + CaO\,SO_3;$$
$$Cu_2Cl + CaO = Cu_2O + CaCl.$$

Another method of applying sulphurous acid was patented by Hunt & Douglas in 1880. They add to a solution of sulphate of copper, obtained from ore or matte by the acid generated in the second stage of the process, enough chlorine as chloride of sodium, iron, or calcium, to yield subchloride of copper under the action of concentrated sulphurous acid gas. The acid is drawn from a brimstone burner, or a pyrites kiln, or a cylinder furnace, and is injected into the solution. It must be concentrated; for if diluted with much air a simultaneous oxidizing and reducing action goes on which results merely in the production of acid, no copper being separated; but if the acid be sufficiently strong and there be no great excess of chlorine present to hold the subchloride in solution, this salt separates as a heavy white crystalline powder, uncontaminated by any impurity which the solution may contain; and an equivalent of free acid is generated for every equivalent of copper reduced. In practice the separation of the copper in this insoluble form is rapid and perfect, and a large excess of free acid is produced, through the oxidation of sulphurous acid by air which is unavoidably injected with it. Theoretically about 1 part of sulphur should suffice to separate as subchloride 4 parts of copper; in practice the consumption is nearly 1:2—owing partly to the cause above stated and partly to the escape from the reducing vat of unconsumed gas, especially towards the close of the operation, when the solution of copper has become weak. The subchloride, if precipitated by iron as metal, yields chloride of iron sufficient to chloridize another charge of copper sulphate; if by milk of lime as suboxide, the resulting chloride of calcium serves the same purpose. The reactions may be thus expressed:

$$2\,CuO\,So_3 + FeCl + SO_2 = Cu_2\,Cl + FeO\,SO_3 + 2\,SO_3;$$
$$Cu_2\,Cl + Fe = 2\,Cu + FeCl.$$

In addition to iron and lime as precipitants, sulphureted hydrogen has been employed. Sinding made it cheaply by passing carbureted hydrogen through heated pyrites. In throwing down copper as sulphide, free sulphuric acid is generated for subsequent use. But a great objection to the method is the intractable character of the precipitate.

Ammonia, hyposulphite of soda, acetic acid (free and in combination), and other reagents, have been tried as solvents, but with indifferent success.

The choice of method.—The foregoing enumeration and brief description confirm the accuracy of the proposition laid down in the introduction, that no humid method is of universal application, but that the character of the ore to be treated, as well as local considerations, must determine, first, the cardinal point whether a wet or a furnace method shall be chosen; and then, if a wet, which can be most economically carried out considering the cost of labor, fuel, and the necessary reagents at the given locality. If the ore is arsenical or antimonial, preference will rest with those methods which separate the copper from these detrimental elements; if the ore carry silver, its economical recovery must influence the decision.

THE ROASTING OF COPPER ORES AND FURNACE PRODUCTS.

BY EDWARD D. PETERS, JR.

The term "roasting" in this paper will be applied to that metallurgical process by which ores containing compounds of sulphur, arsenic, and antimony, and in either a coarse or pulverized condition, are exposed at a moderate temperature, seldom exceeding a bright red heat, to the action of a current of air, and as a preliminary to subsequent treatment for the extraction of their copper contents either by fusion or in the wet way. The term "calcination" is sometimes employed to express this same process, the word "roasting" being reserved to describe the gradual melting down of copper matte in a reverberatory furnace and at a higher temperature, in a current of air, as is the practice in converting white metal or regule into blister copper; but this is a term confined to the English smelters or to those who follow their practice, and writing as an American, I prefer to use the word "roasting" in the manner already explained.

There are various methods of roasting according to the object in view; but these are easily designated by a simple prefix, such as chloridizing-roasting, reducing-roasting, kernel-roasting, etc. In this paper, the simple oxidizing-roasting will be the one chiefly referred to, and that it is well worth careful consideration will become obvious when we reflect that it is usually the first and most important step in the metallurgical treatment of that class of ores from which the greater part of the world's copper is produced. In the United States, it is true, the sulphureted ores form a less important group than in most other countries, owing to the wonderful productiveness of the Lake Superior region, where the copper occurs entirely in a metallic state, and where the interest of the ore treatment is confined almost exclusively to that branch of metallurgy known as mechanical concentration, the subsequent processes being merely a simple fusion followed by refining in the same furnace. As two-thirds of our copper comes from this source, and, roughly speaking, one-half of the remaining thirty million pounds comes from the carbonate and oxide ores of Arizona, New Mexico, and California, it might seem as if there were a very small remnant left to warrant the discussion of a process employed solely in its production; but in this case the metallurgical importance of the three varieties of copper ores referred to stands very nearly in inverse proportion to the quantity produced, and more science, skill, and care must be employed in handling the petty fifteen million pounds of copper, which represent the yield of our sulphureted ores, than in the simple melting and refining, which is all that nature demands in the production of the copper from its metallic or oxidized condition.

The ordinary American practice in the treatment of the carbonate and oxide ores just referred to has been almost entirely built up within the past ten years, and owing largely to the perfection of the water-jacket cupola furnace, and the introduction of simple and inexpensive fan-blowers, is quite economical and satisfactory. It is pretty much identical throughout the Far West, and may be dismissed in a few words, as foreign to the purpose of this paper. The ore is so sorted at the mine as to yield at least ten per cent. copper, and after having been broken to egg size by a jaw-crusher, is fused in a cupola furnace with coke as a fuel, and with the addition of the necessary fluxes—limestone, iron ore, or quartz. The fact that most of the deposits occur in a limestone country, and already contain a considerable proportion of oxide of iron, renders their reduction peculiarly simple and inexpensive. Many of the deposits, however, which at the surface carried their entire copper contents in an oxidized condition, are now beginning to show a considerable proportion of copper glance and other sulphur compounds; and the unwelcome sight of an increasing quantity of matte is commencing to complicate the hitherto almost unparalleled simplicity of the process. At some works it has been the habit to recharge this into the furnace; a highly unscientific and expensive practice, as it merely adds to the amount of fuel used, and in no wise increases the metallic copper production, except in so far as it may become slightly oxidized, and a small part of its sulphur volatilized in its passage through the furnace. At other works, the more sensible method of sacking and shipping it East is in vogue, but this is in most cases an unnecessary expense, and a perusal of the following pages will indicate the proper treatment to those furnace managers who have no experience in the handling of sulphide ores.

The metallic product of these furnaces is shipped East to the refining works, in the shape of black copper assaying usually from 94 to 98 per cent., and the competition for this class of material, and the favorable freight rates on pig copper as compared with ingot, leave little inducement for the establishment of refining works in the neighborhood of the mines.

Having disposed of the metallic and oxidized ores of copper in these few words, I now take up the proper subject of my paper in the shape of the small class still left, and which, in the United States, produces about fifteen million pounds of copper annually.

To the experienced metallurgist it is unnecessary to insist on the immense importance of a thorough roasting of his ore as a preliminary operation, and as a key to its successful and economical treatment during all the subsequent processes. But as this paper is more particularly intended for those who are not professional metallurgists, but yet are called upon to direct important smelting operations, it may be worth while to point out more carefully the far-reaching influence of this step, so often neglected and intrusted to incompetent hands. The difficulties in smelting poorly roasted ore are innumerable. The silica of the gangue rock, not finding sufficient oxide of iron to satisfy it, forms a tough, infusible slag, while the undecomposed sulphide of iron simply melts into a matte, forming a low-grade product, which requires an extension of the subsequent processes with corresponding costs. The difference in the cost of producing ingot copper from the same grade of sulphide ore, in the one case well roasted, in the other poorly roasted, may easily make the difference between profit and loss.

The following figures, taken as accurately as possible from results of work done under my own supervision, will illustrate this point clearly. They show the cost of putting 9 tons of 8 per cent. ore into ingot copper, in one case the original ore being thoroughly, in the other badly, roasted:

Comparative results in poor or careful roasting.

	Well roasted.	Badly roasted.
Heap-roasting 9 tons ore, at 50 cents	$4 50	$4 50
Smelting the same	22 50	31 50
Roasting 2 tons of 36 per cent. matte from well-roasted ore, three roasts, at 50 cents per ton	3 00	....
Roasting 3 tons of 24 per cent. matte from badly-roasted ore, five roasts, at 50 cents per ton	....	7 50
Smelting 2 tons roasted matte, at $2.50	5 00	....
Smelting 3 tons roasted matte, at $2.50	....	7 50
Producing ingot from last matte	14 00	14 00
Total	49 00	65 00

This shows a cost of $5.44 per ton for the well-roasted, and of $7.22 per ton for the badly-roasted ore; thus showing the total cost of treatment to be increased nearly one-third through carelessness in the first operation. In reality, this estimate falls far below the real cost, as I have not taken into consideration the serious expenses that are likely to occur from sticking-up and burning out the furnace, the formation of an increased amount of foul slag that must be resmelted, and many other annoying circumstances, all arising from the siliceous character of the slag, which, in its turn, has occurred from the imperfect roasting of the ore.

For convenience of description, I shall divide all sulphide ores and mattes, according to their mechanical condition, into two classes—coarse and fine. This division is not so unscientific as may at first appear, for the treatment pursued in roasting this material depends principally upon whether it is in lump form or in the shape of fine powder. In the former case, owing to the interstices which are left when the ore is piled in thick layers, and which permit a draught of air throughout the whole mass, we take advantage of the sulphur contents to dispense with fuel, the sulphur, by its oxidation, generating plenty of heat to thoroughly burn itself, as well as to change the various sulphides present into sulphates and oxides. With fine ores, on the other hand, we have to generate heat in a separate grate or fireplace, and expose the ore either directly to the flame, or indirectly through a layer of heated firebrick or tile.

ROASTING OF SULPHIDE ORES OR MATTES IN LUMP FORM.

Without noticing the innumerable plans that have been suggested, but never carried out in practice, and passing over curious modifications that may be pursued at isolated works under peculiar circumstances, I shall confine myself solely to those well-known and approved methods that seem best suited to American conditions. These may be reduced to three in number:

I. Roasting in piles; suited to either ore or matte.

II. Roasting in stalls; suited to either ore or matte.

III. Roasting in kilns; suited only to ore.

Roasting in piles.—Heap-roasting has been profoundly discussed and described by both Plattner and Kerl, who have left little to add from a theoretical point of view. It is unquestionably the cheapest method of desulphurizing pyritous ores; and the results of the roasting, when properly executed and if the cover of the pile is well stripped off to the point where the cooling influence of the external air has interfered with the process of oxidation, are very satisfactory. It can be employed for ores carrying as low as 15 per cent. sulphur, providing a generous bed of wood has been placed under the pile; and ores containing even as low as 8 per cent. can be successfully roasted by mixing a little coke fines, bark, or refuse wood with the ore. The principal drawback to heap-roasting is the slowness of the process where the value of the copper must be tied up for from one to three months, and the fact that, owing to the great size of the heaps, it must be carried on out of doors, whereby much copper is lost by leaching, by blowing away in fine dust, and trampling under foot while loading and unloading. A still more serious objection in agricultural districts is the escape of the sulphurous fumes into the atmosphere at so low an elevation and in such a concentrated form that before they can become so diluted with the surrounding air as to be rendered innocuous, they may do immense damage to vegetation, their influence frequently extending for several miles in the direction of the prevailing winds, and being peculiarly fatal to young, growing crops.

In calcining tolerably pyritous ores, containing, say, 65 per cent. iron pyrites, a convenient size for the heaps is 20 by 50 feet, and 3 to 5 feet in height. A pile of this size, containing perhaps 250 tons, lighted on the leeward side, well covered with fines, and carefully watched, will burn about 9 weeks and will furnish a product containing from 6 to 10 per cent. sulphur. Some weeks before the burning is completed in the very heart of the pile, it can be opened at the ends and two-thirds of its contents removed without seriously interfering with the process. As the whole advantage of heap-roasting lies in its extreme cheapness, every precaution should be taken to save expense in the handling of the ore. It is an excellent arrangement if the ore-car from the mine or dressing-house can be brought on a trestle over a long line of roast heaps, while the track which leads to the furnaces runs parallel to these and on a still lower level. By this arrangement the expenses of roasting can be reduced to a minimum, as the cars from the mine can be dumped directly upon the heaps, requiring only a little spreading into shape, and when the ore is to be carried to the furnaces it can be shoveled or wheeled from the heaps directly into the car, the top of which should be on a level with the ground on which the piles are built.

The shaping and firing of the pile should always be conducted by experienced workmen, as the result of the roasting is largely dependent on the carrying out of a multitude of slight details, which, taken singly, might seem to have little importance, but collectively exert a powerful influence on the quality of the product. The ore should be broken to that size which local experience has shown to be most advantageous. Hand labor, when not exceeding 50 cents per ton (2,000 pounds), is preferable to a jaw-crusher, owing to the smaller proportion of fines produced; in the former case on ordinarily hard ore, about 12 per cent., in the latter, nearer 20. It is highly advantageous to pass the broken ore over two riddles, thus making three sizes. The largest size, constituting perhaps 70 per cent. of the whole, should be dumped directly upon the wood, and will form the main body of the heap, which should be rectangular in form, with straight edges and neat, square-cut corners. The next size, frequently called "ragging," will constitute about 20 per cent. of the ore, and is that portion which has been separated from the larger size by passing through a riddle with three-quarter inch spaces. This should be built up on the outside of the heap with great care, forming a layer some 8 inches thick at the bottom, and tapering up to about 2 inches at the top. The remaining 10 per cent. of the ore consists of fines which have been separated from the ragging by means of a six-mesh screen, and which should be transported to the heap and arranged in piles at a convenient shoveling distance, none being placed upon the heap until the wood has been kindled, and the strong fumes of sulphurous acid show that the ore is thoroughly ignited. Then the lower portion of the pile is rapidly and evenly covered with the fines, leaving the top still exposed until the heat becomes so great as to warn the attendant that the central portion of the ore is in danger of melting. The top is then covered thinly, and for the first few days careful watching is required to keep the combustion regular and gradually increase the protecting layer of fines. By the end of the fourth day the pile should be burning slowly and evenly, smoking slightly from its entire surface, and no hotter in one part than another. From this time until the process is complete, only careful watching is required, and a few shovels of fines scattered in one place or another, as the draught may indicate, comprises all the labor necessary for the roasting of two or three hundred tons of ore. About one-thirtieth of a cord of wood and one-fourth of a day's labor per ton of ore will build and burn the heap and load the roasted ore into cars ready for the smelter.

The brief directions just given apply to cupriferous pyrites, but we are frequently called upon to roast copper matte in heaps, which calls for some slight modifications in its treatment. Owing to the extreme fusibility of this material, and the large amount of copper which would be tied up if we should build heaps of the same size as for ore, it is the practice to burn matte in heaps containing only from 30 to 40 tons. As the matte contains much less sulphur than the ore, it is necessary to use a thicker bed of wood, and after the first burning, which should be completed in five days, the pile should be turned on to a new layer of wood, breaking all the clinkers to egg size again, and piling the outside of the heap, which will be found but slightly affected by the first burning, directly upon the new bed of wood. We cannot avoid the formation of extensive clinkers in burning matte, and I never consider the first burning satisfactory unless at least the central third of the pile has been fused into a solid mass. The second burning lasts about five days, and a third is usually completed in four. Matte containing 30 per cent. copper, after three thorough burnings, should yield white metal (70 per cent.) when smelted rapidly through a cupola furnace, and this white metal broken to proper size and subjected to two more fires, will yield most of its copper in a metallic state.

Heap-roasting is little suited to matte, and should only be practiced when necessity compels its adoption. The great value of the material causes a correspondingly heavy loss, both mechanically as well as by solution in water if the weather be unfavorable. The matte stalls, to be described in another section, are admirably adapted to this class of material, and will soon save their original cost in preventing waste, as well as in the increased thoroughness of the roasting that can be attained by their use.

As the object of heap-roasting is to remove the sulphur contents of the ore, it will be interesting to note how far that result is accomplished under ordinary circumstances. Analyses of heap-roasted ore are not plentiful, and I have made no exhaustive ones, but I have frequently determined the sulphur contents of the ore both before and after roasting, as well as the amount and condition of the copper contained, and the result of a few of these investigations may be instructive.

No. 1. A heavy pyritous ore from the Ely mine, Vermont, containing principally magnetic pyrites and chalcopyrite. It was burnt in a pile of about 300 tons for 11 weeks. The poorly burnt surface of the heap was stripped off, and the analysis given refers to the regular furnace sample, taken from the remainder of the heap.

The raw ore contained:

	Per cent.
Sulphur	32.6
Copper	8.2
Insoluble residue	27.0

The same ore after roasting contained:

	Per cent.
Sulphur	7.4
Copper	9.1
Insoluble residue	31.1

The condition of the copper in the roasted sample was as follows:

	Per cent.
Sulphate of copper	1.3
Oxide of copper	2.1
Sulphide of copper	5.7
Total	9.1

No. 2. A heavy pyritous ore composed principally of common yellow iron pyrites, carrying a little copper, silver, and gold; from the Phillips mine, Buckskin, Colorado.

The raw ore contained:

	Per cent.
Sulphur	46.5
Copper	0.7

After six weeks' burning in heaps of about 60 tons, the well-roasted portion, which constituted 90 per cent. of the whole pile, and was used as a flux for siliceous silver-lead ores, contained:

Sulphur	11 per cent.

These examples are sufficient to show what satisfactory results are obtained by a very crude and inexpensive process, and what a large proportion of the sulphur may be disposed of in one operation.

The chemical reactions that take place during the roasting of a pyritous ore containing copper are extremely intricate as well as interesting; and as it is essential to have some idea of the principles of roasting before we can carry out the process with confidence under differing conditions, I will take this opportunity to briefly indicate the most important chemical changes that are brought about by heat and air, and which remain the same whether the roasting of the ore is accomplished in heaps in the open air, or in close furnaces, and whether it is in egg-sized lumps or in fine dust. Before beginning this description, however, I will mention that at some mines advantage has been taken of the peculiar behavior of pyritiferous copper ores when exposed to heap-roasting, to build up a most ingenious method for the treatment of certain low-grade ores, and, that although only adapted to districts where manual labor can be obtained at the very lowest prices, it is well worthy of notice, as aside from the advantages which may be derived from its employment, its description will lead us to a minute study of the chemical and physical changes which occur in heap-roasting.

Kernel-roasting.—The process referred to is called kernel-roasting, and has been carried out for many years at some of the lesser Norwegian mines, and on a still larger scale at Agordo in Italy, in which places the peculiar conditions occur that alone render it practicable. It depends upon the fact that when pyritous ores, rich in iron and poor in copper, are broken to the proper size, and roasted very slowly in large heaps and at the proper temperature, each lump will be found to be changed more or less completely into a mass of oxide of iron which, when broken across, shows near the center a kernel of rich sulphide of copper, resembling a high-grade copper matte, and which can be separated with a few blows of the hammer from its surrounding envelope. In Agordo this is done by women and children; the crusts are leached to obtain the slight amount of copper they may still contain, and the rich kernels are smelted in a blast furnace, yielding at once a very high-grade product. In order to show the wonderful perfection of the concentration, I will mention that the raw ore at Agordo contains but 1½ to 2 per cent. of copper by chemical assay; the crusts vary from four-tenths to seven-tenths of one per cent.; while the kernels, which of course form but a very minute proportion of the roasted ore, average 33 per cent. All descriptions hitherto given, so far as I am aware, refer to a mixture of chalcopyrite with the ordinary iron pyrites, or bisulphide of iron, but investigations which I undertook some two years since were made upon an ore containing about 1½ per cent. copper, and consisting of massive pyrrhotite, or monosulphide of iron with threads and specks of chalcopyrite. This material has been treated at Strafford, Vermont, for nearly a century, for the manufacture of copperas (sulphate of iron), and as the first step in the production of this chemical consists in roasting the pyrites slowly in immense piles, all the conditions are favorable for the concentration of the copper as a kernel in the center of each lump. The result of these investigations, which were made with considerable care, corresponds very closely with the description of the kernel-roasting of ordinary pyrites, as given by Plattner in his *Roestprozesse*, p. 187, but I shall quote principally from my own note book, merely supplying the few gaps that occur in my own notes from the pages of the celebrated German metallurgist.

As the appearance of any individual lump of pyrites differs very greatly at different stages of the roasting, it seems at first hopeless to explain the numberless variations in appearance which were noticed on breaking these lumps at various stages of advancement. But after making sections of some scores of specimens from various portions of the heap, and at all stages of the process, it was sufficiently easy to recognize a constant and regular series of changes, which were invariable, unless disturbed by portions of gangue rock in the lump, or by either a lack, or an excess, of heat. I have divided the process into four stages (each of which would admit of numberless subdivisions and graduations), and shall endeavor to describe the appearance of a lump of ore at each of these main stages.

No. 1, taken from the interior of the pile ten days after firing. The outside of the lump is changed into an oxide of iron, part being the sesquioxide, and another portion being slightly magnetic and much darker in color. This layer of oxide, which is perfectly regular, and follows every inequality of the lump, is slightly more developed below than above, averaging three-sixteenths of an inch in thickness, and gradually merging into a harder, bluish layer, about one thirty-second of an inch in thickness, which separates it from the main body of the specimen. The latter is apparently unchanged except in color, having lost the brownish hue of pyrrhotite, and taken on the appearance of peacock ore, showing on a fresh fracture shades of yellow, blue, and purple. The sharp division between the dull brown pyrrhotite and the specks of bright yellow chalcopyrite which originally existed in the piece has entirely disappeared, and the whole mass has become homogeneous in both texture and color.

The opening made into the heap to obtain this specimen was carefully closed, and in 26 days from the firing of the pile No. 2 was taken from near the same spot. The surface layer of oxide of iron had become much more developed, and was beginning on the very outside to assume an earthy character. This became firmer and darker toward the interior, and at the depth of three-eighths of an inch gave way to a yellowish layer, one-eighth of an inch in thickness, and closely resembling massive chalcopyrite; the interior of the piece still preserved the appearance of peacock ore. An assay of the outside crust yielded 0.12 per cent. copper; the central body of the piece contained 2.1 per cent., and the thin yellow layer separating these two portions, and which I could not obtain in absolute purity, assayed 17.7 per cent.

No. 3 was taken in 45 days from the firing of the heap. The oxide crust now constituted about 60 per cent. of the entire lump, and had become very earthy and friable. In the place of the single yellow layer, rich in copper, appeared a succession of concentric rings, in color ranging from steel-gray to a bluish purple, and inclosing a central nodule of the same unchanged peacock ore as mentioned in No. 2. The earthy crust of this specimen showed merely a trace of copper; the purplish, concentric layers, constituting about 10 per cent. of the piece by weight, contained 12 per cent. copper; while a single very thin layer, nearest the central nodule, assayed 31.4 per cent. The unchanged center contained 2.4 per cent.

No. 4 was taken from the center at the completion of the burning, which had occupied 75 days, the still hot pile having been quenched with water. The specimen presented a cracked and fissured appearance, and the outside three-fourths was completely changed into an earthy oxide of iron. Inside of this envelope appeared the same purplish, concentric layers as in No. 3, but much less developed, and lacking the metallic luster. The earthy portion scaled off from these without difficulty, but it required considerable hammering to detach them from the central kernel, which was about the size of a common white bean, and on fracture presented the well-known appearance of white metal—subsulphide of copper, as produced in smelting. The assays of this piece are highly satisfactory and interesting:

The earthy envelope contained	traces of copper.
The concentric layers contained	1.2 per cent. copper.
The kernel contained	69.6 per cent. copper.

Having described the appearances presented in the four stages into which I have divided this process, it is not difficult, with the aid of Plattner's researches, and the well-known changes that occur in roasting, to follow the chemical and physical reactions whereby the copper is concentrated so perfectly as a sulphide in the middle of each lump.

In the first place, in a compound consisting of sulphides of iron and copper, and especially when the iron sulphide is present in an overwhelming proportion, the copper is completely protected from oxidation at any ordinary roasting temperature, so long as any considerable amount of sulphide of iron remains undecomposed. As the sulphur is gradually sublimed and oxidized, the sulphide of copper becomes converted into a subsulphide, which, being exceedingly fusible, melts gradually at the high temperature engendered by the oxidation of the iron and sulphur, and eventually becomes concentrated, the whole process continuing gradually from the surface to the center, into a kernel in the middle of the lump. As the oxidation progresses, the sulphide of iron near the surface becomes oxidized to the highest possible point, and this progressing gradually toward the interior, the whole mass becomes finally an earthy mass of iron oxide, with the exception of the last remnant of the sulphur, which, being retained powerfully by its affinity for copper, remains combined with this metal in the center of the lump, and in default of any extraneous heat—there being nothing more to oxidize, and thus produce heat in a lump itself—remains unaltered. An extension of the process may result, as is frequently the case, in the decomposition of this last molecule of cupric sulphide, and the formation of a central kernel of metallic copper.

With the view of determining what would be the result of such a roasting on a working scale, I broke up about 20 pounds of well-roasted lumps, and sorted the fragments, as is done at Agordo, into three classes.

1. The outside envelope of oxide of iron, which crumbled under the fingers and was detached with the greatest ease, forming about 80 per cent. by weight of the whole. It assayed only a trace in copper.

2. The submetallic, concentric layers, which separated the outside crust from the central kernel, and adhered to the latter with much pertinacity. These constituted 16.6 per cent. of the whole, and assayed 1.1 per cent. in copper.

3. The pure kernels, almost entirely freed from any foreign matter, and exhibiting a massive, homogeneous appearance. They formed only 3.4 per cent. of the whole, and assayed 55.7 per cent. of copper.

There only remains to state the result of these experiments from a commercial standpoint, which can be done in a very few words. While nothing could be more satisfactory than the completeness of the concentration in those pieces of ore which were absolutely free from gangue rock, and which had been exposed to exactly the proper degree of heat, and while the outer crust of oxide of iron could be separated from them by a single blow with a light hammer, still such a large proportion of the pile was not properly roasted, and the separation of the rich central kernel from its surrounding concentric layers, already described, was so difficult and imperfect that I was reluctantly compelled to give up any idea of carrying out the process on a large scale. The employment of a rock breaker, with jaws set pretty wide apart, would greatly lessen the expense, but would yield but a poor product, and the unfortunate circumstance that pieces of ore once slightly burned without a good result cannot be retreated with any hope of concentrating their copper contents in a kernel, would seem to involve the waste of so large a proportion of the material as to remove any chance of profit. Still the question is by no means definitely settled, and it is yet possible that care, experience, and appropriate machinery may yet raise kernel roasting to the dignity of an established and successful process.

Stall-roasting.—This practice, though applicable to both ores and mattes, is usually reserved for the latter, as ores, being of comparatively small value, and containing a much greater proportion of fuel in the shape of sulphur, can better be exposed to wind and weather.

Out of a dozen various forms of stalls, I select for description one which I consider peculiarly suited to cheap and thorough matte burning, and admirably adapted to Western circumstances in those districts where, although the principal product of the furnace is black copper, there is still run out an appreciable quantity of rich matte, the subsequent treatment of which has often proved embarrassing to unskilled managers. It is always best to build stalls, of whatever variety, in blocks or rows of from four to a dozen or more, as a large saving in both brick and iron-work is thereby effected, and the heat retained in so large a mass of masonry, and communicated to contiguous stalls, is also highly advantageous to the roasting process. It is a great mistake to build stalls without a brick arch over them, as the arch assists both in retaining the heat as well as in forcing the smoke to ascend to the flue rather than to pour out of the front into the shed, greatly to the annoyance of the workmen. The point of greatest importance in construction, however, is to secure a proper foundation for the brickwork, and to tie the furnaces with strong buckstaves and ¾-inch iron rods, although when the arches are built as semicircles, which is usually the case, there is no lateral thrust. Still the expansion from heat would soon destroy the brickwork if it were not properly tied, and any undue saving in this direction is always mistaken economy.

The ordinary dimensions of the stalls in use at some of the largest copper works in the Eastern States are as follows:

	Ft.	in.
Width	5	
Depth	6	
Depth of ashpit	1	6
Height from grate to spring of arch	4	8
Thickness of main walls	1	6
Thickness of division walls	1	

A stall of the size described will hold 5 tons of white metal, and I can see no objection to increasing its dimensions so that it can accomodate double that amount. In fact, I am quite sure that an increase within reasonable limits would lead to a decided saving both in fuel and labor, and be in no wise detrimental to the process.

After thoroughly clearing the grate bars from any fused matte from the previous burning, and plastering the walls carefully wherever they show signs of wear, with a thick mortar of burned and raw clay in equal parts, about 10 cubic feet of hard wood, in ordinary 4-foot lengths, is arranged upon the grate bars as evenly as possible, and all spaces between the sticks chinked with small stuff and split logs. Hard wood is much preferable to soft, and, from my own experience, I should rate it at about double the value of the latter. Its true worth may not at first be seen, but when the roasting is completed it is not difficult to distinguish a kiln of matte burned with hard wood, by the greater thoroughness of the roast, and consequently its smaller percentage of sulphur, which, as we have already seen, has a powerful influence in subsequent operations. A thicker layer of wood should be placed at the front and sides than in the middle, and as the stall is gradually filled, it is well to fill in with chips and brush (or small coal), both on the front and sides, nearly to the top of the heap. The front is built up loosely with fire-brick placed on edge, and kept from being pressed out, either by bracing it with a couple of cross irons or by giving the whole loose front wall a slightly arched shape, with its convex side, of course, toward the interior of the stall. The matte should be broken to the size of the fist or smaller, and to facilitate this operation the furnace from which it is produced should be tapped on to thick iron plates in such a manner that the matte forms a layer not more than two inches thick, which will be as brittle as glass, and can be spalled by boys at an expense not exceeding 25 cents per ton (New York prices).

Where the matte is only produced in insignificant quantities in comparison to the black copper, and is obtained in the form of a thin layer on the top of each copper bar, it is also in excellent condition for breaking. Under ordinary circumstances it will not be found necessary to screen the matte before filling the stall at the first burning, but care should be taken to avoid mixing the fine stuff with the mass of the metal, and towards the last it is better to separate the coarse pieces from what remains on the floor with an iron rake, and eventually cover the surface of the pile with the fines that are left. The kiln is best fired when the men quit work at night, by pouring a ladlefull of hot slag on a heap of kindling wood, which should be pretty well distributed under the grate, and under ordinary circumstances there will be no more attention required until four days are completed; at the end of which time, if the kiln has ceased smoking, the front wall may be pulled down and cleared away, and the contents of the stall removed with pick and hoe. The matte will be found loose and little burned at the front and sides, but in the center, if the result is satisfactory, will be found a massive clinker, and surrounding this on all sides a greater or less amount of porous and well burned material. Hammer and gad must be called into requisition to break up and remove the clinker, and a long chisel-pointed steel bar will be found of the greatest utility. Meanwhile, the nearest empty stall has been provided with a fresh layer of wood, and the once-roasted matte, as it is removed, is re-spalled with a hammer, so far as necessary, and again piled upon the wood, taking care to place that portion that has escaped burning nearest the fuel. The proportion of fines will be found greatly increased, and must again be spread on top, and sometimes at the third burning the quantity will be so great that it will become necessary to screen out some of the finest dust for treatment in a calcining furnace. As already intimated, a third burning is absolutely necessary if it is desired to obtain a large proportion of the copper contents in a metallic state on smelting. I am now referring to the roasting of white metal. A thirty per cent. matte will require four burnings to give a product fit for black copper smelting, though on the third burning a portion of well roasted matte can be set aside for the smelting furnace, and the contents of two kilns thus depleted, and, at the same stage of advancement, be united for the fourth burning.

This completes all that is necessary to enable any one to obtain fair results in stal roasting, though like every other process, first attempts are often unsatisfactory, and three burnings by a careful and experienced man are better than four by a beginner. It is highly advantageous to provide hanging doors of sheet iron, which, by means of a simple rope, pulley, and counterweight, can be let down in front of the stalls, and thus lessen the annoyance of the smoke, which is sometimes unendurable without this provision, owing to the poor draught, which is a matter of necessity where there is so little heat developed, and there are so many openings for the admission of cold air. If the matte or ore contains a large proportion of arsenic, the front curtain must be sealed closely with clay, and the arsenical fumes conducted through long, subterranean flues connected with a tall chimney. The arsenious acid will be found deposited on the floor of the flue in the shape of a white, crystalline powder, which in some cases is already pure enough for commercial purposes.

The capacity of a stall depends, of course, on the character of the material and the number of burnings required. Assuming that we are treating white metal, and that it is to receive three burnings, we should estimate as follows: First burning, four days; second burning, three days; third burning, two days; filling, and turning twice, three days; total, twelve days. And assuming that we save out a small amount of sufficiently roasted stuff on the second burning, enabling us occasionally to unite the contents of two stalls on the third burning, we can call the total product 6 tons, thus fixing the capacity of each stall at one-half ton daily, which is not far from the truth as determined by actual work. The amount of wood required will be about one-half a cord for the 6 tons, or one-twelfth cord per ton of matte for the three burnings. Any estimates of cost of construction would seem superfluous on such simple straightforward brickwork, which any one can calculate, to correspond with local prices. The most serious expense is the cast-iron gratebars, which are necessarily numerous and heavy.

Roasting in kilns.—Since the introduction of iron pyrites as a substitute for brimstone in the manufacture of sulphuric acid, the roasting of sulphureted ores in kilns has attained the degree of perfection that its importance warrants, and a thorough description of the great variety of kilns now in use for this purpose would lead us too far from our subject.

In the large copper works of both England and Germany the possibility of the continuous roasting of matte in kilns has also been demonstrated, but this is done rather to prevent the destructive influence of sulphurous acid on the surrounding vegetation than with any view of economical roasting, as it is only by the exercise of the very greatest care and skill that it is possible to keep up a sufficiently lively state of combustion to generate sulphurous acid in large quantities without fusing the whole contents of the kiln into one solid clinker. I shall therefore treat of kilns merely as an apparatus for the desulphurization of *ores*, and, as every manager of copper or acid works is constantly receiving inquiries and specimens of ore from nearly every State in the Union, regarding its fitness for sulphuric acid manufacture, and as the greater part of such inquiries evince a complete ignorance of the quality of pyrites that is required by the acid makers, a few words of explanation in this connection will not be amiss.

Quantity is the first desideratum. Unless a deposit is of immense size and very accessible to means of transportation (rail or water) it has not the least chance of competing with the cheap and good Canadian pyrites, which now nearly controls the Eastern market. Even the Spanish pyrites can be laid down on the Atlantic coast at a price which would astonish the uninitiated, owing to the cheapness of westward-bound ocean freights.

A high percentage of sulphur is of course requisite. Forty per cent. may perhaps be put as the minimum, and an ore carrying 45 per cent. would possess nearly double its value. To contain such an amount of sulphur, it must be almost free from gangue rock.

Purity must also be considered. Any appreciable amount of arsenic would condemn a pyrites for the manufacture of sulphuric acid, and an admixture of sulphides of lead and zinc, besides lowering the percentage of sulphur, and producing irregularities in the burners, would also have a more or less deleterious effect on the quality of the acid.

The percentage of copper contained in the pyrites is also a very important matter. While it is commercially advantageous to have as high a percentage of copper as possible, yet in practice anything over 5 per cent. would probably condemn an ore for the manufacture of acid. It is not alone that the substitution of copper pyrites for iron lowers the sulphur contents of the ore (the latter mineral containing nearly 20 per cent. more sulphur than the former), but it also affects the mechanical working of the burners, and owing to its fusibility greatly increases the difficulty of working. This is a point particularly worthy of note, as I frequently receive samples of pyrites containing 10 per cent. and upwards of copper, for which their owner is seeking a market amongst the acid makers. Five per cent. of copper may be looked upon as the extreme limit, and 3 or 4 per cent. would make it a better ore for burning.

But of all the errors that are made by people inexperienced in metallurgical matters, I know of none more frequent or that has been attended by more disastrous results than the attempt to use the mineral known as pyrrhotite or magnetic pyrites in place of the ordinary pyrite or common iron pyrites. The importance of the subject warrants a few words of explanation, which, if they had been uttered in time, might have averted the ruin of the noted New England Chemical Company, as I believe the corporation was called, though long since defunct, and possibly its name may have been assumed by some later and more fortunate corporation.

The difference of behavior of these two minerals in the burners is not alone due to the smaller percentage of sulphur contained in the pyrrhotite (36 as against 53), but also from the fact that the pyrite yields up what sulphur it contains with great ease, even if it is so impure as to carry less sulphur than the pyrrhotite, and burns freely in the kilns without either going out or melting. The other mineral, on the contrary, either scorches on the surface, and then goes out entirely, or escapes control entirely, and melts into a solid mass. It is quite within the range of possibilities that these difficulties may be conquered, and that in time the immense beds of magnetic pyrites in Vermont, Tennessee, and elsewhere may be utilized, but let no inexperienced person attempt this undertaking.

From the foregoing statements it will be seen that the roasting of pyritous ores in kilns belongs properly to the subject of sulphuric acid manufacture, and I will refer any persons who may desire to study this process to Lunge's magnificent work on the manufacture of sulphuric acid, where the most accurate plans and directions, both for building and working every variety of burner, may be found at length. I will merely add that the capacity of a single burner is very small, rarely reaching half a ton in twenty-four hours. Their management requires peculiar skill and experience, and their construction is expensive. On the other hand, they work with much less mechanical loss than is experienced in heap roasting, and there is no tying up of capital in a two or three months' supply of ore.

THE ROASTING OF PULVERIZED MATERIAL, BOTH ORES AND MATTES.

This subject has been so extensively discussed in the metallurgical works of all modern languages, that I allude to it more for the sake of completeness than with the idea of offering any suggestions to be followed, except in a very general way.

The furnaces and apparatus for the chloridizing roasting of silver ores, as a preliminary to amalgamation or leaching, have received an unusual share of attention, and have arrived at a remarkable stage of perfection, particularly the Stetefeldt furnace, which on suitable ores permits of a continuous process, and has an enormous capacity with a very slight consumption of fuel and labor. Brückner's revolving cylinder, and a host of imitations, also answer admirably for the chloridization of silver ores, but neither of these furnaces is at all suited to the oxidizing roasting of copper ores, and the only apparatus at all adapted to this process is Gerstenhöfer's furnace, in which the pulverized ore, fed into the top by means of rollers, is interrupted in its descent through a vertical shaft, by means of an extensive series of fire-clay shelves which retard its passage long enough to give time for a partial oxidation. This furnace, which in Europe is used for the calcination of both ores and mattes, has not proved a success in this country, and under the most favorable conditions is expensive in construction, demands constant and radical repairs, and has a very limited capacity. Various other forms of shelf furnaces are in use at sulphuric acid works for the roasting of fines, but none of them offer any inducement to the copper smelter, whose only aim is to remove the sulphur from his ore or matte at the lowest cost, without caring what becomes of it.

We are therefore reduced to reverberatory furnaces for the preparatory calcination of ores and mattes in a pulverized condition, and so far as my own experience extends, the furnace that is to supersede the present large calciners is yet to be invented. When the sulphurous acid is to be conducted to lead chambers the muffle form of reverberatory is employed, where the gas from the ore is kept entirely separate from the products of combustion. Otherwise, the ordinary open hearth reverberatory is more economical as regards both construction and the consumption of fuel. These furnaces are too well known to require any further description from my pen, but I will add one or two general observations which may be of use in determining the size and shape of furnace to employ under any given conditions.

The saving of fuel is the principal object to strive for, next to a good roast; and this can be attained in treating highly pyritous ores by greatly lengthening the hearth of the furnace, and depending upon the oxidation of the sulphur as a source of heat. Sixty feet is none too long for an ore or matte containing 25 per cent. sulphur, and by introducing the green ore in charges of, say 1,000 pounds, at the flue end of the furnace, and gradually working it forward to the withdrawing door, nearest the fireplace, an excellent roast, large output, and uniform heat can be attained with a minimum of fuel. For less sulphurous ores 30 to 40 feet is about the proper length. Under any circumstances where a large production is required, the hearth should be at least 12 feet broad, with an arch rising $\frac{3}{4}$ inch to the foot. Too much attention cannot be paid to properly supporting the skewback, both with stout horizontal bars or plates of iron, as well as these, in their turn, with strong buckstaves, tied with $\frac{7}{8}$-inch iron. The tie rods should end in loops rather than in nuts, as the thread is frequently stripped by a strain that is less than half of the tensile strength of the rod.

A good draught is of the utmost importance, and this should be so regulated by dampers and by firing, that the flame rolls along the arch in reddish, curly waves, traveling at the rate of three feet a second, and never touching the ore, as otherwise a reducing action is liable to occur.

Until these conditions are fulfilled, no superintendent should be satisfied with the behavior of his furnace.

It is a most economical plan to do away with the huge ashpit at the rear of the furnace, as is the custom in England, where fuel is both plenty and good, and instead of firing on a clinker grate, as nearly all Swansea furnacemen will insist on doing unless positively prohibited, to keep a thin, even layer of soft coal on the grate bars, and have the ashpit open at each side of the furnace, directly under the fire-doors. The ashpit should be provided with close fitting iron doors, which should be ordinarily only a crack open, and if this seems to cause a lack of air in the furnace, a series of holes should be opened in the crown, just even with the front line of the fire-bridge.

Various other methods of treating pulverized material for the removal of its sulphur contents could be mentioned, such as the kneading into bricks, with the addition of a small percentage of lime or clay, and a subsequent roasting in heaps or stalls, but these methods are only carried out under peculiar conditions, and my intention has been rather to indicate the general features of the more common and useful processes, than to compile a text book of rare or curious inventions. (*a*)

BLUESTONE.

The estimated amount of bluestone (sulphate of copper) manufactured in the country during the year 1882 was between 9,000 and 10,000 barrels, of an average weight of 350 pounds. The spot value has been about 5¾ cents per pound, making the total value of the product between $180,000 and $200,000. The principal centers of manufacture are Omaha, Nebraska; Cleveland, Ohio; Philadelphia, Pennsylvania; Salem and Boston, Massachusetts; New York City, New York; Newark, New Jersey; Providence, Rhode Island; Baltimore, Maryland; San Francisco, California, and Dayton, Nevada. About 15 per cent. of the total product is estimated to have been made from foreign ores and matte.

The leading utilizations of bluestone are in pan amalgamation, the manufacture of Paris green and dyes, and in telegraphy.

THE MANUFACTURE OF BLUESTONE AT THE LYON MILL, DAYTON, NEVADA.

BY J. E. GIGNOUX.

The origin of the bluestone industry at Dayton, Nevada, which subsequently attained such magnitude, was due to the endeavors of certain mill owners, who found it necessary to refine, in order to profitably dispose of the bullion which they obtained in working Comstock tailings. By the base process, as the one in vogue was termed, it was found advisable to employ large quantities of copper sulphate in amalgamating, and even as much as 20 pounds to a ton of tailings were used. In consequence the bullion produced contained from 80 to 90 per cent. of base metal, principally copper. Besides the loss in copper the mill owner was obliged to bear a heavy discount on his produce.

The first crude attempts at refining were made by the Lyon Mill and Mining Company, and were in imitation of the sulphuric-acid process

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a Dr. Peters's contribution ends here.

practiced at the mints. The bullion proved to be too base for its success, owing to the great length of time required to dissolve in acid, and it is also stated that a significant mechanical loss of the precious metals was found to be unavoidable.

Subsequently the bullion was subjected to a sulphurizing process, which consisted in placing in iron kettles charges of about 400 pounds of metal with 20 per cent. of sulphur. Layers were made by placing barrel staves alternately with the charge. The kettles were provided with cast iron covers having flanges corresponding with similar flanges and bolt holes on the kettles. When charged, the cover was luted and tightly bolted to the kettle, when a gentle heat was applied for about nine hours. On becoming cool that portion of the metal converted into sulphide was removed, the remainder received new sulphur, and the process was continued until all the metal was converted, for which about 40 per cent. of the original weight in sulphur was found necessary. The sulphurized material was next crushed in a Chili mill, passed through a No. 10 sieve, and sent to the furnace house, where it underwent a desulphurizing roasting. This was performed in a small reverberatory furnace, which was charged with 400 pounds of the granulations. A complete desulphurization was effected in about 10 hours, or until the whole was thoroughly heated to a bright red by a very gradually increasing fire. The charge when drawn was again crushed and passed through a No. 20 sieve, when it was again roasted in the same furnace, and converted into an oxide. Wood, as free from pitch as possible, was used, and air was admitted through the bridge wall. This roasting occupied about 12 hours, and required constant stirring. Leaching was then resorted to, and carried out in almost the identical manner to be subsequently described.

The method in use at the present time is based upon the partial separation which takes place in the retorts when great precaution is used to avoid melting or overheating the amalgam, and the bullion obtained is in such a porous condition as to allow of its being "brittleized," pulverized, and roasted. Two classes, designated as white and base metal, were obtained. The white metal, as its name implies, is of white appearance, and is formed next to the iron of the retort, and is of much denser structure than the base, acting as a coating or shell around the latter. It consists of about 80 per cent. of silver, 15 per cent. of copper, and the remaining 5 per cent. of iron, lead, antimony, with a little gold. The base metal is reddish brown in color and spongelike in appearance, forms in the center of the retort, and consists of about 90 per cent. of copper and iron, and 10 per cent. of silver, gold, and the other metals, nearly all the gold contained in the amalgam going with the base. In quantity the base metal greatly exceeds the white. Formerly these products were treated separately in refining, although the process was identical except as to the quantity used in the charges. The white metal being less bulky, and having less copper to be oxidized, was treated in larger quantities. In roasting, 400 pounds of base and 500 pounds of white metal were usual charges, and in the dissolving tubs 1,000 pounds composed a charge for base, and 1,200 to 1,500 pounds for white metal.

The retorting is carried on for twelve hours. During the first four a low temperature is maintained, but is gradually increased until the quicksilver begins to distil, when the heat is increased until the operation is terminated. Occasionally a small loss of quicksilver is experienced on account of imperfect retorting. This item is, however, insignificant when compared with the saving made by this manner of retorting when the expense of the sulphurizing process is considered. The retorts used are cylindrical, and hold 1,700 pounds of strained amalgam when a little more than half filled.

At the Dayton works the sulphuric acid parting process was introduced, and thereafter no distinction, as previously, between white and base metals was made. All the bullion as it comes from the retorts is broken with a sledge hammer into pieces about the size of an egg, and thrown into the roasting furnace after the roasting charge has been withdrawn, and remains over night on the still heated hearth, no more fuel being necessary. From 2,000 to 3,000 pounds are charged in this manner. In the morning it is drawn, when it presents a dark gray to black color, and has become quite brittle. It is then crushed in a Chili mill, and is sifted by hand through a No. 20 sieve. One Chinaman does the work. The power for the mill is supplied by the main shaft of the pan mill, and is inconsiderable.

The pulverized metal is then returned to the roasting furnace, when it is weighed, and an increase in weight of about one-tenth of one per cent. is usually found, due to the wearing of the wheel and pan of the Chili mill.

The roasting furnace is a small reverberatory, the hearth of which is 6 by 10 feet, with the corners filled, giving an oval shape. The arch is low. There are two working doors, one front and one back, situated about the middle of the furnace. The hearth is laid with Scotch firebrick set on end. A charge of 500 pounds of the metal is placed in the center of the furnace and spread out until about 3 inches deep. It is kept constantly stirred with an iron paddle of $\frac{1}{4}$-inch iron, 5 by 12 inches, attached to a handle of wrought-iron pipe 12 feet long, and terminating in a ring. When the charge has attained a dull red heat the workman throws over that portion furthest from the fire to bring it next to the bridge wall, and then moves all the charge back by slicing it with his paddle, and exposing a new surface to the heat. If the entire charge has become a bright red, care being taken to avoid a greater heat, it is kept in that condition for one hour before drawing. It is then spread out in an iron box 3 by 6 feet and allowed to cool. When cold it is carried to the bluestone works in charges of 1,000 pounds, first being sifted, and any lumps that have formed being crushed. A gain in oxygen amounting in weight to about 5 per cent. of the original charge occurs during roasting. It takes about ten hours to complete the operation, one man doing the work, and requiring about a quarter of a cord of wood.

Circular tubs, 7 feet in diameter and 4 feet deep, are used for leaching or dissolving the copper. They are made with staves cut from 3 by 4-inch joist, and bound together with two iron hoops 3 inches wide made of ½-inch iron. The sides are vertical and the bottoms are let into the sides. The lining is of 6-pound lead, except at the bottoms, and a strip one foot wide on the sides next to the bottoms, which consists of 14-pound lead. They are likewise provided with heavy false bottoms. Steam is admitted through an AA lead pipe, the lower end of which is closed, but has four holes bored in it about one inch from the end. Were the steam allowed to pass directly down through the pipe it would soften and wear holes through the lead bottoms. The upper ends of the pipes are soldered on the iron steam-pipes, which are provided with valves for the convenience of the operator. The pipe system is suspended from the roof of the operating room. Each tub is likewise provided with a cold-water pipe.

A bath consisting of 2½ pounds of 45° Baumé sulphuric acid for each pound of copper contained in the charge is prepared by reducing the strength with water to 20° Baumé, and is steamed until brought to boiling. The charge is then fed with a small scoop, and scattered over the surface of the bath, continual stirring being kept up with wooden paddles 9 feet long and having blades 4 inches wide. The strength of the solution is kept as near 40° Baumé as practicable by occasionally weakening it. Usually it takes two hours to feed the charge, but stirring and boiling are continued for four hours. At the end of that time the bullion should present a white or light gray appearance, which is dependent upon the success of the previous roasting, and it should be .900 fine or over. The dissolving tubs are covered with boards and sacking, the steam is turned off, and the charge allowed to settle for four hours.

At times a small quantity of silver is dissolved, and in order to save it the solution is drawn into precipitating vats in which copper slabs have been laid, and the silver is thrown down as fine metal. The vats are circular, 10 feet in diameter, and provided with steam-pipes, the same style as those used for the dissolving tubs. They are lined with 6-pound lead on the sides, and 10-pound lead on the bottom, no false bottoms being necessary. The floor upon which they rest is lower than the floor of the dissolving tubs, so as to admit of the liquor being drawn over with a siphon. After the solution has remained in contact with the copper slabs for several hours, tests are made with a salt solution to determine the presence of silver, and when no further chloride precipitate is visible the charge is boiled for an hour, and is then allowed to settle for two or three hours before being drawn into the crystallizers.

The bullion remaining in the dissolving tubs is leached several times, first with acid, and then with water, being stirred and boiled each time. The first leachings go with the charge in the precipitating vats, the subsequent ones to the weak-liquor tanks for concentration. The metal is placed in the filters, which are lead-lined barrels, provided with perforated wooden false bottoms covered with muslin, and with discharge-pipes let in below the false bottoms. Clean hot water is run over the metal until no more acid reaction is detected with litmus paper at the outlet pipe. All the water from the filters is collected in a tank, as a small quantity of silver is sometimes carried through. Drying the metal in iron pans heated to redness is next resorted to. The silver is then weighed and charged in the parting kettles, the mint process being adopted, excepting that the gold is not again treated with acid, but is melted when about .700 fine. There being so little of the latter, it was found more economical to pay refining charges. Having the metal in a granulated state very much facilitates the dissolving in strong acid. A charge of 3,000 ounces is dissolved in five hours' time with an armful of wood. The silver usually runs from .997 to .999 fine after melting.

What is termed the bluestone cellar at Dayton contains 40 crystallizers, arranged 20 on a side, with draining tables built along the center of the room. In the floor, about the middle of the cellar, a large tank is sunk in which is collected the liquor drawn from the crystallizers after crystallization, and which is called the pump tank. A leader trough runs along under the draining tables, and is connected with this tank, into which the crystallizers are first drained with a short rubber hose. The crystallizers are 7 feet long and 3½ feet wide on the top, and 7 feet long and 3 feet wide on the bottom. The bottoms and ends are lined with 8-pound lead, the sides with 6-pound. Altogether 473½ pounds of lead are required for each tank. The woodwork is constructed of 2-inch planks, the ends projecting so as to receive ½-inch round iron bolts, two on each end, to hold the sides together. No lead strips are used, it having been found more advantageous to allow the crystals of bluestone to form on the bottoms and sides of the crystallizers, from which they can readily be removed in large cakes requiring to be simply loosened with a bar-chisel. Boards and sacking are used to cover the crystallizers when the liquor is first introduced, and remain on for three of the five days allowed for the crystals to form. Keeping the liquor warm facilitates the crystallization. At the end of the fifth day the strength of the liquor is found to be reduced to 28° or 30° Baumé. The bottoms are first loosened and taken out, then the sides, the bluestone laid on the draining-tables and broken up with a wooden mallet. After remaining 24 to 48 hours on the tables it is packed in barrels and stored.

Bluestone made in the above manner is of the best quality and compares favorably with eastern and imported. It usually commands one-half cent a pound higher price than that which is manufactured from copper ore. Each crystallizer yields from 700 to 800 pounds of good crystals, and about 100 pounds of broken and fine material taken out as slush, which is placed on separate tables arranged with a draining-tank, and when dry is set aside to be redissolved as refuse. About 3,500 pounds make a refuse charge, and with the water necessary fills two crystallizers, and makes first-grade bluestone.

The actual cost of producing bluestone from bullion is difficult to arrive at, owing to the copper having no definite value, and having already served a purpose in the amalgamation. Six cents a pound was paid for the copper contained in base bullion produced by other mills, and no charges for refining were made when under .600 fine in silver. This was found profitable when bluestone could be disposed of at 8 cents a pound. The cost of refining is about 2½ cents a pound for bluestone produced.

All the tailings mills in the vicinity copied at least portions of the process in use at the Lyon mill. At the Atlanta mill pains are taken to closely separate the base from the white metal when it comes from the retorts, the former only being refined, the latter melted and sold as .800 fine bullion. Besides the refining charges, they sustain a loss of 20 per cent. of copper, less the actual cost of refining themselves. This loss is in some measure unavoidable at small mills, as they cannot afford to allow their bullion to accumulate to such quantities as would insure economical refining.

At the Omega mill there is a large refinery for treating all the base bullion produced at the mills controlled by the Pacific Milling Company. Each mill is provided with a Wiegand digester, which is an ingenious adaption to this purpose of an old German method of separating lead from silver amalgam. The late Mr. C. Wiegand succeeded in parting the silver from the copper and gold by leaching the raw amalgam with heated quicksilver. While the silver is carried out of the digester the base amalgam remains. Amalgam treated by his method, after straining, retorting, and melting, gives bullion .900 fine in silver. The difficulty experienced in heating the quicksilver, the loss through imperfect pipe-joints, that is sustained in handling such large quantities, also the cost of manipulation, all tend to make the process expensive; besides which the copper still contained in the bullion, amounting to 10 per cent., is lost to the mills. The base bullion is refined in the manner described, and the bluestone made returned to the mills.

The facilities of the Dayton works for refining bullion and manufacturing bluestone were greatly augmented by the erection of sulphuric acid chambers. The acid is made from sulphur mined in Humboldt county, Nevada, and is produced at an expense of about $20 a ton. The chambers have a capacity of about 2¼ tons a day of 45° Baumé. Concentrators are employed for producing 62° Baumé acid for transportation and supplying the Carson mint.

The demand for bluestone being much in excess of what could be made from the refining of base bullion, large quantities of it were manufactured from copper ore and cement copper. The prices at which the ore was purchased ranged from $2.25 a unit for 20 per cent., to $3.25 for 40 per cent., increasing 25 cents a unit for every 5 per cent. increase in assay for the copper ore delivered at Dayton. A charge of $10 a ton is made for ores which require roasting.

The Walker River mines in Esmeralda county, Nevada, furnished most of the ore, which consisted principally of chrysocolla, azurite, malachite, cuprite, chalcocite, chalcopyrite, tetrahedrite, and chalcanthite in considerable quantities from the Bluestone mine. The cement copper came from Wheatland in California. The advantages which the miners derived from shipping rich ores which did not require to be roasted, led them into the habit of assorting very closely, and reserving sulphuret and low-grade material for reduction at some future period, when the facilities for transportation shall have increased. In consequence, high grades of carbonates and silicates formed the bulk of the ore received at Dayton.

The copper roasting furnace in use is a one-floor reverberatory 30 feet long and 10 feet wide, with three working hearths and six doors, three of which are on a side. The fire room is 17 inches. A low arch and perforated bridge wall, the apertures communicating with the air, are used. The chimney employed for a direct draught is 30 feet high, but when the ore dryer is in use the smoke is made to traverse a distance of 90 feet under drying plates, and is then led off through a higher stack. Ore is fed through a hopper, and is discharged into small iron cars. One man working on a pass of eight hours performs the labor, fuel and ore being brought to him. A charge usually consists of 800 pounds, which is shifted every four hours. It is allowed to remain in the furnace 12 hours, thus making the capacity 4,800 pounds a day. A little over three-quarters of a cord of wood is consumed in twenty-four hours. Enough sulphur is present in the ore to ignite and burn on the first hearth, the charge requiring occasional stirring. On the second hearth it is heated dull red all through, and does not need much stirring unless a disposition to cake is manifested. When the ore reaches the third hearth, the one nearest the fire-bridge, it requires more stirring and frequent removing back from the fire, as the heat is sufficient to melt the charge. A steady bright red heat is maintained during the four hours it remains there. About twenty minutes' time is consumed in discharging, shifting the two other charges, and again charging the furnace. The cost of roasting is estimated at $7.50 a ton.

Ores which do not require roasting, and also those which have been so treated, are carried to the bluestone works, or to the mill-solution tank, where they are used in making bluestone solution, which serves as an economical substitute for dry bluestone.

At the mill tower acid is used for the bath, and many residues from the bluestone which do not contain much copper are also utilized. The solution is run into the amalgamating pans from tanks where it has been reduced in strength to 20° Baumé. The estimated cost of this solution is equivalent to 4 cents a pound for bluestone crystals, making an important saving where such large quantities of low-grade tailings are worked.

The ore at the bluestone works is treated in dissolving tubs similar to those used in refining bullion; acid being added in the bath in excess of 2½ pounds to the pound of copper contained, according to the nature of the ore. The absence or presence of lime or iron is taken into consideration. Sulphate of iron and gypsum, when these substances are present, crystallize with the sulphate of copper, deteriorating the quality of the bluestone, which is then of the second grade. As this grade is sold at lower prices than the first grade, and also because of a prejudice existing among some mill men that better results in silver are obtained from the use of impure bluestone for pan-amalgamation, a more ready sale exists for it than for the purer article. Owing to the impurities mentioned a much larger product is obtained than could theoretically be made from the copper contained in the ore.

The charges vary from 1,300 to 1,800 pounds, and the solution is made from 37° to 40° Baumé strong. Eight hours is the time usually occupied to make and settle a charge. It is drawn directly into the crystallizing tanks in the cellar by means of a four-ply rubber hose, which is attached to a float in the tub to prevent disturbing the sediment at the bottom. A glass tube is inserted in the solution from time to time, and by closing the end before withdrawing it the quantity of clear liquor above the sediment is observed. The utmost precaution is necessary to prevent drawing the sediment into the crystallizers. About the same time is allowed for crystallization of ore solution as for bullion. A better grade of bluestone is generally produced by drawing off the solution sooner, as the sulphates of iron and lime form crystals on the top of those of sulphate of copper.

All the liquor from the crystallizing tanks is drawn into the pump-tank, from whence it is pumped by means of a steam injector, made of lead, into high tanks on the upper floor, and from them fed into the condensing pans. These consist of two leaden pans, one of which is set 8 inches higher than the other. The larger pan rests partly on iron plates, which are so arranged as to protect the lead from too great a heat. They are made of 16-pound lead, 6 feet wide; one 10 feet, the other 8 feet long. The sides are 12 inches high and are surrounded by mason-work. The flues are built parallel with the greatest dimension of the pans, and the heat is made to traverse their entire length three times before escaping into a chimney 40 feet high. The fire-room is 20 inches. At the commencement of the concentrating operation both pans are filled from the high tanks, and a continuous stream, equivalent to the loss by evaporation, is run into the higher pan and siphoned from it into the lower pan. It is kept at a quiet boiling temperature until the strength of the charge in the larger pan has been raised to 41° Baumé;

that from the smaller pan decreasing the strength to 39° Baumé as it is drawn into the crystallizers in the cellar. A long four-ply rubber hose is used for the purpose. Two crystallizers hold the condensed charge and yield from 400 to 600 pounds of inferior bluestone, according to the quality of the solution used. Clear liquor from the settling tanks, into which the residues from the dissolving tubs have been washed, is likewise pumped into the high tanks and concentrated. Two charges can be condensed in the pans during twenty-four hours, with the consumption of one cord of wood. The boiler-man also attends to this fire. About one cent a pound for the bluestone produced was estimated as the cost of concentrating.

All washings containing copper in solution the strength of which is below 15° Baumé are weakened to 5°, and are then run into the iron tanks, in which the copper is thrown down. Old crystallizing tanks are used for the purpose. They are so arranged that the overflow from one passes into another, until the liquor is free from copper. A false bottom is made in them of wooden paddles which are worn too short for further use in the dissolving tubs, and about 300 pounds of scrap wrought iron is laid upon it. When the precipitated copper covers the iron it is washed down into the bottom of the tank and then allowed to accumulate. When removed it is spread upon a wooden platform and sun-dried. It is then screened, and that portion which does not pass through a 20-mesh sieve is melted into bars and used in the refinery for throwing down silver. The finer portion goes to the roasting furnace, to be subjected to an oxidizing roasting and used again in the manufacture of bluestone.

Not an unimportant factor in the product of the Dayton works is the copper obtained from the United States mint at Carson. This institution purchases the acid used in the refinery and partly pays for it with copper solution. As the mint solution carries a great excess of acid, it has to be used in conjunction with cement copper, or rich ore, and is substituted for new acid in the dissolving-tub baths.

The cost of manufacturing bluestone from ore at the Dayton works was estimated at 6 cents a pound when 20 per cent. ore could be purchased at $2.25. The average cost of labor was $3 a day, chamber acid costing $20 a ton, and wood $6 a cord. The wear of the sheet lead, which, with freight added, cost about 11 cents a pound, and a lead-burner's wages at $4.50 a day, he having to be employed continuously, also formed an important item in the estimate.

During the years 1879, 1880, 1881, the output averaged about 320 tons a year. Several years previous a much greater quantity was made and sold, taxing the capacity of the works. Since 1881 there has been a perceptible falling off in the demand, owing to a decrease in the tailings-milling industry. Shipping to a foreign market is out of the question, on account of the cost of transportation, which likewise serves to keep foreign manufactured bluestone from coming into competition with that made in Nevada.

LEAD.

THE LEAD INDUSTRY OF THE UNITED STATES.

BY C. KIRCHHOFF, JR.

Lead mining in the United States is an industry of considerable age. At times during the first half of the present century work was conducted in different localities in the Eastern and Southern States, without, however, ever affording the basis of a steady and sustained occupation. For a long period the output of the mines of Missouri and of the upper Mississippi region constituted the bulk of the make of our country, and during the period between 1840 and 1848 it became so heavy that considerable quantities of the metal were exported, the maximum being reached in 1844, when 8,223 tons went abroad. In 1850 the tide set in in the other direction, nearly 16,000 tons being imported; and this movement continued for many years, until a growing home production, made possible by the connection of the mining regions of the Rocky mountains by railroad with the Atlantic and Pacific coasts, crowded out the foreign lead.

On the whole, as a glance at the following table of the production of lead for a long series of years will prove, there has been a steady increase, especially during the past decade, in spite of some sharp fluctuations in values. The figures from 1825 to 1853 are those published by Whitney; those for the later years have been collected by Mr. Edward A. Caswell, of New York City, who has personally undertaken the task of gathering annually the statistics of production since 1873 with a sagacity and painstaking care which has caused them to be accepted as authoritative by the trade.

Production of lead in the United States.

	Net tons.
1825	1,500
1830	8,000
1831	7,500
1832	10,000
1833	11,000
1834	12,000
1835	13,000
1836	15,000
1837	13,500
1838	15,000
1839	17,500
1840	17,000
1841	20,500
1842	24,000

	Net tons.
1843	25,000
1844	26,000
1845	30,000
1846	28,000
1847	28,000
1848	25,000
1849	23,500
1850	22,000
1851	18,500
1852	15,700
1853	16,800
1854	16,500
1855	15,800
1856	16,000
1857	15,800
1858	15,300
1859	16,400
1860	15,600
1861	14,100
1862	14,200
1863	14,800
1864	15,300
1865	14,700
1866	16,100
1867	15,200
1868	16,400
1869	17,500
1870	17,830
1871	20,000
1872	25,880
1873	42,540
1874	52,080
1875	59,640
1876	64,070
1877	81,900
1878	91,060
1879	92,780
1880	97,825
1881	117,085
1882	132,890

The supply of lead has, however, not varied as widely as the statistics of production would seem to indicate. The increase in the make in this country steadily crowded out of the market the large quantities of foreign metal, which previous to 1872 constituted the principal source of supply. The following table illustrates the decline of this movement:

Imports of foreign lead.

	Net tons.
1862	40,544
1863	14,112
1864	31,248
1865	15,232
1866	30,464
1867	26,012

	Net tons.
1868	26,000
1869	39,324
1870	......
1871	......
1872	......
1873	24,768
1874	20,160
1875	8,182
1876	5,247
1877	6,971
1878	319
1879	2,461
1880	......
1881	3,935
1882	3,538

With the exception of the year 1880, the bulk of the pig lead imported during recent years has been re-exported under the operation of the drawback clause, being chiefly used in the manufacture of solder for tin cans for exporting petroleum and canned fruits and vegetables.

LEAD-PRODUCING REGIONS OF THE UNITED STATES.

Utah.—During the years 1871 to 1874 considerable quantities of Utah ores were shipped for treatment, the local smelting industry meanwhile developing very rapidly. In 1870 local desilverizing and refining works (those of the Germania Company) were started, but they suspended that part of their operations in 1875, to resume again in 1878. Making allowance for the lead in the ore shipments of the earlier days, the production of Utah was roughly as follows:

Production of lead in Utah.

	Net tons.
1871	5,000
1872	8,000
1873	15,000
1874	20,000
1875	19,000
1876	25,000
1877	27,000
1878	21,000
1879	14,000
1880	15,000
1881	24,000
1882	30,000

The most prominent mine to-day is the Horn Silver, which in 1881 made 8,171 tons of base bullion, increased in 1882 to 16,002 tons. The study of the reports of this mine is one of particular interest, because it reveals the different items of cost entering into the production of lead, when working on a very large scale. The cost of mining of course fluctuates within wide limits, according to the character of the deposit and many local conditions. The Horn Silver produced 47,232 tons of ore, at a cost of $4.44 per ton; the smelting at Francklyn costing $14.73, and the refining at Chicago $9.05. The ore carried on an average 37.8 per cent. of lead and 34.2 ounces of silver, the loss in smelting being 9.71 per cent. of the lead and 2.10 per cent. of the silver. The average of the grade of the base bullion produced in Utah was 93 ounces per ton, or, deducting allowance for silver to desilverizing works (5 ounces), 88 ounces per ton, having a value of $95 per ton at New York, with silver at $1.08 per ounce. Even if the average cost of mining, smelting, and desilverizing be very much higher in the average of Utah mines, the silver alone yields enough to pay a very heavy tribute to the railroads for freight, thus leaving a large percentage of the amounts realized for the lead as a profit. In the case of the Horn Silver Company the dividends during 1882 amounted to $1,200,000, while the net receipts from the sale of lead were $1,326,664.23, thus indicating that the silver paid for nearly the entire cost of extraction, treatment, administration, and marketing. This does not of course apply to all the Utah mines, but it furnishes a striking illustration of the advantages which the presence of silver in their ores gives to the producers of the Rocky Mountain States and Territories over the miners of non-argentiferous lead ores.

Nevada.—The climax in the production in Nevada was reached in 1878, as will be noted from the following table, giving the yield during the past six years:

Production of lead in Nevada since 1877.

	Net tons.
1877	19,724
1878	31,063
1879	22,805
1880	16,659
1881	12,826
1882	8,590

Almost the entire product has come from the Eureka district, in which the two principal mines are the Richmond, worked by an English corporation, and the Eureka, owned by a San Francisco company. The ore occurs in large chambers, and the mines have therefore periods of great prosperity, alternating with others when extensive development and prospecting work must be carried on. Recently the Richmond has drawn heavily upon its reserves without opening out new ore bodies. The company, has however, carried heavy stocks of metal, which have been placed on the market gradually. It has followed the policy of selling its lead in large blocks, and has therefore during the past few years exercised an influence upon our markets out of proportion to its product as compared with that of the whole country. The Richmond lead, being refined at Eureka, has usually been placed in the East, while the base bullion turned out by the Eureka Company goes to San Francisco for desilverizing and refining, the greater part of it therefore finding a market on the Pacific coast.

Colorado.—The latest important addition to the ranks of the lead-producing localities of the country, and now by far the heaviest contributor to the lead supplies, is Colorado. Previous to 1878 Colorado possessed only a few isolated smelting plants, yielding only insignificant quantities of lead, until the development of the carbonate deposits of Leadville and tributary camps carried it to the front in a few years.

Mr. F. F. Chisolm, of Denver, has collected the following statistics:

Production of lead in Colorado.

	Net tons.
1873	56
1874	312
1875	818
1876	667
1877	897
1878	6,369
1879	23,674
1880	35,674
1881	40,547
1882	58,642

The returns of one works are believed by good authorities to be excessive, and 55,000 tons is assumed as the most probable actual total. The enormous increase during the past four years is exclusively due to Leadville, which, according to local statistics, has the following record:

Years.	Tons lead.	Ounces silver.	Ounces gold.	Tons of ore.	Value of ore shipments.
1877	175	376,827	3,750	3,300	$400,000
1878	2,324	450,476	897	15,840	2,360,503
1879	17,650	6,004,416	1,100	18,549	2,851,850
1880	33,551	8,999,399	1,687	12,410	1,460,363
1881	38,101	7,162,909	12,192	15,630	1,016,044
1882	39,864	8,376,802	12,615	22,416	1,872,604
Total	131,665	31,370,829	32,241	88,145	9,961,364

It is almost impossible, in view of the great fluctuations in the cost of mining at the different mines and the variations in the prices paid for ores, fuel, and transportation, to arrive at an estimate of the cost of production of the lead. Leadville smelters compete very sharply for ores, and pay greater or less prices, according to their character as an aid in fluxing. Nothing but a minute examination into what are strictly private affairs would admit even of a general estimate. The smelters pay for the silver in the ore, deducting 5 per cent., or less in some cases, and return from 25 to 43 cents per unit for the lead, instances being known where as low as 1 per cent. has been accounted for. In addition to this, a smelting charge of $7 to $12 is deducted from the gross value. The ores are as a general thing low in lead, carrying only from 10 to 20 per cent., while the smelting charges range from 8 to 12 per cent. in that metal. Higher percentages are the exception. The cost of smelting averages from $10 to $12, the loss in lead being 15 to 16 per cent., and the loss in silver 3 per cent. The smelting industry has been developed to a high degree of perfection, and with a fair fuel (El Moro or Crested Butte, Colorado, coke), which costs, delivered at Leadville, about $13 per ton, the expense of smelting has been brought down to a low figure. The sharp competition between the smelters in Leadville, in Pueblo, and in Denver keeps prices for ores high. These circumstances all contribute to a heavy production. They have done much to build up mining in Red Cliff and other camps tributary to Leadville, and with the enormous developments of the mines of that section, and an activity stimulated by the wonderful success of some mining ventures, it is likely that for some years to come the present rate of output will be maintained.

Considerable quantities of galena are produced by the mines of Georgetown, in Clear Creek county, and by the San Juan district, which includes the counties of Hinsdale, Ouray, San Miguel, La Plata, San Juan, and Dolores. The ores of this district are generally more refractory, though richer in silver. There are a number of local smelters, but the extension of the railway system throughout the State seems to favor the centralization of the smelting business. A very encouraging feature also is the attention given to the mechanical concentration of low-grade ores, an element tending to steady the supply and thus cheapen the cost of production.

Montana.—During the past few years Montana has produced increasing quantities of lead. In different sections of the Territory large bodies of low-grade ores are known to exist, and very elaborate though misdirected efforts have been made in one or two instances to work them. In other cases careful management has been rewarded with ample success—the Hecla Company, of Glendale, which produced 2,600 tons of lead in 1882, yielding a good profit to its owners. A number of deposits are known to exist in different parts of Montana, and many of them have been worked at different times with more or less success. It is probable that the advent of the Northern Pacific railroad will do much to stimulate this industry and place Montana in a position to contribute more largely to the supply of the country. The production in 1882 is estimated at 4,100 net tons.

Idaho.—The greatest share of interest during the past few years has been absorbed by the promise of important developments in the Wood River country and adjacent regions. Numerous and large deposits of ore high in lead and in silver have been opened, and a number of smelters have been built; but until the spring of 1883 the lack of proper shipping facilities has held the district back. Since it has been tapped by a branch railroad, production will probably be considerably stimulated. The ores, being largely galena, carry heavy amounts of lead, and a comparatively small number of smelting plants will be able to turn out large quantities of metal. It is estimated that in 1882 the product of Idaho was 5,000 tons of lead, of which the bulk, however, was shipped as ore to Utah and elsewhere, appearing in the product of the localities to which it was shipped. Competent authorities look forward to a notable increase in the lead output of Idaho in 1883.

Missouri, Kansas, Illinois, and Wisconsin.—Southwestern Missouri and southeastern Kansas have become the seat of a very important lead mining and smelting industry, closely identified with the zinc mining. The Joplin district, which was opened out in 1871, and the younger producing sections in Kansas, support a number of large smelting works. Mr. Caswell has gathered the following statistics for the output of Missouri and Kansas, covering the period from 1873:

	Gross tons.
1873	13,433
1875	17,053
1876	17,165
1877	22,084
1878	19,891
1879	22,625

During the same period the output of the Galena district, embracing the production of Illinois and Wisconsin was as follows:

	Gross tons.
1873	6,550
1875	5,000
1876	6,425
1877	5,730
1878	4,011
1879	2,500

Since then the returns have been made in the aggregate for both the Missouri and Illinois and contiguous districts. In net tons the estimates by Mr. Caswell are as follows:

	Net tons.
1877	31,152
1878	26,770
1879	28,130
1880	27,690
1881	30,770
1882	29,015

A considerable portion of the lead production is made by a few large smelting companies, among which the Desloge, Saint Joe, Mine la Motte, and Lone Elm are the principal ones. There are besides a large number of small producers, their scattered yield being heavy in the aggregate. The mines of Missouri, in spite of frequent predictions that they would be crowded out by the competition of the silver-lead mines of the Rocky mountains, have held their own remarkably well. It is believed that the majority of the larger producers are capable of laying down their lead at Saint Louis at a cost varying between 3 and 3.50 cents per pound.

Other sources.—Lead has been produced in minor quantities in almost all of the other States and Territories of the Far West, though never in quantity to appear as a factor in the markets of the country. In New Mexico and Arizona a number of deposits of lead ores have been opened. They are rich in lead, though generally poor in silver, but steps are being taken in different places to smelt these ores, using the lead as a carrier for silver. The smelters buy high-grade refractory silver ores and smelt them together with their poor lead ores, a rich base bullion being produced in fair quantity in some instances. Argentiferous lead ores are found in many portions of California, especially in Mono, Inyo, and neighboring counties, but the State can hardly yet be numbered among the regular producers.

LEAD METALLURGICAL WORKS.

The lead refining and desilverizing business has developed into magnificent proportions. The only two mining companies which do their own refining are the Richmond, having works at Eureka, Nevada, and the Horn Silver, which has a plant at Chicago. In addition to these there are the Selby works at San Francisco; the Germania works at Salt Lake City, Utah; the Pueblo works at Pueblo, Colorado; the Omaha, Kansas City, Aurora (Illinois), the Saint Louis, Chicago, and Pittsburgh works; the works of Balbach & Sons, at Newark, New Jersey; the Delaware Lead Works at Philadelphia; the Manhattan and the Crooke works at New York. In addition to these fifteen establishments a new plant is building at Nathrop, Chaffee county, Colorado, by the Nathrop Refining Company. All but the Richmond Company use the Parkes desilverizing process, or slight modifications of it. The tendency during the past few years has been to lessen the supplies of bullion to Eastern refiners; two of them are idle, while the others run only at a fraction of their capacity.

REVIEW OF THE LEAD MARKET.

The history of the markets of lead has been influenced during the past decade chiefly by the rapid and steady increase in the production, notably in those sections where lead is a carrier for the precious metals. The increase in the facilities for the transportation of fuel and supplies and the shipment of the product from the Rocky Mountain States and Territories; the improvements introduced in smelting and refining; the skill with which these metallurgical operations are carried out, all these circumstances have combined to cheapen the cost of reduction, or, what amounts to the same thing, to enable lower grades of ores to be treated with a profit. This is an important fact, the significance of which will be readily understood by all who have had experience in mining. It emancipates the industry from many of the vicissitudes incident to the working of all ore deposits. It gives to districts where large areas of ore-bearing grounds are worked a steadiness in the production, where formerly there were violent fluctuations between intense activity and total idleness. The growth of the railway system in the Rocky mountains has had the further effect of concentrating smelting operations, at the same time opening a market for ores for purposes of mixture, which could not be treated alone. It is to be expected that in the future, as in the past, new districts will rapidly assume a commanding position as competitors, and others which have for many years played a leading part will sink into insignificance; still, these fluctuations in the supply will not have so telling an effect because it is not so dependent upon high grades. There is much new territory known to be promising to open out, and therefore absolutely no prospect of a serious or sustained falling off in the production. On the contrary, there are evidences that the very heavy output of the present time will be eclipsed in the near future; and the belief is frequently expressed that overproduction at an early day will force us once more to become exporters of lead. These views are based upon an exaggerated opinion as to the output and a misapprehension of the business in the country, growing out of recent changes. In the past the bulk of the lead made in the West and in the Rocky mountains came to the Atlantic coast to be desilverized, refined, and manufactured into pipe, shot, or sheet lead, or corroded. Much of this manufactured lead was shipped back westward until refineries, mills, and corroding plants began to spring into existence along the lines of travel in the West, tapping the stream of crude and refined lead for local consumption. Thus the western trade was gradually but steadily wrenched out of the hands of the eastern manufacturers, in spite of their magnificently appointed plants and large capital, and of late they have been attacked in their own home markets. The consequence has been a striking falling off in the business, or an absence of any increase in proportion to the general expansion of consumption throughout the country. The result has been that the eastern trade and those connected with it have generally taken too gloomy a view of the future, and the heavy amounts of lead absorbed by the West, in spite of the dull business in the East, have repeatedly been a subject of surprise. To the lead producing and consuming interest in general, these changes can only be welcome. Ultimately they tend to stimulate consumption. The movement, it appears, has been encouraged by western railroad companies, which naturally prefer to build up a local industry with all the advantages in fixing population and stimulating local traffic, this being more remunerative than a share only in low through rates to eastern cities. This has been most significantly shown in the gradual transfer of the lead desilverizing industry from eastern to western points. It is charged that the railroads discriminate against eastern refiners; and while this charge has never been proved, the diversion of business and the evident advantages it possesses makes it probable that the bulk of the lead desilverizing business has been permanently removed westward. With this shifting of the center of the lead trade, Saint Louis and Chicago have gained much as leading markets and points of distribution. An important point to be considered in connection with the American lead trade, as contrasted with that of Europe, is that here the metal is almost exclusively consumed in the form of manufactures and white lead, while abroad important quantities are always required for armament purposes. On the other hand, town and village water service is by far more general in this country than elsewhere, while white lead is used in enormous quantities.

The great bulk of the lead produced in this country is disposed of in the open market, though a different policy is pursued by different producers. There has always been a speculative element in the trade, and as a very large share of the product goes into the hands of a comparatively limited number of manufacturers, the contending influences in the market are generally strong.

The course of the market from 1875 to 1883 has been as follows:

1875.—The fluctuations during the year were:

Price of lead in 1875.

[Cents per pound.]

Months.	Highest.	Lowest.
January	6.20	6.00
February	5.90	5.85
March	5.75	5.62
April	5.87	5.80
May	5.95	5.90
June	5.90	5.75
July	6.00	5.95
August	5.95	5.87
September	5.87	5.70
October	5.65	5.60
November	5.87	5.65
December	5.95	5.87

Occasional speculative purchases in the middle of March and towards the close of June, at the lowest figures noted in the tables for those months, prevented any heavy fluctuations. By thus taking the supplies at intervals, strong parties were able to distribute them at fairly remunerative prices in spite of a steadily growing production. This, however, was counterbalanced by a falling off in imports, due to the stiffness in the foreign markets created by Government purchases for warlike purposes. By care in working, American refiners were beginning to free us from dependence upon Europe for corroding lead. Then the collapse of the Carlist movement made an increase in the Spanish output feasible. The business of manufacturers in this country during the year was not active, and during the greater part of that time they maintained an attitude of expectancy.

1876.—Values underwent but little fluctuation during the year, as the following summary shows:

Price of lead in 1876.

[Cents per pound.]

Months.	Highest.	Lowest.
January	(*a*) 6.00	5.87
February	6.37	6.00
March	6.50	6.40
April	6.40	6.12
May	6.50	6.10
June	6.50	6.25
July	6.35	6.20
August	6.37	6.25
September	6.25	6.00
October	6.00	5.80
November	5.80	5.70
December	5.70	(*a*) 5.65

a Gold.

Business during the first months of the year was quiet and dull, the moderate supplies available being firmly held. The market gradually weakened, until in May a surplus (chiefly of Richmond lead) was cleared away by some heavy sales. A good demand abroad, largely for armament purposes, kept prices so high there that very little foreign metal could enter this market, which, however, was so amply supplied by home production that towards the end of the year prices slowly fell off again. The sales of Government lead, which had for years been a leading feature in our markets, were practically closed out during 1876. Freight rates from Saint Louis, the market for Missouri and much desilverized lead, fluctuated considerably, going as low as 23 cents and as high as 54 cents per 100 pounds.

1877.—The range of prices during the year 1877 is particularly interesting, because it reflects the beginning of a movement which culminated later.

Price of lead in 1877.

[Cents per pound.]

Months.	Highest.	Lowest.
January	(*a*) 6.15	6.12
February	6.40	6.20
March	6.75	6.50
April	6.50	6.25
May	6.00	5.55
June	5.70	5.60
July	5.60	5.37
August	5.12	4.90
September	4.85	4.75
October	4.35	4.25
November	4.75	4.50
December	4.60	4.50

a Currency.

Under the pressure of a heavy production, chiefly in Utah and in Nevada, the year was, on the whole, one of a heavy decline. In the first months of the year an effort was made by a speculative movement in the western markets to hold the metal high; but consumers did all within their power to struggle against the maintenance of artificial figures, and the pressure of lead shipped from San Francisco led to a break in May, which was the beginning of a decline hastened by the selling out of their holdings by the speculative element. In September the export point had nearly been reached in San Francisco, but it was not until October that the large consumers, tempted by low offerings, and somewhat frightened by the signs of heavy speculative purchases, took hold at 4.25 and 4.30. The concentration of the stock forced small buyers to pay more during the balance of the year, the market being very quiet.

1878.—The year 1878 was remarkable for the low prices reached.

Price of lead in 1878.

[Cents per pound.]

Months.	Highest.	Lowest.
January	4.35	4.00
February	3.87	3.65
March	3.87	3.62
April	3.75	3.50
May	3.50	3.25
June	3.50	3.12
July	3.62	3.25
August	3.50	3.20
September	3.45	3.25
October	3.60	3.37
November	3.95	3.60
December	4.00	3.90

The year opened with a heavy stock, accumulated during the winter months, during which consumers had been working off former purchases, and had bought but little in consequence. Instead of drawing upon the stocks as usual during the winter months, when production was generally less than the demand, the output outstripped the consumption. Matters were taking so serious a turn, in spite of the often repeated assertions that the Rocky mountain producers would soon cease to work, that at the suggestion of the Missouri interests a meeting of leading lead miners and smelters throughout the country was held at Saint Louis in March. The members of the American Pig Lead Association, then formed, agreed to bind themselves not to sell lead at a price less than 4 cents delivered in New York. The effort proved a complete failure, and lead fell steadily until $3\frac{1}{8}$ cents was reached in June. Then the falling off in the production of Utah and the shipment of surplus supplies of Nevada lead to China began to strengthen the position somewhat, though consumers showed little confidence. The rumors of the extraordinary development in Leadville caused uneasiness, though the reports coming from there were generally accepted with reserve. Towards the end of the year the market gradually got into better shape, and ruled firm after strong parties had obtained control through a speculative concentration of the stock.

1879.—Prices varied as follows:

Price of lead in 1879.

[Cents per pound.]

Months.	Highest.	Lowest.
January	4.50	4.00
February	4.50	4.50
March	4.50	3.25
April	3.25	2.87
May	3.12	2.87
June	3.80	3.12
July	4.10	3.90
August	4.05	4.00
September	4.00	3.75
October	5.50	4.00
November	5.62	5.00
December	5.60	5.50

January and February dragged along with quotations almost entirely nominal, consumers holding off obstinately, while holders insisted that low prices had so much curtailed consumption as to seriously diminish the supply. So far as Utah and Nevada were concerned this was undoubtedly the case, but the falling off there was fully compensated by the constant and rapid increase at Leadville. Under the pressure of heavy receipts the market delined heavily in March and April, and in May reached the lowest figure ever touched, $2\frac{7}{8}$ cents. Speculative purchases and buying on the part of consumers gradually forced prices upward; and when in the autumn of 1879 the great "boom" period set in it carried lead along with it until a high price was reached in December, when importations of foreign lead again became profitable. The year will always remain one of the most memorable in the lead trade of the country, as having witnessed its deepest depression and one of its most sudden revivals. That the majority of the Western and Missouri mines could not for any length of time, at the rates of labor and freights then ruling, stand the strain of prices as low as 3 cents in New York is beyond all doubt; but the decline taught economies and the necessity of improved methods, which have not been lost upon producers.

1880.—Transactions during the year were based on prices varying between the following monthly extremes:

Price of lead in 1880.

[Cents per pound.]

Months.	Highest.	Lowest.
January	6.10	5.50
February	6.00	5.87
March	5.95	5.30
April	5.75	5.40
May	5.25	4.40
June	4.75	4.50
July	4.75	4.25
August	5.00	4.30
September	4.90	4.80
October	4.87	4.65
November	4.85	4.75
December	4.75	4.25

The rise begun in the fall of 1879 continued during the first months of 1880, but its limit was set by the fact that foreign lead began to appear freely upon our market, and a steady decline of quotations there, together with a rapid receding of the speculative excitement here, leading to the sale of lots held by speculators, forced prices down gradually, until in August the market was cleared and heavy sales were made at advancing figures. In October a large block of Richmond lead was taken, but the winter demand proving a disappointment, quotations slowly fell off towards the close of the year.

1881.—Prices fluctuated within the extremes in the following table:

Price of lead in 1881.

[Cents per pound.]

Months.	Highest.	Lowest.
January	5.00	4.30
February	5.10	4.80
March	4.85	4.62
April	4.85	4.37
May	4.70	4.25
June	4.50	4.25
July	4.90	4.50
August	4.95	4.75
September	5.37	4.95
October	5.25	4.87
November	5.25	4.90
December	5.25	5.00

Repeated heavy purchases kept values fairly steady during the first four months of the year, and after prices had declined in May large lots were again taken out of the market in June, July, and August. They were sustained by a fairly active demand, fully capable of coping with an increased production. The chief cause of this improvement was the great activity in the building trades in all parts of the country, that being by far the most important channel for manufactured lead and for white lead.

1882.—Prices of lead fluctuated as follows during the year:

Price of lead in 1882.

[Cents per pound.]

Months.	Highest.	Lowest.
January	5.15	4.95
February	2.20	5.09
March	5.12	4.85
April	5.00	4.90
May	4.85	4.60
June	4.90	4.55
July	5.15	4.90
August	5.10	4.95
September	5.15	4.95
October	5.15	4.87
November	4.90	4.50
December	4.75	4.50

During the year a good demand, with the aid of strong parties, sustained the metal fairly, in spite of a very heavy production. In January the market opened with signs of growing weakness, the pressure coming chiefly from the West, and being aided by the fact that a large block of Richmond lead was to be placed on the market. In February 2,000 tons of the Richmond lead was sold at 5 cents, and a better feeling prevailed for a time. But the urgency of representatives of foreign lead in endeavoring to gain a foothold caused a weakening, which changed to a temporary standstill when it became known that the Richmond Company had succeeded in making arrangements to ship a portion of its heavy stock at Eureka via New Orleans. In April that company again placed 3,000 tons at 4.85; but after a temporary spurt the market again fell off until it reached 4.55 in the beginning of June. It rallied during the month, and in July the Richmond Company succeeded in marketing an additional lot of 5,000 tons at 4.92½, the bulk of it being taken on speculative account. Simultaneously the large consumers took a large quantity in the aggregate, and small buyers were forced to cover their requirements of jobbing lots at higher figures. In October and November, however, the market again weakened, until some round sales cleared away the surplus and warranted better figures.

1883.—During the first six months of the present year quotations have moved within the following monthly range:

Price of lead in the first six months of 1883.

[Cents per pound.]

Months.	Highest.	Lowest.
January	4.70	4.60
February	4.60	4.50
March	4.65	4.50
April	4.62	4.40
May	4.55	4.40
June	4.45	4.40

Opening quietly, though with some firmness, notably in the West, until in the beginning of the month of March about 3,000 tons were taken, principally by the trade, an effort to depress prices being made later in the month by additional sales at lower prices. April passed quietly, while May opened with the placing of about 3,000 tons among consumers on the part of the representatives of two large works. Buyers were thus tolerably well supplied, especially as the demand for manufactures during the first quarter of the year was very light. The result has been an accumulation of supplies, which is looked upon with solicitude by many, though the principal blocks of stock are held by strong parties. It is argued that with production going on at an unabated rate, while the consumption (notably in the East) has very materially fallen off, values cannot be maintained for any length of time at their present figure.

LEAD IN FOREIGN COUNTRIES.

The practical cessation of imports of lead from foreign countries renders the development of the mining industry abroad comparatively unimportant to home producers, at least at the present time, though past experience has taught that in times of excessive production here we must be prepared to compete at least in the markets of the East, while in periods of extraordinary advances in values here a check is put upon the rise by free offerings of foreign lead. This part of the subject will be passed over lightly.

Great Britain.—The statistics of the lead trade of Great Britain are of particular interest, because they show the growing weakness of the English producers, who are struggling with difficulty against foreign competitors, and the variations in the imports and exports. Formerly English desilverizing works handled the bulk of the argentiferous lead produced in Spain, but the fostering of local desilverizing works has diverted a large share of that business, and it seems only a question of time when London will cease to be the principal market for the lead produced in Spain, as efforts are being made to reach consumers direct.

Lead statistics of Great Britain.

Years.	Production.	Imports.	Exports.	Home consumption.
	Gross tons.	*Gross tons.*	*Gross tons.*	*Gross tons.*
1872	60,455	69,841	44,330	85,966
1873	54,235	62,563	32,010	84,788
1874	58,754	61,987	36,353	84,388
1875	57,453	79,825	35,398	101,880
1876	58,667	80,649	35,921	103,395
1877	61,403	94,486	42,467	113,422
1878	58,020	100,141	34,385	123,776
1879	51,635	102,089	36,776	116,948
1880	56,949	95,049	33,551	118,447
1881	48,587	93,400	43,109	98,878
1882				

The principal customers of Great Britain are as follows:

Exports of pig, sheet, and pipe from Great Britain.

To—	1879.	1880.	1881.
	Gross tons.	*Gross tons.*	*Gross tons.*
Russia	10,487	7,318	8,355
Germany	1,171	1,063	1,041
France	3,384	2,417	3,390
United States	1,022	258	598
China, etc	5,879	10,011	12,824
British India	3,282	2,589	3,349
Australia	3,133	1,929	4,715
Other countries	8,418	7,966	8,837
Total	36,766	33,551	43,109

The most interesting figures in these columns to American producers are those relating to China, the total receipts of lead in that country being on an average 20,000 tons. England, it will be seen, generally furnishes fully one-half, the bulk of the remainder coming from Germany.

Spain.—The great rival of the United States as a lead producer is Spain, the principal seat of the mining industry being the province of Murcia, on the southeastern coast. Very few data are available on which to base an estimate of the capacity of the Spanish mines to furnish lead cheaply, but the fact that production has steadily increased during the past few years, in spite of an almost uninterrupted fall in prices, proves that the establishment of better railway communication and the encouragement offered by the Government have carried the limit of profitable working downward. It has been repeatedly asserted of late that production in Spain would be seriously checked when certain minimum prices were reached, £13 in London being named last year. The prophets seem to have made their predictions without taking into account the compensating circumstances named. The exports from Spain during the past few years have been as follows:

Exports of lead from Spain.

	Tons.
1878	90,842
1879	100,336
1880	92,400
1881	105,809
1882	116,132
1883 (January, February, and March)	29,534

Germany.—Germany has a very ancient lead industry, the principal districts, in the order of their importance, being the Rhenish provinces, Silesia, the Hartz mountains, Nassau, and Freiberg, Saxony. The latest figures available are those compiled by Herr Landsberg, giving the production of the various districts and works for the years 1881 and 1882. The production of silver from the same works is added. It has an important bearing on the question of the capacity of the works to resist foreign competition or meet the markets of the world.

Production of lead and silver in Germany.

	Lead.		Silver.	
	1881.	1882.	1881.	1882.
	Metric tons.	*Metric tons.*	*Kilograms.*	*Kilograms.*
Prussia:				
Stolberg Company	13,996	14,919	20,227	26,130
Rhenish-Nassau Company	7,200	6,239	6,212	7,608
Mechernich Company	22,409	25,055	4,438	5,108
Commern Company	2,362	2,727	1,181	988
A. Poensgen & Sons	3,189	3,100	1,382	1,175
Rothenbach Works	55	40	969	901
Walther Cronek Works	5,489	5,858	4,056	3,679
Friedrichs Works	8,450	8,683	5,532	5,245
Hanover:				
Upper Hartz	9,428	10,447	26,385	32,592
Lower Hartz	424	579	3,854	3,575
Nassau:				
Ems	5,772	5,803	6,887	7,403
Braubach	2,721	3,176	5,515	6.085
Saxony:				
Freiberg	4,494	5,064	39,133	50,985
Total	85,989	91,690	125,771	151,474

The works of the Hartz and of Freiberg are Government property; and even if in the course of events they should not prove able to compete, it is likely that they would be subsidized, to maintain a large resident population almost entirely dependent upon the working of the mines.

The Stolberg Company are also manufacturers of spelter, and it is impossible from the reports submitted to arrive at a definite conclusion as to their possibility to meet much lower prices. The Mechernich, the largest works in the country, are fully able to cope with foreign competitors. During the year 1882 this company, the greatest single lead producer in the world, paid dividends amounting to 17 per cent. on the capital stock, besides providing amply for depreciation of plant and a reserve.

Nearly one-half of the production of lead in Germany must seek foreign markets, as the following statistics of exports and imports, which the German legation at Washington has kindly furnished, show:

Imports of lead and manufactures of lead into Germany.

	1879.	1880.	1881.	1882.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Pig lead	4, 019	2, 616	2, 658	1, 973
Sheet lead	187	74	38	....
Manufactures of lead	461	171	142	....
Total	4, 667	2, 861	2, 838	....

Exports of lead and manufactures of lead from Germany.

	1879.	1880.	1881.	1882.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Pig lead	43, 360	45, 419	46, 799	41, 875
Sheet lead	840	1, 206	1, 303	....
Manufactures of lead	1, 652	2, 289	2, 163	....
Total	45, 852	48, 914	50, 265	....

Other foreign sources.—No other countries are great producers of lead. Greece exported in 1881 11,700 tons of lead. France has a small native industry, and besides desilverizes and refines considerable quantities of base bullion from the Laurium mines of Greece. Austria, Russia, and Italy produce comparatively small quantities. Outside of Europe and the United States, Mexico is the only country which does a lead-smelting business. What little Mexican base bullion is made for export goes to England now instead of to this country, as it did at one time; and this movement is restricted by the inaccessibility of the mines, so that the lead is usually cupelled on the spot, the silver alone reaching the markets. Thus far the development of the railroad system in that country has not yet sensibly affected the shipments of lead.

THE SMELTING OF ARGENTIFEROUS LEAD IN THE FAR WEST.

BY O. H. HAHN.

Early attempts.—Twenty years ago the smelting of argentiferous lead ores was an unknown thing in the Far West, under which collective name the States and Territories west of the Mississippi river are generally known; and although there were persons to be found in the mining districts who were familiar with the methods of smelting current in European countries, the first attempts in this branch of the metallurgical industry were failures, because the appliances used and the grade of the ores to be treated were not adapted to the requirements of the localities of that vast yet sparsely settled stretch of country, then entirely devoid of cheap transportation facilities. Who would ever think nowadays of building a Flintshire or a Carinthian furnace, or a Scotch hearth, or a Mexican "chacuaco" in the wilds of Nevada or in the Rocky mountains to smelt lead ores? Yet such was the apparatus first resorted to in the beginning of our smelting industry, evidences of which may still be found in the ruins of Galena (Washoe county) and Washington districts, Nevada; in the Patagonia mountains of Arizona; in Little Cottonwood and Rush valley, Utah; Cerro Gordo, California; and other localities. It seems that the early smelters did not calculate the cost of their product, or imagined that they were operating on the sea-coast, where fuel, labor, and everything else is cheapest.

The first smelting works with an appearance of success sprang up near Helena, Montana, and at Oreana, Nevada, a station on the line of the Central Pacific railroad, in 1866 or 1867. In both places the ore treated had a sufficiently high silver tenor to leave a margin over and above the cost of working it and the expense of transportation of the silver, which is no small matter if we consider that not only had the ores to be smelted, but the resulting bullion had to be calcined and cupelled on the spot to obtain the silver in salable shape. For the lead, or litharge rather, there was no market in those days, all wants being supplied more cheaply by the Missouri and European producers. The year 1869, when the two great Pacific railroads were united to form an uninterrupted line of communication between San Francisco and New York, the great commercial centers of the East and West, gave the signal for the beginning of smelting operations on a more extensive scale than heretofore, and for the gradual expulsion of foreign lead from our markets. Till then mines producing "cooking ores," as lead ores were scornfully termed at that time, did not find ready purchasers, especially as those ores generally occurred in limestone formations, which were then considered as very unreliable ore producers. But the success of the firm of Buel & Bateman, who had bonded the mines now known under the name of the Eureka Consolidated, and who turned a perfect stream of rich bullion from two small furnaces on to Balbach's refinery at Newark, New Jersey, wrought a sudden change. Lead mines, good, bad, or indifferent—but "true fissure veins" they must of necessity be—were at a premium, and smelting works sprang up like wild-fire everywhere. The nucleus of excitement, however, centered about Salt Lake City, whose neighboring mountains were known, from the explorations of the Mormons and the soldiers of General Conner, to teem with lead ores. The comparative poverty of the ores in silver, their siliceous and frequently refractory character, the close competition in their purchase, the bad quality of the fuel and furnace lining, and a good many other things, sharpened the intelligence of the Salt Lake valley smelters, more so than that of others; and it is to them that we owe the introduction of improvements which led to a more economic handling of the ores. Iron ore and limestone were here used intelligently as fluxing material for the first time; Connellsville coke superseded, at least partially, the miserable charcoal which was made from the light woods of Utah; water-jackets replaced the outwalls as well as the costly firebrick lining of the furnaces; dust chambers were erected to save the escaping finest particles of ore; and a number of very complete sampling works were erected, which opened a liberal market to the miner and afforded the smelter an opportunity to select for purchase such ores as suited his wants. It is true, Eureka, Nevada, has been, so to speak, the cradle of the art of smelting in the West; to Arents we owe the introduction of the siphon tap, the construction of the first large and successful furnaces, and the reintroduction of the boshes in lead furnaces, but beyond these Eureka does not offer any innovations in the smelting process itself. The same routine is observed there as of old. The principal reasons for this conservatism are, first, the docile character of the predominant ore (of Ruby Hill), which requires little or no flux to give economically satisfactory results; and, secondly, the fact that mines and smelters of the leading companies are managed by the same person, generally a miner or a business man who is reluctant on general principles to adopt improvements of a scientific nature.

Recent progress.—In localities where mines and reduction works are not united under one head, and where, on the contrary, the miner sells his product to the smelter who pays him the most money, there is no room for nursing prejudices. Business, art, and science have to go peaceably together; and it is owing to the coöperation of these three factors that we are progressing day by day in the search for the most profitable methods in the art of smelting.

Silica percentage of slags.—It is taught in the mining schools that in smelting lead ores the object is to make a singulo-silicate slag, or one between this and a bisilicate, of the earthy matter in the ore, which best enables us to effect its separation from the metallic matter; it is also taught that simple singulo-silicates are not as easily fusible as compounds of two or more singulo-silicates; for instance, a compound of the singulo-silicate of ferrous oxide with that of calcic oxide. It was further known in practice for a long time that if in fluxing an ore the proportion of lime to oxide of iron is kept as one part of the former to two parts of the latter a good slag would be the result; that is, one which will form with the least amount of fuel, keep the furnace open, and be free from lead and silver. But, with all this knowledge, more bad slags than good ones were made, till several thinkers were led to the right track by giving their attention to crystallized slags, which presumably are real chemical compounds and therefore have a constant composition, while amorphous slags might be considered as mere mixtures of different silicates or solutions of one silicate in another. It was observed that some crystallized slags behaved better than others in the furnace. If such a slag, then, could be made at will, a great problem was solved; any kind of ore could be smelted without the least trouble by giving it the lacking constituents in the same ratio as they are found in the analyzed slag. This necessitates, of course, an accurate knowledge of the slag-constituting ingredients of ore, fluxes, and ash of the fuel, which can only be arrived at by chemical analysis and an accurate weighing of all the material into the furnace. Taking all these precautions, a slag of the same crystallization as the typical one will almost invariably result, other things being equal. I say "almost invariably," because oxide of zinc seems to prevent crystallization; at least such was my experience in Colorado. The slag-forming matter of an ore which has to be most frequently dealt with in lead smelting consists of the following substances:

1. Silica.
2. Alumina.
3. The oxides of iron and manganese.
4. Lime and magnesia.

Baryta and strontia are of rarer occurrence, and the oxides of the alkaline metals exist only in such subordinate quantities that they may be neglected.

All the above-named substances are hardly ever found present in the same gangue, and much less arranged in such a proportion as to yield at once a suitable slag in smelting. By supplying the ore with the deficient ingredients we *flux* it and form a "smelting mixture." According to the amount of combined silica present in a slag we distinguish three degrees of acidity:

1. Subsilicates, in which the oxygen of the bases is to the oxygen of the acid as 2 : 1—

$$4\,RO+SiO_2=R_4SiO_6;\ \text{or}\ R_2O_3+SiO_2=R_2SiO_5.$$

2. Singulo-silicates, in which the oxygen of the bases is to the oxygen of the acid as 1 : 1—

$$2\,RO+SiO_2=R_2SiO_4;\ \text{or}\ 2R_2O_3+3SiO_2=R_4Si_3O_{12}.$$

3. Bisilicates, in which the oxygen of the bases is to the oxygen of the acid as 1 : 2—

$$RO+SiO_2=RSiO_3;\ \text{or}\ R_2O_3+3SiO_2=R_2Si_3O_9.$$

Subsilicate slags.—The subsilicates are not made at present, at least not intentionally, on account of their evil behavior; but they are mentioned because they may be used as a flux on account of their capability to saturate themselves with silica. The subsilicates of alumina and those of the oxides of the alkaline earth metals are infusible; but the subsilicate of iron is very easily fusible, and at a lower temperature than singulo-silicates. It has a high specific gravity, runs very thin, solidifies very rapidly, and has a bluish metallic luster and fine-grained texture. It forms accretions in the furnace hearth, causes the furnace to blaze, and entangles metallic particles. It also has a highly corrosive action on the masonry of the furnace.

Bisilicate slags.—Bisilicates are not made in this country, to my knowledge, except unintentionally, as there are no furnaces of sufficient height to make them without evil results. Those highly siliciferous slags which Mr. A. F. Schneider describes in Vol. XXXIV., page 283, of the *Engineering and Mining Journal* are still singulo-silicates, because the combined oxygen of all their bases is to that of the silicic acid as 1 : 1. Bisilicates have a glassy flow and generally a black color, and do not *often* crystallize, as we glean from the latest metallurgical publication (Balling's Compendium der Metallurgischen Chemie). It appears from analyses quoted in metallurgical books that they always carry considerable oxide of lead, which is probably due to their faulty composition.

The most interesting slag to the lead smelter is the *singulo-silicate*. A typical one of the form 6 FeO, 3 SiO_2+4 CaO, 2 SiO_2, in which the percentage proportion of oxide of calcium is to protoxide of iron as 1 : 2, has been long known, and has nevertheless not been often made, if we may judge by the analyses published in metallurgical papers, until Mr. A. Eilers, and probably a few other metallurgists, recognized its great virtues. This is a most magnificent slag; its physical appearance in the slag pot is so marked that one who has once seen will never forget it. If the proper amount of fuel has been given to the charge it will contain neither lead nor silver; and it is my opinion that if it ever is metalliferous it is through small globules of matte dissolved in it, which have not been separated on account of lack of heat in the furnace. Running on such a slag a furnace can never get out of order except through gross carelessness. It is, however, the duty of the metallurgist to correct the slag if it shows imperfections; for instance, if it shows an excess of iron, a lack of silica, etc. An addition or a reduction of a few pounds of one flux or the other will show itself in the appearance of the new slag as soon as it gets down to the hearth. This explains why in throwing the charge into the furnace by volume, and not by weight—the old "shovel system"—a typical slag (that is, one of a fixed composition) cannot be obtained. Each pot of slag running out of the furnace will differ from the preceding one, and if the furnace becomes deranged it may be impossible to perceive what caused the trouble. On breaking a cake or cone of slag as it comes out of the pot, after cooling, it will show cavities filled with large crystals. Unfortunately they are never entirely developed, so that one can be able to determine to which crystallographic system they belong.

Various slag components.—Heretofore we have assumed that a slag is only composed of silica, iron, and lime. An ore or a flux may, however, contain notable quantities of other substances which would play an important part in the formation of a slag, such as manganese, magnesia, etc. Experience has shown that manganese acts analogously to its related metal, iron; magnesia, baryta, and strontia to lime. In the case of alumina we have to make the slag more acid by an amount of silica corresponding to the alumina, according to the formula of a singulo-silicate, viz., $2\ Al_2O_3$, $3\ SiO_2$; otherwise we should obtain too basic a slag. It is obvious that a slag of the above composition, needing so much lime, would make the treatment of some kinds of ore, such as carry much ferruginous or manganous matter, very expensive, inasmuch as it reduces the percentage of ore in the smelting charge very considerably. This point occupied the attention of Mr. Eilers while treating the ferruginous ores of the Flagstaff mine in Utah; and after much labor and many sleepless nights he succeeded in making a slag which very nearly corresponds to the formula

$$6\ FeO,\ 3\ SiO_2+2\ CaO,\ SiO_2,$$

and in which the proportion of calcic oxide is to ferrous oxide as 1:4. The physical appearance of this slag is still more striking than that of the first one; it is simply beautiful, and it crystallizes also, but in a different system. It has a black color, frequently with a rusty brown film, and a fibrous texture. It fills all the requirements of a good slag, metallurgically as well as commercially, but it is not quite as free from lead oxide and silver as the former. It keeps the furnace open (that is, free from hearth accretions), and is especially adapted for smelting ores containing a large percentage of zinc, this greatest enemy of the lead smelter. Oxide of zinc makes a slag difficult to fuse, and silicate of zinc is infusible; but both dissolve readily in an excess of the slag just described, while the more calcic slag becomes much less fluid. In other words, ferrous oxide increases the liquidity of zinciferous matter, while lime decreases it.

If the proportion of ferrous oxide is raised beyond the limits just given, but at the same time the degree of acidity corresponding to a singulo-silicate is maintained, the remarkable fact is observed that the slag becomes rich in lead oxide. In consequence of this, its physical appearance changes entirely. It shows a bluish hue and waxy luster in its fracture, runs like stearine, and forms hard accretions in the furnace hearth. This slag was formerly made at some works in Leadville, at which the necessity of using lime in their smelting mixtures was decried, and thus a great waste in lead and silver resulted.

The lack of iron in the Utah ores, and the great cost of iron flux as compared with limestone, induced prominent Utah smelters to search for a type of slag in which the proportion between lime and protoxide of iron is greater than 1 of the former to 2 of the latter, and they seem to have succeeded very well. I have seen a sample from the Horn Silver works which had a color like stove polish, a greasy luster, and well-formed crystals in its cavities. Schneider gives its percentage composition as follows:

SiO_2	35
FeO	25
CaO	26
Al_2O_3	10
Not determined	4
	100

This would correspond to the formula

$$6\,FeO, 3\,SiO_2 + 8\,CaO, 4\,SiO_2 + 2\,Al_2O_3, 3\,SiO_2.$$

As will be observed, there is a large amount of alumina in this slag; and it might, therefore, be questioned whether such a slag could be made if alumina were lacking.

Estimation of slags.—In the early stage of smelting at Leadville great difficulties were encountered at most of the works in making a good slag, and the "muscular" method had to be frequently resorted to in freeing the furnaces from sows. This evil was in great part due to disregarding the alumina contained in the ore; and also to the manganese, which was not regularly determined on account of the tedious methods then in use. The result of this oversight was a very basic slag, which would naturally close up the furnaces. Mr. T. Macfarlane, in a paper read before the American Institute of Mining Engineers, suggested that by determining the specific gravity of a slag a clue might be obtained for improving it if not correct. If the specific gravity were higher than that of the typical slag, this would prove an excess of the bases of the heavy metals in the faulty one. But whether it required an addition of silica, or of lime, or of both, the determination of the specific gravity could not tell us. In the case of a slag which is far out of the way, correct chemical analysis alone, however tardy it may be, can give us information. Since the introduction of more rapid volumetric methods for the determination of manganese (for example, Guyard's), and the estimation of the alumina in slag computations, all troubles of this nature have ceased.

A fact to which Dr. Iles, of the Grant Smelting Works, now at Denver, first called attention, and which it appears might be turned to account in correcting a slag, is the behavior of its powder under the magnet. Some slags are highly magnetic, while others are not. Would this not indicate that magnetic oxide is dissolved in the slag, which has escaped reduction to ferrous oxide, and thus causes a waste of precious flux?

Elimination of sulphur, arsenic, antimony, etc.—The subject of slags has been dwelt upon at some length, because the metallurgical success of smelting depends in a great measure upon their composition, and it may be said *altogether* in the case of cerussite ores. But as soon as sulphur, arsenic, antimony, and other electronegative elements enter into the composition of an ore, this alters the case; we have to eliminate them in some other manner before we can extract the pure lead without difficulty. There are two ways of doing this—

1. By precipitation by means of metallic iron.
2. By roasting the ore.

Precipitation by iron.—The iron-precipitation process is only applicable to galena ores and lead ores contaminated with small quantities of the sulphides, arsenides, and antimonides of other metals, to which should be added all sulphates, arseniates, and antimoniates, as they are reduced in the furnace to sulphides, arsenides, etc.

This process is based upon the fact that iron has a greater affinity for the electronegative elements than lead and silver. If, therefore, iron is brought in contact with molten sulphide of lead or silver it will, as soon as it has acquired the proper temperature, combine with the sulphur, while lead and silver are set free as reguline metals. The affinity of silver to sulphur is, however, stronger than that of lead, which is the reason why some sulphide of silver is undecomposed, remaining with the sulphide of iron.

The compound of iron and sulphur is metallurgically called a *matte*, while that of iron and arsenic or antimony is termed *speiss.* The latter has a higher specific gravity than the former, which is the reason why if both are produced during a smelting operation the matte floats on top of the speiss. The mattes retain more silver than the speisses, while with gold the case is exactly the reverse. Lead enters the speiss only in the metallic state in the form of shots, while in matte it will be present as sulphide. Copper enters into either as sulphide and arsenide respectively, as it has a strong affinity for both sulphur and arsenic.

The iron may be present in a matte either as diferrous sulphide (Fe_2S) or as ferrous sulphide (FeS), but never as ferric disulphide (FeS_2), because the latter on being exposed to a strong heat is decomposed into magnetic sulphide and free sulphur. The former does not fuse well; it is mushy and liable to chill in the furnace, thus forming an accretion. It is therefore well to aim at making ferrous sulphide (FeS) in computing a charge. If copper be present in a lead ore it will go into the matte as cuprous sulphide (Cu_2S). On the strong affinity of copper for sulphur is based its separation from lead. Iron and other heavy metals combine with arsenic in a great many proportions, according to the statements of metallurgical authors, who speak of

$$R_2As, R_3As, R_4As, R_5As, \quad . \quad . \quad . \quad . \quad . \quad R_nAs.$$

Yet experience has taught the practical smelter that only crystalline speisses of a bloomy texture, similar to that of spiegeleisen, from R_5As towards R^nAs, will work well in the blast furnace. Speisses from R_4As on towards R_2As run very thick, if at all, and form hard accretions (speiss sows) in the furnace. They are fine-grained and always contain entangled metallic lead. An addition of metallic iron will therefore improve the liquidity of a speiss. How far we can go in augmenting the proportion of iron to arsenic I am unable to state from my own experience; yet it may be surmised that an excess of iron in a speiss may be just as injurious to the operation of a furnace as an excess of arsenic.

Purely antimonial speisses have never come under my observation, so I cannot say anything about them.

Form in which iron is used.—As it is not easy to obtain metallic iron in every locality, and as it is generally not in a proper shape for being weighed out and mixed accurately with ore and fluxes, it is preferable to supply the iron as a desulphurizer in its nascent state, in which it can be obtained by using a properly constructed furnace and making a slag of sufficient acidity, at the same time adding so much ferruginous matter to the smelting mixture as will correspond to the amount of metallic iron required for the saturation of sulphur, arsenic, etc. Furnaces with straight walls from top to bottom are poor reducers, while those provided with boshes operate very well indeed. Basic slags are not good reducers either, because they form at a temperature at which iron is not reduced; they will therefore merely mechanically dissolve the magnetic oxide which forms out of the additional ferruginous matter in the upper part of the furnace.

From the preceding remarks it may be inferred that this process is not a perfect one, because it gives rise to the formation of intermediate or by-products which contain gold, silver, and lead. If thrown away, these metals will be lost entirely. If we wish to extract them, additional processes will have to be resorted to, and then the question arises, Will it pay? It is therefore advisable to subject only such ores to the iron-precipitation process as contain a minimum of sulphur, etc. What the maximum should be can be determined by the local price of the iron flux compared with the cost of roasting.

The roasting process.—By roasting an ore we wish to expel its sulphur, arsenic, or antimony, and convert the metals in it into oxides, in which form they are best adapted either to be carried into the slag or into the metallic state during the subsequent smelting. The roasting is carried out by exposing the ore to the action of heat and air, in consequence of which sulphur, arsenic, and antimony are volatilized as sulphurous, arsenious, and antimonious anhydrides, respectively, while the metals remain in the oxidized state. According to the apparatus in which the operation is performed the result will be more or less complete. The roasting of arsenical and antimonial ores is rendered more difficult by the simultaneous formation of arsenic and antimonic acid, which combine with the metals to form arseniates and antimoniates. These compounds can only be decomposed by repeated additions of carbon and access of air, whereby the arsenic and antimonic acid are reduced to their arsenious and antimonious anhydrides and thus gradually volatilized.

Ores containing sulphide of zinc (zincblende, sphalerite) are also difficult to desulphurize by roasting, inasmuch as zincic sulphate is always forming, which is only completely decomposed in a white heat. Mr. Stetefeldt found that sulphate of zinc is the most constant compound in the fire next to sulphate of manganese. While during the first two hours of roasting nearly all the sulphate of iron had been decomposed, there was still a large percentage of zincic sulphate undecomposed at the ninth hour. This behavior of zinc makes zinciferous ores difficult to work. In the blast furnace any sulphate of zinc remaining undecomposed after roasting will be reduced again to sulphide. This substance goes partially into the matte, if any is forming, partially into the slag, which it makes thick and stiff; it also carries silver along, and thus gives rise to losses above and beyond those inherent to all metallurgical processes.

Roasting furnaces.—With regard to the apparatus used for roasting, preference is given in this country to reverberatories, ranging from 30 to 40 feet in length and from 10 to 12 feet span, divided into four or five hearths. This arrangement admits of keeping four or five charges in the furnace, in as many different stages of treatment. As soon as one charge is drawn, each preceding one is moved forward one by one, and a fresh charge is put in. The time of roasting varies with the amount of sulphur in the ore, the bulk of the charge, the quality of the fuel, and also with the altitude of the locality above the sea-level. The size of the ore has a great influence upon the completeness of the desulphurization, and the more zincblende there is in it the finer it should be. At Robinson, Colorado, for instance, the ores could not be crushed finer than walnut size, and although a charge of 1,300 pounds remained in the furnace for thirty-six hours, there was still from 7 to 8 per cent. of sulphur left in the ore. The ore being highly zinciferous (21 per cent. ZnS), the slag resulting from smelting contained considerable silver. From Przibram, Bohemia, it is reported that blende ores have been roasted down to 1 per cent. sulphur.

If copper is present in an ore there should be sufficient sulphur left in the charge to get rid of it as matte; otherwise it will deteriorate the quality of the lead or be lost in the slag. Galena ores almost free from other sulphides roast better in a short furnace than in a long one, especially if the fuel does not yield a long flame.

For subsequent smelting it is more convenient to have the ore in lump shape than in powder. Wherever, therefore, it is practicable, as in the case of ores with a large percentage of lead, to slag the ore, in other words to convert it into silicates, it should be done. This slag should be drawn and after cooling broken up into lumps of suitable size. As zinciferous and ferruginous ores cannot be slagged very easily, it will be sufficient to sinter or "agglomerate" them.

Wood is used as fuel in places where its abundance makes it cheaper than stone coal, and it is preferable when it is of a resinous character. Mineral coal is, however, preferable to oak, mahogany, mesquite, or the lighter woods.

Matte roasting.—In the foregoing outline it has been observed that whenever there is any sulphur in a smelting mixture it has to be saturated with the necessary quantity of iron to form a matte of the right composition. To extract the lead and silver which these mattes retain, it is necessary to roast or calcine, and afterwards flux and smelt them exactly in the same manner as an ore. If they are so poor in lead that there is danger of its being kept entangled in the slag and thus lost, it is advisable to add plumbiferous ores or products in sufficient quantity to effect a complete separation of lead and slag in the furnace. A charge containing 10 per cent. of lead will be safe to answer this purpose, yet it is possible to obtain the same result with as little as 6 per cent. The question now arises, Will it pay to roast matte in a reverberatory, as it costs something to reduce it to powder besides the roasting itself? If the matte is rich in silver, it does; if not, then it requires close figuring of all expenses. I have known localities where poor matte was roasted in heaps. The only preparations it needed were coarse crushing, a bedding of wood to pile it on, and setting it on fire. The crushing is easy enough after it has been exposed for a while to atmospheric influences, which cause it to crumble. But the calcination is extremely tedious, as it will burn for a month or more, and then the whole pile will have to be turned over to assort the well-calcined stuff from the half-calcined and crude matte, from which a new pile or heap has to be formed. These manipulations have to be repeated till no more crude matte is left, and it will take months before that result is achieved. However well this matte may be roasted in heaps it will always contain from 7 to 8 per cent. of sulphur, which in the following smelting operation will cause another matte to be formed. It appears to me that this mode of roasting is not worthy of imitation in a progressive country where time is an object, and I find that most smelters take the same view. They are simply laying aside the poor mattes for a time when these may be reduced more cheaply and quickly than at present.

Attempts to roast ore in this manner have been frequently made, but just as often discarded as tedious and imperfect. An ore which does not bear the expenses of roasting in a reverberatory furnace should be left alone.

During the past year experiments have been made at the Germania works, near Salt Lake City, to calcine mattes in an Unterharz kiln, but with what result I am not informed.

Retreatment of speiss.—The question of reworking speisses for the silver and gold they contain has been left in abeyance as yet, although it is known that those produced in Eureka, Nevada, in the early stages of that camp ran as high as $70 per ton in gold and silver. The speisses of Utah contain comparatively little silver and gold, but considerable cobalt and some nickel, also varying quantities of copper and lead. It is, however, more than doubtful whether it would be profitable to extract any of these metals. Speiss is, at all events, more difficult of treatment than matte. It requires grinding and bolting to separate metallic particles, and roasting at a very low temperature to prevent fusion. The process is, besides, very dangerous to the workman, as the dust produces painful sores wherever it settles on the skin.

Smelting furnaces.—The object of the smelting process, now to be described briefly, is to reduce the lead and silver contained in an ore to the metallic state, while the other metals remain in part combined with sulphur, arsenic, etc., and the remaining constituents of the ore unite with the earthy matter, forming slag. The smelting operation is performed entirely in blast furnaces of different patterns and sizes, which should be adapted to the supply and grade of ore, character of fuel, cost of labor, and other local requirements. The cross-section of the shaft furnaces of this country has varied from polygonal to circular and from square to rectangular, while the height has remained almost the same for the treatment of easily reducible as for hardsmelting ores, viz., 12 to 14 feet above the level of the hearth plates. Experience has proved that smelting in furnaces of small area can only pay in special cases, where, for instance, small supplies of rich ores, or refinery drosses, etc., are to be treated. For this reason furnaces built on the Piltz principle of circular section are losing ground every day, while those of increasing rectangular section, like Rachette's, are rapidly replacing them. The diameter of a circular furnace cannot be increased beyond 4 feet without evil consequences when working under blast of the customary pressure of half a pound per square inch. Blast of a higher pressure would require a corresponding increase in the height of the furnace; otherwise the furnace would become unduly hot at the throat and cause great losses by volatilization. The capacity of rectangular furnaces, however, can be largely increased without raising the pressure of the blast by leaving the width stationary and merely increasing the length of the hearth area. There are furnaces running now successfully which have a section of 3 feet by 7 feet 10 inches, while the success of 54 inch "cupolas" is still to be announced. The smelting capacity of furnaces is, however, greatly modified by other conditions, viz.:

1. The nature of the fuel used, whether charcoal or coke.
2. The volume and pressure of the blast.
3. The size of the material to be smelted.
4. The fusibility of the smelting mixture—to which may be added the temperature of the water, if water jackets are used.

Charcoal of good quality will smelt more charges in the same time and under the same circumstances than coke, but coke will make cleaner slags and less flue dust than charcoal. A mixture of charcoal and coke will be more advantageous economically in many localities than either alone. The size of the blower and the quantity of air it supplies should be adequate to the size of the furnace, else it cannot reach its highest effect. In using blast of a low pressure less material will pass through the furnace than with one of higher pressure; but it is advisable to work with a moderate blast, so as to allow the smelting mixture sufficient time for complete reduction. Hard ores require a blast of higher pressure than easily fusible ones. The formation of flue dust can also be regulated by the pressure of the blast, aside from the fuel.

The best size of material for smelting is that of a goose egg; iron and limestone flux, however, may reach the size of a man's fist, while quartz should be broken much smaller. Such material smelts very rapidly. Pulverulent ores give much trouble by sifting through the fuel and arriving before the tuyeres in a raw state, where they will cake together and form a sow, or enter the slag and cause a loss of metal. Very fine ores, such as slimes from concentrating works, especially if they are rich in silver, should be agglutinated with milk of lime previous to putting them into the furnace; otherwise a large proportion will be blown out of the furnace as flue dust. If roasting precedes smelting it may be found judicious to bind the roasted ore also with lime. If the slag should show undue quantities of precious metals this would indicate the necessity of such a method.

The fusibility of an ore is greatly enhanced if it contains much lead and little silica, alumina, and above all no zinc compounds. A large percentage of oxide or silicate of zinc in an ore, even if properly fluxed, is liable to reduce the smelting capacity of a furnace to one-half of what it would be if running on more favorable ores. This I have found to be a stern fact in my own experience.

These remarks will prove that, in the first place, a lead blast furnace has no fixed smelting capacity in tons of material; and, secondly, if we do rate its capacity we should express it in tons of smelting mixture or charge, and not of ore.

The modern type of furnace.—All smelting furnaces are at present built with much more care, though probably at greater first cost, than the works of fourteen years ago, and with a view of saving every particle of metal that will leave a profit.

The hearth or crucible of the furnace is so strongly incased in cast-iron plates, and secured underneath by a bottom-plate, that the lead has very little chance to escape in that part. The interior is lined with firebrick all around; the bottom is made of firebrick also, in the shape of an inverted arch, so that any lead which might creep through the joints cannot raise it up; and no tamping, to the composition of which old smelters paid so much attention, is used. The depth of the hearth is arbitrary within certain limits, say 22 and 30 inches. In one side of the hearth, close to the bottom, a channel 4 inches square (or round, if preferred), running up toward the top of the hearth plates, is started for an automatic outflow of the lead. This may widen into a bowl at the top to admit the introduction of ladles for dipping the metal, but not necessarily, as in many works the lead is tapped through an orifice a few inches below the upper edge of the hearth plate into a cooling kettle, so as to admit the skimming of the dross or impurities which may be suspended in the lead previous to its being cast into molds. The water-jackets are placed on top of the hearth lining in such a manner that their interior lower edges are flush with the walls of the hearth. These jackets may be made of cast iron, wrought iron, or any other suitable metal, and may be set perpendicularly or inclined, or they may be provided with boshes of different angle (usually 65° or 70°) to suit the fancy of the smelter, and they may reach to the charge floor or may be only a few feet high. I prefer the jackets of Mr. Eilers's construction. They are 3 feet 6 inches high, and have a bosh commencing 10 inches above the center of the tuyere openings, which are cast into the jackets. They are also provided with a large, projecting lip, rising 4 inches above the top of the otherwise closed jacket. This lip is open, and mainly serves for the purpose of keeping the jacket filled with water; but it also prevents the formation of steam, allows the introduction of tools to remove scale, and receives the feed water. It is also provided with an outlet for the hot water. The cold water, on account of its greater density, sinks gradually to the bottom, while the heated water rises and flows into a waste-trough. This jacket, and in fact the whole furnace, has been adopted by many smelters with slight changes, but these changes are only of degree and not of kind. The tuyeres are 10 inches from the bottom of the jacket, and distributed symmetrically about the interior of the furnace, except in front—where they have been found inconvenient and even unnecessary—in the proportion of one tuyere of 3-inch opening for about every 2 square feet of hearth area. So a furnace of 3 feet by 6 feet 6 inches area would receive nine tuyere-openings; one of 3 feet by 5 feet, seven, and so on. The object of the boshes is to enlarge the horizontal section of the upper part of the furnace, with a view to diminish the velocity of the escaping furnace gases, and thus cool them. The front jacket—or jackets if made in sections—is shorter than the others, and reposes on 10 inches of brickwork, in the midst of which the slag hole is located. This is done in order to facilitate the cleaning or "barring out" of the furnace by mechanical means, should it ever become necessary. Where the charge is of such a nature that the resulting slag will soften the brick front too much, a Luerman cinder-block can be inserted to advantage. The upper part of the furnace, including the chimney, rests on cast-iron plates supported by wrought-iron girders or rails, which are bolted at their ends to the top plates of four cast-iron posts. The space intervening between the tops of the water-jackets and these cast-iron plates, which may vary from one foot to two feet, and is left to facilitate the extraction of leaking jackets, is filled in with courses of firebrick. The charge doors are on the long sides of the furnace, not directly opposite each other, but each near diagonally opposite corners, in order to compel the feeders to spread their charges uniformly. The doors are high enough to allow a man to stand erect in them in case wall accretions have to be cut out; they are usually closed to within 2 feet from the bottom of the frame.

At a convenient height above the charge floor a tube or flue, 4 feet in diameter, made of stout sheet iron, is inserted into one of the walls of the chimney—which one, local circumstances will dictate—at an angle of not less than 45°, terminating in a dust chamber or a system of dust chambers, which are again connected by a flue of sufficient size with a tall stack. The top of the chimney is provided with a door or damper which can be opened or closed instantly by means of a chain reaching through the roof close to the feeder's grasp. In the flue connecting the furnace with the dust chambers, frequently called the "downcast," there is also a damper, placed in such a manner that the feeder can at once open or shut off communication with the chambers. This arrangement is necessary to prevent explosions in the chambers through the sudden blazing up of the furnace, and to protect the workmen from the noxious fumes while the dust chambers are being cleaned out.

At the new Grant Smelting Works near Denver the gases and fumes are drawn off below the level of the charge door by a plan similar to the arrangement at Freiberg. For a full description of those works and drawings accompanying it the reader is referred to the files of the *Engineering and Mining Journal*, Vol. XXV., No. 12.

Water-jackets.—Water-jackets have been adopted in every place where there is a sufficiency of water. But wherever the supply of water is scanty and unreliable, I should not advise their use, even if the material for lining the interior of the furnaces is not of unexceptionable quality. On this ground, I believe, the Eureka Consolidated Company have retained their ponderous stone furnaces, for the relining must be certainly expensive, if we consider that the sandstone has to be hauled a distance of 35 miles, and that mechanics there receive very high wages. It is true, I saw several years ago a furnace in operation there which had been in continuous blast for more than a year, according to the statements of the foreman, but such campaigns are exceptional and are sometimes made for effect; probably it might have been wiser and better for the furnace if it had been blown out sooner.

Air-jackets.—In May, 1878, the Eureka Consolidated Company had an experimental furnace erected by Mr. Gerrish, in which air jackets were to take the place of water-jackets. These jackets consisted externally of sheet iron, to which were bolted by means of flanges copper plates 1½ inches thick, forming the interior of the furnace. There were eight tuyere openings with 4-inch mouths in the jackets, and one foot above the hearth. Eight inches above these there was another row of openings of the same diameter, but only in the outer shell, which were connected with the former by closely fitting pipes. The object of these connections was to allow the hot air from the jackets to pass directly into the furnace. Each sectional jacket had of course a connection with the blast-main. The furnace was elliptic in shape and its hearth area corresponded nearly with that of the other furnaces, and was 3 by 6 feet. The blast was supplied by a No. 5 Baker blower making 104 revolutions per minute. Unfortunately the experimenter did not provide his furnace with a forehearth, as is customary in Eureka; and, as he did not or could not flux the ore at all, he did not get the slag to run. A speiss sow frustrated the completion of his experiments. The impracticability of air-jackets was, however, proved to the satisfaction of the company and that of the numerous pilgrims who flocked to Eureka from White Pine, by the appearance of the copper plates, which were perforated like colanders by the action of the speiss.

Except at Eureka and a few other localities, all furnaces are now provided with closed breasts, and the slag is run out intermittently instead of continuously. The slag-pots are so constructed that they hold about 300 pounds, which corresponds to a charge of about 400 pounds.

Blowers.—The blowers mostly in use are the various sizes of the Baker patent, which have driven out of the field nearly all the Sturtevant fans and a good many Root's blowers. They give universal satisfaction and do not require so much attention as the others. The blast is measured either by mercury or by water gauges which are attached to the blast-supply pipe of each furnace. A column of 2 inches of mercury or of 28 inches of water is equal to the pressure of one pound to the square inch.

Fuel.—The fuel is either charcoal or coke, or both mixed. Too much stress cannot be laid on the soundness of the wood from which charcoal is made. In southern Arizona, and perhaps also in other regions, all attempts at smelting with charcoal alone have failed, and I found that all the oak timber, which was the most abundant for making charcoal, was rotten in the core. Hard charcoal from mahogany, cedar, etc., is also to be rejected for use in a blast furnace, because it decrepitates into small particles, which have the same effect as coal slack or waste in chilling the slag through reduction of the temperature. Nut pine (piñon) makes the best charcoal, and this was formerly the principal fuel at Eureka. Charcoal from lighter woods, such as yellow and white pine, quaking aspen, etc., cannot be used alone without reducing the temperature in a furnace. Every smelter who has practiced in Leadville will agree with me on that point.

The best coke I have used is an English patent coke which is shipped extensively from Cardiff, Wales, to San Francisco, where it costs $14.50 per ton. It is porous and light, and leaves a very small percentage of ash. The Connellsville coke is the next best; it is very dense and heavy, and yields about 5 per cent. ash; but it has been driven almost entirely out of the market in the West by the English and Colorado coke, on account of the freight charges, which swell its price to a high figure compared with the others. There are two kinds of Colorado coke in the market, the El Moro and the Crested Butte. I prefer the latter, others prefer the former; yet the difference is but trifling.

Owing to the different fusibility of different ores the percentage amount of fuel must be referred to tons of charge in comparing the consumption in various localities. This brings out the remarkable fact that smelting at a high altitude requires more fuel than at a lower one. In Leadville, for instance, the consumption of mixed fuel amounts to from 22 to 24 per cent. of the weight of the smelting mixture, while in Salt Lake valley it amounts to from 14 to 17 per cent., the lower figure corresponding to the summer and the higher to the winter season, when the ores absorb more moisture than in summer.

Where charcoal alone is used the percentage of fuel is somewhat higher, probably between 26 and 28 per cent. Correct data are lacking because this kind of fuel is usually thrown into the furnace by bulk, and the weight is only approximated. How little reliability can be placed on such approximations I had occasion to experience in a remote mining district, where more fuel was used than the proprietor of the works had purchased (inclusive of waste). This is, of course, an absurdity. It is therefore advisable in the interest of regularity of the furnace operations to weigh not only ore and flux, but also the fuel, as accurately as possible.

Fluxes.—The fluxes most frequently used are:

1. Quartz, sandstone, clay slate, or other highly siliceous rocks, to supply any deficiency of silica which might be required to saturate the basic gangue in an ore.

2. Hematite, magnetite, limonite, and specular iron ore, and the various manganese ores, if iron is lacking in an ore.

3. Limestone, dolomite, and calcareous shale, if calcic oxide is not in sufficient quantity in an ore to form a slag of the type desired; to which may be added slag and metallic iron if we follow Webster's definition of flux as "any substance or mixture used to promote the fusion of metals or minerals."

The action of slag, is however, more of a mechanical than of a chemical nature, unless it should have the characteristics already pointed out in the discussion of slags. If a coarse-sized smelting mixture is to be worked, an addition of slag to promote its fusion is entirely superfluous and would only increase the cost of smelting; but, if the charge is very fine or if much zinc is present in it, slag will very materially promote its fusibility. I have found the correctness of this statement to be confirmed while at Robinson, Colorado.

It is a matter of the greatest moment that fluxes should be as free as possible from impurities to insure success in smelting. So, a bituminous or a si iceous limestone would not be exactly the correct flux to select if we wanted lime for ore. As carbonic acid does not take any part in the composition of a slag, burnt lime would theoretically be the best; but, as it rapidly attracts carbonic acid and water, thereby reducing its money value, and as it presents mechanical difficulties in the furnace, its application has never become general. It was at one time extensively used at the American Smelting Works in Leadville.

An iron ore containing 22 per cent. of silica and 68½ per cent. of ferric oxide would be indeed a very bad flux, since the 22 per cent. of silica requires a certain amount of ferrous oxide and also a certain amount of calcic oxide to form a slag of the same composition as is desired. The ferrous oxide required by the silica of the flux has then to be deducted from the ferrous oxide corresponding to 68½ per cent. ferric oxide. The remainder will be the real available ferrous oxide (or "excess of iron" as it is termed in Leadville) which will probably not amount to one-half of the original 68½ per cent. An admixture of iron pyrites in an iron ore would reduce its value in a similar manner, as so much metallic iron would have to be deducted from the total iron contents as is necessary to convert FeS_2 into FeS.

It does not require much reflection to perceive from the foregoing that the presence of extraneous minerals in quantity increases the bulk of the fluxes at an alarming rate, while the ore may become the smallest part of the smelting mixture. In this case the percentage of lead in the charge will arrive at a point where smelting is no more profitable. Such cases have occurred in southern Arizona, where bad fuel and poor fluxes have ruined the lead smelter.

Conditions for economical working.—It is obvious that smelting can be conducted most cheaply at a point where ores of a different character find a joint market, and where at the same time, railroad facilities enable the smelter to procure his fuel, flux, and other necessary materials, and ship his product at low rates of freight. Such a place is Leadville. There we have siliceous, ferruginous, and calcareous ores, which can be combined with each other in such a manner that the least possible quantity of flux is required to smelt them properly; there we have cheap fuel also. But competition has assumed such proportions at Leadville that it requires no small amount of commercial skill to purchase ores in suitable proportions to flux each other, and large smelting capacity to make the business profitable. The advent of the railroads has been of immense benefit to the camp, and the increase of capacity has reduced the cost of labor almost by one-half, as a comparison of the following figures will show:

The average price of fuel in 1879, when the terminus of the railroad was 35 miles off, was for charcoal, 14 cents per bushel of 14 pounds; coke, $36.70 per ton of 2,000 pounds. In 1882, charcoal, 10½ cents per bushel; coke, $15 per ton.

The average cost of fuel per one ton of ore was: In 1879, $8.92; in 1882, $5.66.

In 1879 we had, however, much more favorable ores to smelt, which accounts for the difference not being larger in proportion. The cost of labor when we had to worry along with two 42-inch circular furnaces in 1879 was $5.20 per ton of ore; and in 1882, when we ran five large furnaces, $2.79 per ton.

Tendency to increase of capacity.—This will at once show that large capacity will materially decrease the cost of labor. There is a growing tendency now to establish smelting works in even more central points, where competing railroads intersect each other, and where the items of fuel and labor are open to still further reduction—like Denver, Pueblo, and other places. In Denver is the extensive Grant Smelting Works, which for convenience of construction, effective work, cleanliness, and architectural beauty yet seeks its rival; in Pueblo is the largest and most complete establishment in the United States, that of the Pueblo Smelting and Refining Company, with its multitude of roasting furnaces and blast furnaces, its sampling machinery, and its refining plant; and there is still another plant in the course of construction in the same town, that of the Colorado Smelting Company. In regard to individual capacity of furnaces the Richmond Company of Eureka is ahead of all others, if we may accept the statements of the Eureka *Sentinel*, which in its issue of August 29, 1879, gives the following items about a new furnace then building there:

	Ft.	In.
Length inside jackets	10	8
Width inside jackets	8	4
Height of jackets	2	6
Height of furnace from bottom of crucible to feed floor	16	
Number of tuyeres	17	

Smelting capacity, 100 tons.

Considerable stress is laid on the number of bars which this furnace will produce per shift. I should not like to run a furnace of such dimensions; not that I care for the inside length of the jackets, but the width is monstrous, and must require a blast of 5 pounds to the square inch to penetrate the charge. I hope for the intelligence of the constructor that the *Sentinel* is in error.

Furnace reactions.—The reactions taking place in the blast furnace have been so often described that it is superfluous to go over the same ground again.

Operating lead furnaces.—In regard to furnace manipulations only a few remarks need be made. In blowing in a furnace it is advisable after the hearth has been heated up sufficiently to charge it with alternate layers of fuel and bullion, and afterwards with light charges of smelting mixture and slag, to the top, before turning on a weak blast. The hearth should contain so much bullion that the latter will rise to the top of the hearth in the channel forming the automatic tap. A hearth of 3 by 6 feet 6 inches by 30 inches deep requires nearly 11 tons of bullion to fill it up. I have had occasion, however, several times to blow in furnaces in new districts where no bullion could be had to start with. In this case the automatic tap was closed at its lowest interior opening with a clay plug, which was removed after the lead showed itself at the slag-spout. This is not a very agreeable operation, inasmuch as the formation of a bottom crust is unavoidable, and this can only be perforated, but not removed by skill or by force, while the furnace is in operation. As long as the communication between the furnace and the channel can be kept open by driving holes through the crust, smelting may proceed; but as soon as this method fails, it is best to blow out the furnace at once. If the furnace is in good working order, when it is *open*, the lead in the tap-channel or well must be of a bright red color; frequently it emits arsenical fumes, in which case it should be covered with lime or ashes, which may be removed before dipping or tapping. The well should also work with the blast, that is, the lead should go down in the channel when the blast is shut off and rise again as soon as the blast is turned on. This is well known by the furnace-men, who begin testing their well as soon as the lead commences to assume a dark color and a sow makes itself felt in the furnace. Usually there is a tuyere above or near the lead-well. By taking off the cap of the tuyere-pipe and replacing it the same object is reached as by taking off the whole blast and turning it on again. The presence of a sow makes itself also known at the top, as it commences to blaze up now and then, and as the charges refuse to descend. A change in the composition of the charge is needed, or a water-jacket which may be leaking into the furnace requires to be taken out. The cause is easily discovered and remedied by the metallurgist, yet it takes time to improve a furnace by changing the charge. In a charcoal furnace a new slag will show itself after the lapse of two or three hours; while in a mixed-fuel furnace it will take six or seven hours. To enable the furnace-man to dip the lead in proportion to its percentage in the charge, he should be informed how much of a bar or how many bars are contained in a charge. He will then know whether he should keep his lead high or low in the hearth. If there is little lead in a charge, say seven or eight per cent., great care must be taken to prevent the lead in the hearth from being lowered so much that a crust would be formed by the chilling of matte or speiss when they get too far below the tuyeres. Below the tuyeres the separation of the molten masses according to their specific gravity takes place in the following order: lead, which is of course alloyed with the bulk of the gold and silver contained in the ore, at the bottom; speiss floating on the top of the lead; matte floating on the top of the speiss, and lastly slag. In most places slag, matte, and speiss are run out together into a slag-pot, which is allowed to cool and is then emptied of its contents. The three products are separated in three distinct horizontal layers. The matte from zinciferous ores makes an exception; having a lighter specific gravity, approaching that of the slag, it does not separate in a horizontal layer, but is scattered through the slag as a scummy mass. An addition of copper pyrites establishes a perfect separation in such a case. If metallic zinc forms during a smelting operation the blast will blow a portion of it out through the slag-hole, whence it will appear in its oxidized state as a yellow powder, which on cooling turns white. Another portion of the zinc is volatilized in the shaft of the furnace, and will appear as a white powder in the flue-dust.

Variations in practice.—The manner in which smelting mixtures are made is not the same in all works, nor is the system of feeding or charging the furnaces the same. In some smelting works the weight of the fuel is stationary, that of the charge or quantity of smelting-mixture corresponding to the fuel variable; in others the fuel is variable and the charge stationary; in still others the weights of both are variable. The later plan is an irrational one. I prefer the one where the charge is stationary and the fuel variable, because the furnace is less sensitive to a large quantity of fuel taken off than to changes of charge.

The weights of both fuel and ore charges should be adapted to the area of the furnace at the throat, covering it in thin layers. For a furnace which has an area of 4 feet 8 inches by 8 feet 2 inches at the throat, a good proportion is from 192 to 216 pounds of fuel (half charcoal, half coke) and from 800 to 900 pounds of charge, which is fed into the furnace in half charges through two doors and spread uniformly over the fuel. The furnace is kept filled up to the bottom of the charge-doors. The feeding is done by hand, by means of shovels; but it seems that experiments with automatic feeding apparatus ought to be renewed, as they have not had a fair trial.

The best plan for making a smelting-mixture or charge, as it is also called, is of course to mix a large number of tons of ore with iron ore and limestone, or whatever the flux may be, and then weigh out the charges to the feeder. But wherever there is a variety of ores of different character which may vary in moisture, size, and other conditions, an immediate mixture with the fluxes will hardly give a homogeneous material which will make itself felt in the slag. In this case it is better to weigh each component part of a charge or a half charge separately into a wheelbarrow or car and dump it at or into the furnace. A furnace of the above dimensions will take seventy charges per twelve hours, and will require eight men to serve it.

Furnace products.—The products of smelting may be—

1. Silver-lead, argentiferous lead, also and preferably called "base bullion" in this country, in distinction from gold and silver bullion This is a marketable product and is sold to the highest bidder. There

are a number (ten or eleven) of refineries in the country which make it their object to separate the silver, lead, and gold, and to utilize the by-products gained in the refining process.

2. *Speiss.*—This is not utilized anywhere in the United States.

3. *Matte.*—Is either roasted and smelted again or thrown over the dump.

4. *Slag.*—Is only partially re-used.

5. *Furnace-accretions.*—There are two kinds: wall-accretions and hearth-incrustations or sows. The former consists of sulphide of iron in combination with sulphide of zinc and sulphide of lead, and they contain a small amount of silver. They should be roasted before resmelting; but as most smelting works have no facilities for doing this, they are usually thrown on a charge. The hearth-incrustations do not contain enough silver and lead to make it worth while to have them broken up and resmelted. They are thrown over the dump.

6. *Cleanings, furnace-refuse.*—These are fragments of bricks with metallic lead adherent; they are roughly assorted and the waste thrown away.

7. *Flue-dust.*—This is the most important product aside from the lead. As it contains the finest, and in some cases the richest, particles of the ore in admixture with the dust of coal and coke, it is, of course, worth while to save and rework it. Where much fine ore is smelted, as was the case in Eureka during several seasons, the formation of flue-dust amounts sometimes to 15 per cent. of the weight of the ore. In the face of this it is to be wondered at that so many hundred, nay even thousand, tons of flue dust were blown to the winds before provision was made for saving it. The Richmond Company, at Eureka, were the first to go to work in earnest by building spacious flues for catching the dust escaping from the furnaces; the previous attempt at the Ruby Consolidated works having been a failure.

The great question heretofore has been to get the flue dust in such a form that it will stay in the furnace and not be blown out again. Simply wetting it is not of much use and is even injurious to the furnace, as it will form wall accretions which grow thicker and thicker very rapidly. Mixing it with slaked lime has also its drawbacks, as it contains coal dust, which has a tendency to counteract the agglutinating power of the lime; therefore from eight to ten per cent. of lime is at least necessary to make a mortar which will harden. I have found that sulphate of iron, the copperas of commerce, is the best agglutinator, but it could only be used where it is cheap. Thoroughly incorporated with a solution of copperas and made into bricks, which are dried in the sun, the flue-dust becomes as hard as rock and is in the best shape for smelting. I once suggested, in 1878, the use of a brick-machine to make the flue-dust into adobes (with lime, of course) but the season was too far advanced, the bricks froze and on thawing burst, and the experiment was given up. At the Germania works, the flue dust was sintered in a roasting furnace, which is the best but not the cheapest way. The most common plan now is to work it up with lime and use it along with the ore as fast as it is made.

Losses.—In roasting, as well as in smelting, there are certain losses which cannot be avoided entirely, but which may be reduced to a minimum. In roasting an ore it first experiences a loss in weight owing to the chemical reactions taking place; it loses water and carbonic acid; sulphides of metals are converted into oxides, and thereby decrease in weight. If the roasted ore will then show more silver by assay than the crude ore this would prove that no loss of silver had taken place. If roasting is carefully conducted the loss of silver by volatilization should not be over three per cent.; but antimony, arsenic, and zinc cause a much higher loss by carrying off silver along with them to an extent which, if the temperature has been too high, may approach 20 per cent. I am not in possession of correct data from works where roasting is carried on, as in Montana and northern Arizona. The cost of roasting at Robinson, Colorado, was nearly $6 per ton.

The losses in smelting are caused by the formation of speiss, matte, and other by-products which are thrown away. Slag also will cause a slight loss in metals, even if of normal composition. Zincblende will increase the loss in the slag considerably. The loss by volatilization is very slight so far as the silver is concerned, and may be entirely avoided by having enough lead in the charge to "cover" the silver. It is, however, not known what exact minimal quantity of lead is required to cover a certain quantity of silver and prevent loss. Smelting in Leadville has proved the fallacy of Kerl's statement that 300 times the amount of lead is required to cover one unit of silver. The volatilization of lead is very large where charges low in lead are smelted; as in Leadville, where frequently charges containing only 7 per cent. lead are treated. The loss of silver at Leadville is between 3 and 4 per cent., while the loss of lead from all sources amounts to from 13 to 15 per cent. At the Horn Silver works the loss of lead is stated at 8.71 per cent., but there they treat charges richer in lead.

ZINC.

THE ZINC INDUSTRY OF THE UNITED STATES.

BY C. KIRCHHOFF, JR.

The development and the present position of spelter statistically and commercially are, more than that of any other metal, enveloped in a mystery which the reticence of many of the leading producers has created. As the industry possesses no literature, and no well-organized effort has ever been made to present the conditions under which it labors in different sections of the country, the first attempts in that direction are met by an indifference which must be pleaded as the cause of the incompleteness of the present review. Though cordial support by some of the gentlemen identified with the industry is acknowledged, even bare figures of production have been withheld by others, so that estimates, indirectly obtained, had to be substituted for official figures in some cases.

PRODUCTION.

The records of the production of spelter and zinc in the United States are very incomplete. The following figures are the only ones worthy of some consideration which are available:

Production of spelter in the United States.

	Net tons.
1873	7,343
1875	15,833
1880 (census)	23,239
1882	33,765
First six months of 1883, estimated	18,000

The zinc statistics are sometimes stated in pounds. For 1882 the corresponding figures would be 67,530,000 pounds; and for the first half of 1883, 36,000,000 pounds.

The capacity of the Western works.—During the past year the capacity of the works of the West has grown very rapidly, both by the building of new plants and by the enlargement and alteration of old establishments. The following table gives an approximate estimate:

Annual capacity of the Western zinc works.

ILLINOIS.

	Tons of zinc per annum.	
Excelsior Concentrating and Smelting Works, Collinsville (3 Belgian furnaces)	800	
Illinois Zinc Company, Peru (3 gas, 10 Belgian furnaces)	7,200	
Mathiessen & Hegeler Zinc Company, La Salle (4 double gas furnaces)	12,500	
		20,500

MISSOURI.

	Tons of zinc per annum.	
†Missouri Zinc Company, Carondelet (14 Belgian furnaces)	4,000	
Glendale Zinc Company, Carondelet (8 Belgian furnaces)	3,000	
†Carondelet Zinc Company, Carondelet (4 Belgian furnaces)	1,000	
*Southwestern Lead and Zinc Company, Rich Hill (1 Belgian furnace, 1 Siemens furnace)	2,250	
*West Joplin Lead and Zinc Company, Joplin (6 Belgian furnaces)	2,250	
		12,500

KANSAS.

J. H. C. Gross, Weir City (8 Belgian furnaces)	3,500	
R. Lanyon & Co., Pittsburgh (8 Belgian furnaces)	3,500	
S. H. Lanyon & Bro., Pittsburgh (4 Belgian furnaces)	1,500	
*M. & J. Lanyon, Pittsburgh (2 Belgian furnaces)	750	
*Granby Manufacturing and Smelting Company, Pittsburgh (1 Siemens furnace)	1,250	
		10,500

ARKANSAS.

†American Zinc Company, White River (4 Belgian furnaces)		1,000
Total capacity		44,500

This represents the capacity of all the works built. Some of them, those marked with a †, have not been running for some time; others are and have been running only at one-half or three-quarter capacity at times, and those to which an asterisk is affixed have either been only recently completed or are still in course of construction. The works capable of working under fairly favorable conditions of trade have a capacity of fully 40,000 tons and can therefore meet the demand.

According to an estimate made by good authority the product in 1881 of the Western works then running was about 24,000 tons, distributed as follows:

Output of the Western zinc works in 1881.

	Net tons.
Illinois	16,250
Kansas	5,000
Missouri	2,750
Total	24,000

For the year ending August 31, 1882, a committee of producers estimated the output at 26,425 tons.

Direct returns and estimates place the make of 1882 as follows:

Production of zinc in the United States in 1882, *by States.*

	Net tons.
Illinois	18,201
Kansas	7,366
Missouri	2,500
Eastern States	5,698
Total	33,765

A considerable proportion of this metal is sold as sheet zinc, the quantity having largely increased in 1882. One works, that of the Mineral Point Zinc Company, Wisconsin, makes only oxide.

A question which is seriously threatening the prosperity of the Western makers of spelter and makes it nearly impossible for all of them to work to full capacity, is the inadequacy of the supply of ore. Southwestern Missouri and southeastern Kansas, the principal source, are capable of furnishing approximately 60,000 tons per annum. It is estimated that the requirements of the furnaces, if running fairly up to capacity, are about 100,000 tons annually. The result is a sharp competition for ores, which forces the less favorably located works into idleness, and runs the cost of production to figures making imports possible.

During the past year a subsidiary industry, that of manufacturing sulphuric acid from the sulphurous acid generated in roasting blende, has been started by one large producer. As yet this branch is in its infancy and does not seem capable for the present of a very great expansion or a general introduction in view of the limited local market for the acid. There is reason to believe, however, that in time it may afford an important relief in reducing the cost of manufacture. For the present it has the advantage of reducing the nuisance of noxious fumes, against which in time public opinion might declare itself.

In addition to the supply from domestic sources, varying quantities of metal and of manufactures have been imported, chiefly from Germany and Belgium. During the period from 1873 to 1880, when the home industry trebled its output, this movement lost much of its force; while, on the other hand, since 1877 considerable quantities of high-grade spelter were exported. This continued until a heavy demand, outstripping home consumption, again brought our markets into a position favorable for imports. Meanwhile home manufacturers had begun also to make sheet zinc on a more extended scale, and had succeeded in crowding back foreign competitors. The speculative excitement of the "boom" period again opened the gates, and this country was made the outlet for a heavy quantity of metal. A temporary reaction stopped the influx, but in 1882 the imports assumed dimensions not reached for more than a decade, and led to an overstocking of the market which weighed heavily upon it, carrying prices lower than those of lead, an unprecedented position for spelter. The great expansion of the demand, which made so sudden an increase in the supply possible without causing more disastrous consequences than it in reality led to, must be chiefly attributed to the great increase in the amounts called for by galvanizers. The expansion of the wire industry, notably the barb-wire for fencing purposes, created a demand which our works could not meet so suddenly. As illustrating the quantity of metal used for protecting barb wire alone, it may be mentioned that one manufactory alone consumes upward of 3,000 tons of spelter per annum for that purpose. The fact that some of the heaviest iron manufacturers using spelter for galvanizing are near the seaboard, thus handicapping Western producers to the extent of the freight, did much toward making the invasion of foreign spelter more easily possible. During the calendar year 1882, 12,826 net tons of spelter were imported; but, since, the movement has nearly ceased, and home producers again have full control of the market. It is alleged, though there are no facts to prove the statement, that in times of depression abroad foreign makers continue to divert a surplus to other markets, this country being among the favorites. It is certainly strange that when continental producers form "syndicates" to uphold prices they do not order any restriction to put the market in a position, so far as the supply is concerned, to enforce their higher demands. Experience in this country has amply proved that without such a restriction combinations among producers are doomed to be failures.

IMPORTS AND EXPORTS.

The following tables show fully the imports and exports of spelter, sheet zinc, ores, and oxide. The small quantity of ore shipped abroad comes exclusively from the New Jersey mines, being used at a Belgian works to manufacture zinc white by the Wetherill process.

Zinc, spelter, or tutenegue, imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

Years.	Blocks or pigs.		Sheets.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
1872	12,683,411	$565,739	14,280,107	$820,879
1873	6,336,736	329,022	9,453,072	621,776
1874	2,254,802	125,630	4,431,733	322,214
1875	2,087,571	109,912	7,238,894	445,766
1876	505,798	27,354	4,731,722	301,026
1877	1,273,301	64,956	1,256,387	77,713
1878	1,310,859	59,001	1,247,357	69,582
1879	1,390,637	52,182	1,177,080	56,312
1880	8,514,826	393,334	5,101,902	260,056
1881	1,813,615	73,421	2,356,619	107,267
1882	18,427,309	739,319	4,264,456	198,687
Calendar year 1882.	25,651,567	1,024,324	4,668,561	215,793

Zinc ore, oxide, plates, sheets, pigs, or bars exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Of foreign production.				Of domestic production.			
	Blocks or pigs.		Sheets.		Ore or oxide.		Plates, sheets, pigs, or bars.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Cwts.*		*Pounds.*	
1872	....	....	20,514	$1,068	3,686	$20,880	62,919	$5,726
1873	....	....	201,612	14,834	234	2,304	73,953	4,656
1874	1,100	$75	58,815	4,098	2,550	20,037	43,566	3,612
1875	....	....	31,879	2,326	3,083	20,659	38,090	4,245
1876	....	....	31,018	1,958	10,178	66,259	134,542	11,651
1877	....	....	12,477	849	6,428	34,468	1,419,922	115,123
1878	2,753	195	....	....	16,050	83,831	2,545,320	216,580
1879	....	....	7,038	416	10,660	40,399	2,132,949	170,654
1880	....	....	48,350	2,566	13,024	42,036	1,368,302	119,264
1881	....	....	58,955	3,287	11,390	16,405	1,491,786	132,805
1882	....	....	18,829	876	10,904	13,736	1,489,552	124,638
Calendar year 1882	....	....	11,335	583	3,817	14,477	1,159,949	98,008

REVIEW OF THE SPELTER MARKET.

There are inherent in the nature of the industry in this country many reasons which make a systematic and general review a task of much difficulty. The conditions affecting one zinc-producing section differ so widely from those of another that they appear almost as independent of one another as though different metals were the product. In the East the splendid deposits of New Jersey, Pennsylvania, and Virginia furnish an abundance of ore yielding a metal of exceptional purity, finding a market readily. In the West, in Illinois, Missouri, Kansas, and Wisconsin, there is a constant struggle between the mine owners and the smelters, and the competition for the raw material frequently carries prices for it to a point where profits are impossible. The markets for the lower grades of metal there made are subject to fluctuations, to sudden expansion and contraction, and are constantly threatened by foreign competitors.

The Southern States possess very important deposits of zinc ores, but until now the production of the metal there has been limited, though considerable quantities of ore have been shipped to the North, notably to the Mercer Zinc Company, at Trenton, New Jersey, where it is used for the manufacture of oxide. There are now under construction two zinc works near Knoxville, Tennessee, the East Tennessee Valley Zinc Company, and the Edes, Mixter & Herald Zinc Company. There is a movement on foot also to build another works in Virginia.

With improved railroad facilities for the carriage of ore and refractory material, with cheaper coal and very large supplies of ore at some points, there is a good prospect for a rapidly growing industry, especially as the quality of the spelter made is very high.

The bulk of the spelter made in the Eastern States finds its market directly through the dealings of the producers with the consumers, who are willing for their special purposes to pay a very much higher price for the pure metal. We shall therefore in the following brief summary refer almost exclusively to the fluctuations in the demand for the ordinary western domestic spelter and its chief competitor, the Silesian and Belgian spelter, which has at times sold in large quantities and almost always places a limit to a rise in values beyond a given point. A considerable quantity of these grades does not reach the open market, so that the records of current transactions are often meager.

1875.—Higher prices in Europe allowed home producers to carry the market to a better figure, though the general apathy in business and the feeling among consumers that prices were unduly high, made the market exceedingly quiet during the year. In the spring an association was formed among producers with a view to maintaining and controlling values. This association of Western makers began by fixing the price at 7 cents, and raised it in May to 7¼ cents currency; but finding the metal moving off sluggishly, went down to 7.15 cents in June, returning, however, to 7.35 cents in July. It became apparent that some producers could not resist the temptation to force sales by concessions, and the combination rate was reduced to 7¼ cents in August. Even then there seemed to be little difficulty in getting supplies at lower figures. Still the price of 7¼ cents was reaffirmed in spite of the sluggishness of the market, and for November was raised even to 7.40 cents. All efforts to keep "outside lots" from drifting into the market proved ineffective, and values continued unsettled till the close of the year. The "combination" rates are in parentheses.

Price of spelter in 1875.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	6.75	6.37
February	6.67	6.25
March	6.50	6.20
April	(7.00)	6.50
May	(7.25)	7.15
June	(7.25)	7.15
July	(7.35)	7.25
August	(7.25)	7.10
September	(7.25)	7.10
October	(7.40)	7.15
November	(7.40)	7.15
December	(7.40)	7.15

1876.—The year opened with a firmer market, and the association succeeded by forcing up the nominal rate successively to 7.60 and 7.75 cents in carrying the market higher, underselling going on steadily. In March, consumers in anticipation of a further advance bought more freely, but no steps in that direction were taken until the beginning of April, when 8 cents was announced as the official price. Meanwhile stock was accumulating at the seaboard, and considerable eagerness being displayed by second hands to realize, made the breach between the nominal and actual prices greater and greater. The "combination" gradually went to pieces. In June its announcements had lost all practical interest, and with this artificial support withdrawn from it the metal gradually sank during the rest of the year by its own weight, the production being heavily in excess of the requirements.

During the year the transactions were based upon the following quotations:

Price of spelter in 1876.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	(7.60)	7.40
February	(7.75)	7.50
March	(7.75)	7.62
April	(8.00)	7.60
May	(8.00)	7.75
June	(8.00)	7.25
July	7.25	7.12
August	7.25	7.00
September	7.12	6.80
October	6.75	6.62
November	6.62	6.37
December	6.50	6.37

1877.—Continued dullness and a partial decline in prices led to a curtailment of the production, and in February to the first export sale of 200 tons of high-grade spelter at 8¾ cents currency. Consumers, however, maintained an unshaken attitude of reserve, unaffected by speculative attempts to rally the market, which drooped steadily, being only temporarily relieved. The foreign metal was entirely forced out of the market in spite of the fact that values abroad were low.

During the year values moved within the following monthly range:

Price of spelter in 1877.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	6.50	6.25
February	6.62	6.50
March	6.50	6.37
April	6.37	6.25
May	6.25	6.00
June	6.12	5.87
July	5.87	5.62
August	5.90	5.80
September	5.87	5.75
October	5.90	5.70
November	5.87	5 62
December	5.75	5.50

1878.—A heavy production and a light demand, together with low offerings of foreign metal, pressed upon the market, and a convention of producers at Saint Louis, held in March, was unable to apply any remedy for existing evils. Towards the middle of the year there was a better feeling, due principally to an upward movement abroad; but towards the end of the year continued dullness carried the price down to a very low point, heavy exports of high-grade metal being meantime made to Europe.

The range of prices of spelter was as follows during the year:

Price of spelter in 1878.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	5.75	5.50
February	5.62	5.25
March	5.62	5.25
April	5.25	5.00
May	5.00	4.62
June	4.62	4.25
July	4.75	4.50
August	4.87	4.50
September	4.87	4.75
October	4.62	4.50
November	4.75	4.50
December	4.37	4.25

1879.—As in all other branches of the metal trade, the year 1879 opened with a very discouraging outlook in spelter. Prices continued to droop in spite of an effort made early in February to revive the old association of producers. The same evils which wrecked the earlier attempt were at once manifested, and the metal was soon allowed to drift its own way untrammeled, until in July a better feeling began to develop. In August a decided upward tendency carried up the market here and in Europe, where an agreement was arranged among the Belgian and the Rhenish and other German producers. In September and the succeeding months spelter was caught by the speculative tide which bore up all metals so very rapidly, and values were quickly advanced to figures which again rendered imports possible. The closing months of the year were exciting in all branches of the iron, steel, and other metal trades, and lifted spelter out of the mire into which it was sinking.

The price of spelter varied monthly as follows:

Price of spelter in 1879.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	4.50	4.25
February	4.62	4.40
March	4.62	4.37
April	4.75	4.25
May	4.50	4.25
June	4.37	4.12
July	4.75	4.37
August	5.62	4.89
September	6.00	5.62
October	6.37	6.00
November	6.25	5.87
December	6.25	6.00

1880.—The market temporarily recovered from the slight reaction of the first weeks of the year and held its own well for months, until an increasing pressure of foreign metal caused prices to weaken in May and June, and for the balance of the year there were alternating periods of dullness and slight reactions, the net result being a further decline.

Values moved within the following range:

Price of spelter in 1880.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	6.50	5.87
February	6.75	6.37
March	6.75	6.50
April	6.50	6.12
May	6.00	5.62
June	5.50	5.12
July	5.00	4.87
August	5.25	4.87
September	5.12	4.75
October	5.00	4.87
November	4.90	4.65
December	4.75	4.65

1881.—The year opened quietly. A slight improvement which developed towards the middle of January was lost, and a period of dullness followed, with a steady declining tendency which caused the suspension of work in some of the Carondelet establishments. In June this had grown to utter stagnation, but towards the end of July a better demand sprang up, and inquiries increasing in volume and growing in urgency caused greater firmness and warranted a gradual rise in prices, which only the beginning of sales of foreign spelter checked. Spot stocks had been almost exhausted and importations began to assume unheard-of dimensions.

The fluctuations in the prices during the year were as follows:

Price of spelter in 1881.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	$5\frac{1}{4}$	$4\frac{7}{8}$
February	$5\frac{1}{4}$	$5\frac{1}{8}$
March	5	$4\frac{7}{8}$
April	$5\frac{1}{8}$	$4\frac{3}{4}$
May	5	$4\frac{7}{8}$
June	5	$4\frac{3}{4}$
July	5	$4\frac{3}{4}$
August	$5\frac{1}{8}$	5
September	$5\frac{1}{4}$	5
October	$5\frac{5}{8}$	$5\frac{1}{4}$
November	$5\frac{7}{8}$	$5\frac{1}{2}$
December	6	$5\frac{7}{8}$

1882.—The scarcity of spelter continued during the first weeks of January, and consumers bought quite heavily for delivery over the first three months of the year, the metal placed being almost exclusively

European. The heavy offerings of Silesian and Belgian spelters, many of the brands being unknown in our markets and of inferior grades, made concessions necessary, especially as the majority of consumers were well supplied. The market was dull, therefore, during February and March and showed a weakening tendency. In March there were repeatedly cases of heavy cutting, and towards the beginning of April western domestic metal, which had until then been entirely absorbed by the local trade, began to appear in the eastern markets. Simultaneously came the news of the forming of a "syndicate" among European producers, which had the effect of making consumers here cautious. In May and June, under large sales of Silesian spelter at lower figures and very heavy offerings of foreign metal, the market began to decline. Stocks of foreign spelter were known to be very heavy, while on the other hand the demand on the part of galvanizers was dropping off. The market in July was heavy and dull, and the pressure to sell led to a demoralized condition of affairs, the struggle of western makers to regain a foothold complicating matters. Still the demand continued good, and low prices induced consumers to make heavy contracts in August. This struggle dragged along in September and November, buyers beginning to be frightened and holding off persistently. It was not until December, however, that the domestic metal had succeeded in crowding back foreign spelter, values having meanwhile fallen very considerably. During the closing months of the year the output in the West had grown materially by the completion of a number of new works.

Values fluctuated within the following range during the year:

Price of spelter in 1882.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	6	$5\frac{3}{4}$
February	$5\frac{3}{4}$	$5\frac{5}{8}$
March	$5\frac{5}{8}$	$5\frac{3}{8}$
April	$5\frac{1}{8}$	$5\frac{1}{4}$
May	$5\frac{5}{8}$	$5\frac{1}{4}$
June	$5\frac{3}{8}$	$5\frac{1}{4}$
July	$5\frac{3}{8}$	$5\frac{1}{8}$
August	$5\frac{1}{2}$	$5\frac{1}{8}$
September	$5\frac{3}{8}$	$5\frac{1}{8}$
October	$5\frac{3}{8}$	$5\frac{1}{8}$
November	$5\frac{1}{8}$	$4\frac{7}{8}$
December	$4\frac{7}{8}$	$4\frac{1}{2}$

1883.—The leading feature of the markets during the first half of the present year has been the heavy falling off in the demand, which caused an early cessation of the importations of foreign spelter, and again gave complete control of the market to home producers. The trade showed a slight recovery during the spring, but has since relapsed into great lullness. The output is more than ample for the requirements of a restricted market.

Quotations were as follows:

Price of spelter in the first six months of 1883.

Months.	Highest.	Lowest.
	Cts. per lb.	*Cts. per lb.*
January	$4\frac{5}{8}$	$4\frac{1}{2}$
February	$4\frac{5}{8}$	$4\frac{1}{2}$
March	$4\frac{3}{4}$	$4\frac{5}{8}$
April	$4\frac{3}{4}$	$4\frac{1}{2}$
May	$4\frac{3}{4}$	$4\frac{1}{2}$
June	$4\frac{5}{8}$	$4\frac{3}{8}$

THE PRINCIPAL FOREIGN PRODUCERS.

Our home producers are so frequently and so seriously affected by the movements of their foreign competitors that a brief review of recent development in the few great zinc manufacturing centers of Europe will aid in gauging their strength.

Germany.—The greatest producer of spelter and the most vigorous competitor of our western manufacturers, notably in the markets of the seaboard as far inland as Pittsburgh, is Germany. The two great producing districts are Silesia and the Rhenish provinces and Westphalia, the product being divided as follows:

Production of spelter in Germany.

Years.	Silesia.	Rhenish Provinces.	Total.
	Metric tons.	*Metric tons.*	*Metric tons.*
1876	49, 377	33, 664	83, 041
1877	57, 423	37, 320	94, 743
1878	59, 619	35, 518	95, 137
1879	63, 476	33, 008	96, 484
1880	65, 443	33, 968	99, 405
1881	67, 547	37, 798	105, 345
1882	69, 448	45, 354	114, 802

Silesia occupies its commanding position, in spite of the low grade of its ores and the remoteness from the seaboard, because its raw materials, coal and ore, are cheap, and because mines and smelting works are in the hands of the same owners. Until recently, too, the lead ores associated with the calamine paid for a part of the cost of mining (in 1879 over 14,000 tons of lead ore were raised from zinc mines), but since the ores have turned more to blende in greater depth, the lead is more difficult to separate, and, moreover, is poorer in silver. In 1879, 1880, and 1881 the average grade of the ore was only 12.7, 12.3, and 13.15 per cent., respectively; but the consumption of fuel, which was 2.7 pounds of coal per pound of ore in 1860, has been brought down to 1.53 pounds in 1880, and 1.37 pounds in 1881, chiefly by the introduction of gas-firing and Siemens furnaces, the fuel being, besides, largely cheap slack, instead of more expensive special sizes. Spirek gives the following figures of the cost of production in four Silesian works in 1880, which well illustrates how great in proportion to the other expenditures is the cost of the ore. It may be stated that the selling price has since declined to about 300 marks at Breslau.

Cost of producing spelter in the Silesian works.

	1.	2.	3.	4.	Average.
	Marks.	*Marks.*	*Marks.*	*Marks.*	*Marks.*
Cost of ore at works	203.8	209.0	200.0	195.0	202.0
Cost of fuel	82.0	60.4	40.0	38.0	52.6
Other expenses	80.0	67.7	67.8	65.0	70.1
Total cost	365.8	337.1	307.8	298.0	324.7
Selling price	338.0	338.0	338.0	338.0	338.0
Loss	27.8	....	....	....	....
Profit	....	0.9	30.2	40.0	13.3

The Rhenish Provinces and Westphalia treat chiefly blende from home mines and calamine obtained from Spain, Sardinia, and Greece, a source of supply which, however, threatens to diminish rather than increase. The following data from the official returns of the Prussian Department of Mines well illustrates the source of supplies and the character of the ores:

Zinc ores mined in Prussia.

	1879.	1880.	1881.
Silesia:	*Tons.*	*Tons.*	*Tons.*
Calamine	435,423	457,000 }	501,517
Blende	65,340	118,386 }	
Rhenish Provinces, etc.:			
Calamine (German)	9,091 }	73,792	73,714
Blende (German)	79,401 }		
Imported	....	16,595	17,134

It should be noted that the imported ores are usually very rich, so that they take a higher rank as source of metal than the tonnage figures would indicate.

Belgium.—Belgium has always been one of the greatest zinc mining and smelting countries of the world, the Liége district, with the works of the Vieille Montagne Company, being the scene of the greatest activity. The mines of the country have been incapable of supplying the growing quantities of ore required, and Sweden, Norway, Spain, Sardinia, and Greece have been laid under contribution.

According to a report on the Liége district for the year 1881, the great center of the zinc industry of Belgium, eleven works treated 19,200 tons of Belgian ores and 145,000 tons of foreign ores, of which 40,000 tons came from Greece, 39,080 tons from Italy, 35,000 tons from Spain, 13,000 tons from Sweden, 13,000 tons from Germany, and 3,800 tons from France, the product reaching 69,800 tons of spelter, with a consumption of 375,000 tons of coal.

Great Britain.—Though the quantity of spelter produced in England has largely increased, that country has become more and more dependent upon producers in other countries for its supplies of crude and manufactured zinc, as the following tables show:

Production of zinc in Great Britain.

	Gross tons.
1860	4,357
1870	3,936
1875	6,713
1881	14,947

Imports of zinc into Great Britain.

Years.	Crude zinc.	Zinc manufactures.
	Tons.	Tons.
1860	24,416	
1865	32,191	
1870	31,103	
1875	37,870	
1876	29,466	14,719
1877	35,094	16,102
1878	32,750	16.207
1879	34,180	15,474
1880	33,409	16,648
1881	46,198	19,302

Other foreign countries.—The exports of calamine from Greece, according to the latest statistics, were 40,278 tons in 1881, of which 28,045 net tons went to Belgium.

Spain has of late years become a producer of spelter, having made 4,221 tons in 1880, and 7,032 tons in 1881. The bulk of its shipments is, however, ore, the exports having been 36,115 tons in 1880, 30,604 tons in 1881, and 25,832 tons in 1882.

For the period of 1875 to 1879 the production and exports of zinc ores from Italy were 65,000 tons.

The quantities supplied to English, German, Belgian, and French consumers from outside sources are then approximately 130,000 tons.

THE MINING AND METALLURGY OF ZINC IN THE UNITED STATES.

By F. L. Clerc.

The present status of zinc mining and metallurgy.—Even the most superficial inquiry into the condition of the zinc industries of the United States cannot fail to expose the barrenness of the literature pertaining to the subject and the entire absence of reliable statistics by which any comparison may be made with the state of these industries in other countries. A compilation of nominal market quotations shows litt'e more than sudden fluctuations in the price of the various zinc products, which neither the custom-house returns nor the ruling price of foreign products will satisfactorily explain. A more careful examination into the methods of manufacture at the different works, and inquiry into the general results obtained, are apt to leave the impression that the whole subject is enveloped in mystery, belonging more properly to a secret art in the Middle Ages than to a growing industry of the present century. Every year or two some European expert makes a rapid tour through the country, and announces that our ores are "equal to the best in Europe, but that our methods of mining and preparing them are extremely wasteful, and our methods of smelting are crude and extravagant, and fully a generation behind European practice in technical value and economy." It cannot be denied that there is much justice in these criticisms; nor is a comparison any more favorable to this country, if we regard only the magnitude of our output or the cheapness of our products.

This inferiority cannot be excused on the ground that the art of mining or that of zinc smelting are still in their infancy in this country, but it can be explained in part, first, by certain general limitations to improvement imposed by the nature of the operations necessarily involved in the smelting of zinc, and second, by the peculiar condition of our ore supply. In its essential features the metallurgy of zinc is the same all over the world. The metal must be distilled in fire-clay vessels, in the presence of carbon, and condensed out of the reach of oxidizing agents. The dimensions of the distilling vessels are restricted within very narrow limits, by the nature of refractory materials and the thickness of the charge through which the necessary heat to effect reduction can be economically transmitted, and but little improvement is to be hoped for by a change in these dimensions. The operations to which the ore and products must be submitted are numerous, and the repeated handling of them cannot be avoided. The recent improvements in European practice have not been the results of changes in the form of the furnaces, or in the methods of treating the ore, but have resulted from careful economies in the use of labor, fuel, and ore, and have only kept pace with the concentration of mining and smelting industries into the hands of strong companies, and are in general such as can only be introduced by companies with abundant capital, and where operations of a certain magnitude are carried on. Moreover, the policy of these companies has been, by regulating the output of the mines and the disposition of the metal, to give a steadiness to the value of both the metal and the ores, which has rendered comparatively safe such investments of capital as would otherwise have been precarious.

Such a condition of affairs can only be gradually brought about in this country, owing largely to the circumstances under which existing works were established, and to the peculiarities of the ore supply. The conditions under which smelting is carried on at the different works in this country are so various that only a general description of them is practicable; and the question of ore supply is so important that it merits more than a passing notice. The greater part of the ore used in this country is obtained as a more or less valuable by-product in the mining of lead ore; and its selling price is not controlled, either by the value of the metal it contains, or by the cost of its discovery and mining. Hence its value is subject to sudden changes, and the investment of capital in zinc mining is rendered more or less unsafe. This fact has exerted a controlling influence on the methods of mining and selling the ore, on the districts most extensively worked, on the location of the principal smelting works, and on their policy towards the ore producers, and its effects will probably long continue to be felt on the zinc industries of the country. Its full importance may perhaps be obscured by the fact that lead and zinc ores are almost universally found associated together; but where the selling price of both ores is controlled by the value of the metal they contain, each bears its proper proportion of the cost of mining, and neither unduly depreciates the value of the other. The inland location of existing mines and works in this country, as compared with the mines and works of Europe, makes them more dependent on railroad transportation and less easily adaptable to changes in the mining and smelting centers. The metallurgy of lead is so simple that when rich deposits of lead and zinc ore are discovered the lead ores are quickly made available by furnaces erected to treat them, and are mined extensively; while large amounts of zinc ore are often neglected or thrown aside as worthless. The metallurgy of zinc is so complicated and expensive that it is slow to adapt itself to new localities, and the works within reach of the new ore fields have a practical monopoly of these markets.

Sources of supply.—The present sources of ore supply may be grouped under three divisions: the Eastern, including New Jersey, Pennsylvania, and Virginia; the Middle, including Wisconsin, Illinois, and Tennessee; and the Western, including Missouri and Kansas. These divisions correspond very nearly with distinct types of furnaces and different systems of mining; and may conveniently be treated of separately.

EASTERN DIVISION.

New Jersey.—In the Eastern division, the most notable deposit of zinc ore is in Sussex county, New Jersey, where, near the town of Franklin, there is found an absolutely unique deposit of the three rare minerals zincite (red oxide of zinc), willemite (anhydrous silicate of zinc), and franklinite, forming a rock-like mass not unlike in appearance an eruption of granite, in which the franklinite represents the quartz, the willemite the feldspar, and the zincite the mica. This mass fills the space between limestone walls, and is crossed by numerous "trap" dikes, ranging from a fraction of an inch in thickness up to 20 feet; and is interspersed with occasional bunches of calcite, fowlerite, and other crystalline minerals. The principal mine is on Mine hill. The ore is reached by a tunnel about 75 feet below the outcrop, and has a width of from 40 to 50 feet. It appears to be a chimney-like deposit, of the form so common in magnetite mines; no limit to it has yet been found in depth or in horizontal extension. This deposit, which has been the subject of numerous long and expensive litigations, is now controlled and worked by the New Jersey Zinc and Iron Company, with a capital of $3,000,000, which in 1880 consolidated rival claims. The ore is easily mined and requires little selection. The cost of mining and putting it on cars should not exceed the cost of quarrying an equal amount of limestone.

An average sample would contain about 36 per cent. oxide of zinc, 22 per cent. metallic iron, and 11 per cent. metallic manganese. Owing to its low percentage of zinc and high percentage of iron and manganese, this ore is unsuitable for the manufacture of spelter. The mechanical separation of the zinc ores has been found impracticable on account of the intimate chemical and mechanical mixture of the different ingredients. The ore is, however, particularly adapted for the manufacture of oxide of zinc, or "zinc white," for which purpose it is exclusively used. The works of this company are at Newark, New Jersey, at which point they have excellent facilities for obtaining a cheap supply of pea and slack anthracite coal, and direct communication with the mine by canal and railroad.

A smaller vein on Mine hill, called the "front vein," has been proved for several hundred yards; it varies from 8 to 20 feet in width, and is occasionally pinched out by the wall rocks; it carries a less proportion of zincite and a greater proportion of calcite than the large vein, but its ores are of a similar character. Part of this vein is owned by the above-named company, and part is at present furnishing ore to the Lehigh Zinc Works, at Bethlehem, Pennsylvania.

Similar veins are found at Sterling Hill, about 2½ miles distant, and have been worked to a depth of about 200 feet by the New Jersey Zinc Company, now incorporated with the New Jersey Zinc and Iron Company, and by the Passaic Zinc Company. On the property of the latter company they are accompanied by irregular beds of beautifully crystallized calamine, from which, as it is almost entirely free from lead, a high grade of spelter is made at the works of the company at Jersey City. Mining at this point has been almost entirely suspended during the last few years, as the Passaic Company has had a contract for ore from the large vein on Mine hill.

The shipments of zinc ore from this county for the year 1882 are reported by the State geologist to have been 40,138 tons; and the total output up to the present time can safely be stated at upwards of 250,000 gross tons.

Pennsylvania.—The zinc deposits in the Saucon valley, Lehigh county, Pennsylvania, which were once extensively worked, now produce but little ore. Their history, however, has a special interest from their connection with the introduction of spelter-making into this country, and from the fact that they belong to a class of deposits which seems to warrant a belief in their continuance to a considerable depth, and because they are a good illustration of the general effect of the characteristic feature of the ore market, above referred to. Three principal deposits have been discovered, known respectively as the Ueberoth, Hartman, and Saucon mines; they occur in magnesian limestone of the Lower Silurian formation, and have many points in common, while they also present some striking differences. They were all at one time owned or controlled by the Lehigh Zinc Company, whose works were at Bethlehem, four miles distant. The Ueberoth mine, which is, so far as developments have shown, the largest, was worked continuously from 1853 up to the fall of 1876. It was for many years the main dependence of these works, and produced in the neighborhood of 300,000 tons of ore. The strata of limestone are here very much disturbed and tilted up almost to the vertical, apparently by the obtrusion of the syenite ridge of the neighboring South mountain. The ore came close to the surface, and a very rich pocket was found in the clay above and around limestone bowlders, which is estimated to have produced 100,000 tons of ore. When this body of ore was exhausted, the ore was followed down in crevices between the bowlders. These crevices lie in planes parallel to the bedding of the limestone, or in planes perpendicular to it, and preserve great regularity in their position, and a parallel course for several hundred yards in a northeast and southwest direction; they are nearly vertical, and at the depth of 225 feet, to which the mine was worked, showed no signs of closing up. The ores at first were exclusively calamine and smithsonite, but at greater depth blende made its appearance, coating the walls of the crevices, and in some cases penetrating into them several feet; in other cases segregated as rich seams, which nearly filled the cross openings. At first it was confined to the northeastern end of the mine, but at the lowest depth reached it could be traced almost continuously to the extreme southwestern end. The dip of the ore body appeared to be regular, and to the southwest. Six of these parallel crevices were worked, and about as many crossings; and where they intersected rich bunches of ore were found, some of which were as much as 60 feet across and 20 feet thick. All the indications seemed to point with increasing certainty to the existence of a backbone or underlying deposit of blende, out of the reach of the action of meteoric waters, from the continuation of which the oxidized ores have been derived. Timbering the mine was always a serious difficulty, but the greatest obstacle to be overcome was the water. Even at a depth of 46 feet the flow was already very strong; at the depth of 150 feet it was found necessary to put in what was then the largest pumping engine in the world. This engine, which is a single cylinder, double acting, condensing, walking beam engine, with a pair of flywheels, has a 110 inch cylinder and a 10-foot stroke, and is calculated to work four 30-inch plunger pumps and four 30-inch lift pumps, with 10-foot stroke, and to take water from a depth of 300 feet. At the time it was stopped it was running from six to seven strokes a minute, and was working three pairs of 30-inch pumps and one pair of 22-inch pumps, and was easily handling all the water that came to them. The pump shaft and foundation for the engine were no less remarkable in their way. The latter was built up from the solid rock, 60 feet below the surface of the ground, of hewn blocks of Potsdam sandstone; the former, which measured 30 feet by 20 feet in the clear, was started on a small crevice, and timbered with 12-inch square yellow pine sticks, and divided into three compartments, and further strengthened by two open brattices of the same heavy timber. When the pitch of the vein carried it out of the shaft the rest of the depth was sunk through solid rock.

The Hartman mine, distant about half a mile, was worked at first exclusively for calamine. Its exploitation gradually exposed a central "horse" of blende, which the method of mining adopted made it necessary to leave for the support of the timbers which carried the roof. The increasing importance of this blende at the lowest level worked, 150 feet, caused a change to be made in the methods of mining. The mine was operated for a year after the large engine was stopped, and the last work that was done was the putting in of a slope to develop this deposit of blende. The water in the Hartman was always less strong, the pitch of the crevices less steep, and the surrounding rock less disturbed than in the Ueberoth mine; the strike of the crevices was more to the west, and the blende came nearer to the surface.

The Saucon mine, however, affords the simplest and best illustration of this form of deposit. It is distant about a quarter of a mile, and was originally leased by the Passaic Zinc Company, by whom it was sublet to the Lehigh Zinc Company on high royalties. When the rich deposit of calamine first discovered was apparently exhausted, this sublease was surrendered by the latter company, and in 1875 the original lease passed to the Bergen Point Zinc Company, by whom the mine has been worked ever since. A face of blende was uncovered at the western extremity of the open pit, and the ore followed under a heavy cap of limestone for a distance of 250 feet up to the property of the Lehigh Zinc Company on the west. On this property it was reached at a depth of 110 feet, under 100 feet of solid limestone, and was followed 150 feet farther on the course of its strike. On both properties it was followed to a depth of nearly 200 feet. In the fall of 1879 all the property of the Lehigh Zinc Company passed into the hands of its bondholders under foreclosure of its mortgages, and in the spring of 1880 all the mining property was sold to the proprietors of the Bergen Point Zinc Works.

The workings of these two mines, taken together, show a remarkable regularity of width, pitch, and course, and the deposit is clearly shown to be a large chimney or chute of ore of irregular cross-section, which, however, preserves a lenticular shape, the longer axis of which is about 60 feet, and pitches to the south at an angle of about 30°; the transverse axis measures about 30 feet. The axis of the ore body dips to the west-southwest with a slope of about one foot in four. The weathered outcrop has evidently given rise to the pit of oxidized ores and to certain irregular detached deposits which lie in the same course several hundred yards beyond it.

Here, then, are three similar deposits of zinc ore, with their nearly parallel chimneys of blende and their corresponding beds of calamine, which have evidently been brought up from below, by solution in thermal springs, through crevices formed in the limestone by the gradual upheaval of the neighboring South mountain, and have undergone subsequent alteration from the action of meteoric waters. Nearest the mountain, where the strata are most tilted and the ground most disturbed, the water is strongest and the largest deposit of calamine is found. In the Hartman mine the strata are more nearly flat, the blende is sooner met with, and the water is much less strong; and in the Saucon mine the blende is met with at the edge of the pit, and only moderate sized pumps are required in working it at a depth of 200 feet. That the water in these mines comes from the same surface springs which supply the Saucon creek is evident from the fact that, when the big mine was abandoned, this creek shrank at once to a small fraction of its former volume, and only gradually recovered it as the mine filled up. Very careful surveys of the bed of this stream failed to discover any point at which it showed any diminution of its volume or seemed to sink into the ground. It is therefore very improbable that the water, having once come to the surface, found its way back into the mine. It was probably tapped in underground courses connected with the springs which give rise to the creek. This is the more probable, as the mine which has the most water is on the highest ground and is farthest from the creek, and the mine having the least water is nearest the creek. It is therefore reasonable to suppose that nearly the maximum quantity of water likely to be encountered was already handled, and that if a solid body of underlying blende were developed it could be profitably worked with the machinery already in place. The Saucon mine is still the main dependence of the Bergen Point Zinc Works, but its continued working must be attended with increasing cost and uncertain risks.

The ores of this region are remarkably free from lead, arsenic, and antimony, and it is this circumstance that gives them their principal value and interest, and has been the basis of the very high reputation of the metal and oxide obtained from them. Only the richest of the ores are in the present state of the ore market available as spelter ores, but even the leanest of the oxidized ores produce a very fine quality of oxide. The blende is very peculiar. It is massive and rarely shows even traces of crystallization; when pure it has a bluish slate color, has a very characteristic conchoidal fracture, is translucent on thin edges, and gives a clear ring when struck. As generally sent to the works, it resembles broken limestone; is somewhat mixed with iron pyrites, and assays from 35 to 40 per cent. of zinc. It is not easy to concentrate, both on account of its non crystalline structure and of the pyrite it contains.

The causes which led to the extinction of the Lehigh Zinc Company and the abandonment of the two first-named mines were briefly these: the impossibility of competing successfully in the oxide market with the owners of the big mine in Sussex county, New Jersey, after the expiration of the patents covering the oxide process left them free to take the trade, or in the sheet zinc and metal market with the western smelters using cheaper and richer ores, at a time when a general depression of all manufacturing enterprises made it unusually burdensome to carry the heavy bonded indebtedness incurred during a period of high prices and general inflation in acquiring mines and putting up machinery to work them. Under more favorable circumstances it is probable that these mines could have been profitably worked for years to come; for although the pumping expenses were heavy, they were not excessive, considered as a royalty on the ore, and these charges per ton would diminish in proportion to the amount of ore mined. Now, however, it will probably be left for another generation to discover what value they still have.

Other deposits of zinc ore have been discovered in the same Silurian formation in Pennsylvania, Maryland, and Virginia, which have been worked from time to time, but have produced very inconsiderable amounts of ore. Small oxide works were built at an early day near Birmingham, Blair county, and at Landis Station, in Lancaster county, Pennsylvania, but they were soon abandoned. At the latter point shallow beds of rich carbonate of zinc were first discovered, but were worked out. About 1876, expensive concentrating works and two blocks of spelter furnaces were put up to treat the grains and kernels of crystallized blende scattered through the underlying limestone, before sufficient exploration was made to warrant such an outlay of money; they have for years been lying idle.

Virginia.—In Wythe county, along New River valley, zinc ore is scattered over the surface of the ground, and in connection with lead ores several thousand tons have been mined and sold to various eastern smelters to be made into oxide. One deposit is at present worked by the Bertha Zinc Company, which has erected concentrating works and furnaces at Martin's Station, and finds a market for the limited amount of spelter which it produces, at prices above the market for western spelter because of its freedom from lead.

MIDDLE DISTRICT.

Illinois and Wisconsin.—With the establishment of zinc works at La Salle, Illinois, began a revolution in the zinc trade, and eastern smelters were soon to be restricted to the limited market for special brands of spelter. The lead regions around Galena, Dubuque, and Mineral Point had long been known and extensively worked, and large quantities of zinc ore had been discovered in prospecting; thousands of tons had been mined and stowed away in abandoned drifts, or hoisted to the surface and thrown on to the dumps, or scattered around the wash places as worthless "jack"; for years ore was to be had for very little more than the cost of loading and hauling it to the smelters, and in these years were laid the foundations and established the business of those companies which dominate, if they do not control, the zinc industries of the United States. Gradually, as the ore already mined became exhausted and other companies, attracted by the large profits there seemed to be in the business of smelting, were induced to embark in it, and as the richest deposits of lead ore were worked out and the lower price of that metal caused a falling off in lead mining, zinc ore rose in price and began to be mined for its own sake, and the condition of affairs now existing was brought about. Southern Wisconsin and the Galena district are still important zinc-producing centers, but far larger amounts of ore are now drawn from the still richer lead regions farther west. The best authorities estimate the total output of the lead region of Wisconsin prior to 1876 at 115,000 gross tons, the largest amount shipped in any one year being 19,621 tons in 1872. The output in 1880 is estimated to have been about 15,000 tons. In comparing these figures with the output of eastern mines it should be borne in mind that they represent a considerably larger amount of metal than their amounts would indicate, as only the richer ores are sent to the smelting works, and the poorer are scattered around the mines. With a few exceptions (as in the case of the Illinois Zinc Company, which bought out and consolidated the different interests in an important mine in the Galena district, and by systematic working and better equipment has made it an important feeder to the works), all the mining is done by small companies, mostly unchartered associations of persons living in the immediate neighborhood. The royalties paid to the land owner vary from one-tenth to one-quarter of the ore raised. Some storekeeper, farmer, or local capitalist furnishes the small amount of money needed for tools; and the men who work in the ground in winter usually engage in farm work during the summer. The ore is generally raised to the surface by a windlass, and cleaned by hand with a "pickawee" hammer, or crushed with a "bucking iron" on a flat stone, or by an itinerant horse-power crusher, and is concentrated by sluicing and hand-jigging, and is then exposed for sale. The smelting companies which draw their ore supply from this district have their resident or traveling agents who examine the ore as it is raised, and either contract for the output of the "diggings," or buy the ore in the ricks. Most of the miners are poor and unable to work their diggings to good advantage, or to hold their ore long after it is cleaned. The output from any given locality is small, but the aggregate is very considerable. The ore raised in this region varies greatly in quality. What has been said above refers particularly to the shallower deposits, or the old abandoned lead workings where water is not troublesome. There are shallow deposits of "dry bone" (carbonate of zinc) which are extensively worked in this way, some portions of which are very rich; but these rich layers have ordinarily a thickness of only a few inches. Above and below them are heavier layers largely contaminated with limestone, too lean to be sold as spelter ores, which cannot be concentrated. The mining for the rich ores alone is seldom very profitable, and large amounts of the lean ores are still scattered through the mines above and below ground. If a reasonable market could be found for this, many mines could be worked which are now abandoned. In 1879-'80 three or four thousand tons were shipped by the Lehigh Zinc Company to Bethlehem and made into oxide. When proper care was taken to keep out any material that would discolor the oxide, a very fair quality of paint was made, and a yield of 30 to 33 per cent. was obtained. Within the year oxide works have been erected at Mineral Point to run on this material.

This district, which is called the Upper Mississippi lead region, has been known to contain lead since the beginning of this century, and lead mining has been extensively carried on for upwards of fifty years, and has in some cases proved very profitable. The lead occurs in the Trenton and Galena limestones of the Lower Silurian formation, which preserve their horizontal position. It is found in vertical and horizontal crevices, of which in Wisconsin alone more than 2,232 have been surveyed by Mr. James Wilson, jr.; of these 1,325 were east and west, and 482 north and south, the balance being irregular in strike. These crevices are associated under more than forty different groups, and most of them contain some zinc ore. The east and west openings are found to be most productive, and the lowest contain the greatest proportion of blende. Where the blende is associated with galena it is capable of being brought up to a high percentage at the mines, but where the two ores are intimately mixed and free from gangue, they are generally bought by the smelters as mined, and separated in the dressing works at the furnace. There is also a silicate of zinc, much mixed with galena, which is treated at the mines to a rough calcination with wood in piles, after which it is crushed and the galena is washed out. Anything like an accurate description of this region is out of the question. Diggings are opened, change owners, are shut down, cave in, are reopened, and abandoned; little record of the yield of particular ground is kept. The skilled miners who work here are of a roving disposition; each one who wanders away carries his secrets with him; all over the country may be seen abandoned workings of which no one knows anything beyond vague report.

Tennessee.—In Tennessee, near Knoxville and elsewhere, deposits of zinc ore have for many years been intermittently worked, and considerable amounts of ore have been calcined and shipped to eastern smelters (and it is now proposed to build works nearer the mines); but they may be passed over, for the reason that they have had very little effect on the metal output of the country, and for the same reason the more important deposits along the line of the Saint Louis and Iron Mountain railroad, which for many years were the principal source of supply of the Carondelet smelters, will only be alluded to.

WESTERN DIVISION.

The lead and zinc region of southwest Missouri.—The lead and zinc region of southwest Missouri is known to embrace the greater portion of Greene, Dade, Lawrence, Jasper, Newton, and McDonald counties, and to it adjoins the mineral region of the eastern part of Cherokee county, Kansas. Throughout the whole of this region both lead and zinc have been found; but the most productive district, and the only one at present worked, is confined to the northern half of Newton county, the southern half of Jasper county, and the eastern end of Cherokee county, Kansas, and to the area drained by the three streams, Center creek, Turkey creek, and Shoal creek, which flow west and north and empty into Spring river within six miles of each other. In this region the towns of Granby, on the south, and Joplin, on the north, are the centers of the principal mining activity. A very careful and intelligent account of this region, so far as it had then been developed, is to be found in the report of Dr. Adolf Schmidt and Mr. Alexander Leonhard, published in the Geological Report of the State of Missouri for the year 1873–'74, to which the reader is referred. Work on the survey was interrupted in 1876, and has not since been resumed, for which reason few reliable statistics have since been published. The importance of this region as a source of zinc ore dates from the year 1871. In this year the first regular shipments of ore were made from Granby to the zinc furnaces at Carondelet. The discoveries of rich deposits of lead ore at Joplin in the same year, and their wonderfully rapid development, had also an immediate effect on the prosperity of this region. Here, as in Wisconsin, the discovery of zinc ore is proportional to the activity in prospecting for lead ore. The production of zinc ore for the year 1874 is given as 19,000 tons, and the present output is variously estimated at from 1,000 to 1,500 tons a week. There is no doubt that the latter figure is often reached, and could be maintained from present developments, except when mining is extensively interrupted either by wet weather or excessively low prices for lead or zinc ore; or that more than two-thirds of the spelter made in this country comes from ore mined in this region. The ore is found in the sub-Carboniferous formation, and there is an evident connection between the known deposits of ore and the present system of surface drainage. Dr. Schmidt observed, as a remarkable fact, that the largest deposits do not lie along the principal streams, but at the heads of the smaller tributaries. The deposits of Webb City, Carterville, Empire, Galena, Sherwood, Belleville, and

Blende, discovered since his examination, and now the principal sources of zinc ore, fall under the same rule. These throw new light upon the character of the mineral formations, and seem to warrant increased confidence in their extent and depth. The most important zinc mines of this region are those at Carterville and Webb City, which are really parts of the same deposit. They produce more than half of the zinc ore raised, and are worked principally for zinc ore.

As these deposits are very regular in their formation, and in a measure rule the ore market, and as the method of mining them is essentially the same as prevails throughout their entire district, a general description of them and the method of mining them will here be given. These mines lie in the open prairie, which was once cultivated in farms, about five miles northeast of Joplin, near the head of a small branch of Center creek. They were discovered about the year 1877. Here, at a depth of from 40 to 100 feet, and often under a cap of limestone and flint 60 feet in thickness, has been found an immense deposit of zincblende, which has been worked continuously for over half a mile. The deposit is in the form of a bed of flint, traversed in various directions by solid bars of barren flint, but in general resembling a breccia of sharp, angular pieces of flint, closely cemented by crystallized blende, with occasional masses of bright, crystallized galena. With the exception of these bars and occasional pillars to support the roof, the whole body is blasted out. Draining is difficult, and rock drifts are sometimes necessary to unwater the ore. Dr. Schmidt considers a secondarily deposited quartzite to be the cementing material between the chert and the zincblende in the very similar deposits found at Oronogo; but this is certainly not the case in the best mines at Webb City nor at Sherwood, and zinc buyers soon learn to detect the difference. Where the cementing material is pure blende, the blende breaks freely from the chert, and can be almost entirely cleaned by crushing and jigging; where the cementing material is quartzite, or black sand, as the miners call it, crushing is difficult, and a satisfactory separation is impossible. The mines spread over about a section of land, 640 acres. Their weekly output is about 700 tons. The method of working them is as follows: When a good prospect is discovered in new ground the land around it is leased from the original owners on royalties ranging from 10 to 25 per cent. by a number of individuals, who organize various mining, or as they would more properly be called, land companies. These companies have the land divided up into lots 200 feet square, and a plat of it made; select certain lots for themselves, and throw the others open to miners. They usually start a shaft on one of their own lots, and put in a pump. If the indications continue good, many of the lots, particularly those near the pump shaft, are quickly taken up by parties of miners, who sink shafts upon them, timber the ground, put up hoisting contrivances, furnish all supplies, and bear all expenses.

When ore is struck it is drifted on and followed in all directions up to the boundaries of the lot in question. The ore is raised to the surface and crushed and washed by the miners, and is sold to one of the zinc or mineral buyers. It is weighed over the company's scales, and paid for to the company, which deducts a royalty of 25 per cent. on zinc-blende and 50 per cent. on "mineral" (galena); and if it has pumps running, a pump rent of $1 a ton on zinc ore and $2 on 1,000 pounds of galena; and pays over the balance to the miners. The royalties, of course, vary with circumstances, but the above are general. The holders of lots hire other labor to do the mining, at from $1 to $1.50 a day; and usually put up crushing and washing machinery on their lots. Very often the same parties control two or three adjoining lots or fractions of lots, and sometimes neighbors go into partnership. Most companies do not allow ores to be taken from the lots on which they are mined until they have been cleaned and have paid royalty. The machinery is usually of the simplest description—a farm or small stationary engine, covered by a shed of rough boards, a small-sized Blake's breaker, set over a pair of rolls, and a horse whim or a whip. The jigs are ordinary hand jigs, with an overhead breakstaff, working a sieve 2 by 3½ feet up and down in a box of water. The jigging is usually done by contract, and is paid for by the ton of cleaned ore. It is common to see from 10 to 20 of these jigs grouped together under a shed of poles, covered with branches of trees or rough boards. The ore as crushed yields from 10 to 50 per cent. of cleaned ore, and the No. 1 grade assays about 60 to 62 per cent. of metallic zinc. The tailings must in most cases be piled up on the lot from which they have come; they are drawn up into a mound with two-horse scrapers or belt elevators, and it is not an unusual sight to see jigs and crushing machinery perched on top of these mounds 15 or 20 feet above the surface level, the shafts being timbered up to a corresponding height. Several land companies have put in fairly effective pumping machinery. Plunger pumps working in pairs, with wooden walking beams or bob cranks, and driven by gearing and a crank shaft, are the most common; but direct-acting steam pumps, like the Worthington or Blake, have been largely introduced of late, notwithstanding the disadvantages they labor under from the gritty water of the mines. From a distance these mines, with their swarms of busy men and heaps of tailings piled around the shafts, remind one strongly of gigantic ant-hills, and present a sight not soon to be forgotten. No one can fail to be struck with the glaring defects of such a method of mining, the absence of system, the useless duplication of machinery, the cheap yet expensive expedients, and the crowding together of conflicting operations. Below ground the effects are if possible worse. Each lot is affected by the policy of its neighbors; pillars are left only where they are thought to be absolutely necessary; each miner tries to get as much as possible out of his own lot, is only interested in it as long as he expects to work it, and is not disposed to improve the value of adjoining lots by unwatering them or proving their ore. The roof and pillars are badly trimmed, and in many cases dangerous, fatal accidents being distressingly common. The officers of the land companies are generally individually interested in one or more lots, and all sorts of questions are continually arising from the conflicting interests of the company and the miners.

Looked at altogether, as the main dependence of the zinc industries of this country, such a condition of affairs is far from satisfactory, and yet it is not easy to suggest a practicable remedy. If a single company with sufficient capital could control all the lots and work them in connection with each other, the output could be largely increased, the cost of mining and dressing the ore greatly reduced, and the value of the mines kept up for a longer period, and the ore could be sold to better advantage than can be hoped for under the existing method. But this is seldom possible after the present system is once in operation; too many individuals have acquired rights in the mines, which they value at what they hope to get out of them. Nor is the present arrangement without obvious advantages in a new country, and it is seriously questioned whether any other could be as effective or as economical. When mineral is once discovered, it requires but little capital to open mines, and consequently the individual risks are small. The miners, working on their own account, with hopes of large ultimate gains, have every inducement to work hard and cheaply, and to follow every clew that may lead to the discovery of ore. There is a large body of keen, hard-working prospectors, who during the season wander from place to place, live in wagons, under tents, or in the open air, and carefully observe and follow every real or supposed indication of ore. How else, it may be asked, could prospecting be so well or so cheaply done? And there is a class of enterprising, skillful, well-to-do miners, naturally associated as partners, who have made one or more good strikes, and are always ready to take hold of any new venture that promises well, either in working a lot or in forming a land company to open new mines. Where else could be found capitalists so willing to risk their money in a speculative venture? Men of this sort are always ready and able to work themselves, or to direct the work above or below ground. How else could be obtained as willing and as watchful superintendents, foremen, and clerks? New towns are started every year, and the mining district is rapidly extending. No uniform development seems to lead to this extension; chance and the policy of the land owners appear to be the only determining causes.

The towns of Galena and Empire, on Short creek, in Kansas, were brought into sudden prominence in 1878 and restored the waning fortunes of the Joplin region by the exertions of two land companies, which, on the strength of two or three rich but undeveloped prospects, laid out two rival towns, and sold town lots without reserving mineral rights; and by extensive advertising throughout Missouri and neighboring States created an excitement which had a purely speculative basis, but led to the collection of a large number of miners and a considerable aggregate of money. Fortunately the results very nearly justified their most sanguine representations. The land companies then withdrew all of their remaining lots from the market, and the success of the mines was secured. They are now the principal mines for lead ore in the region, and their output of zinc is increasing.

For the discovery and working of shallow deposits the present system seems the best that can be devised, but it is clearly not adapted to solve the problems of discovering deeper deposits or working them to advantage. No system can be defended which involves extravagant expense in mining and preparing the ore for market, forces the sale of it without regard to its value, and renders worthless large bodies of ore that might be profitably worked by a better system; and no basis for a great industry, like the zinc industry, which makes it depend on a hundred chances independent of the price of metal, the cost of smelting, or the known deposits of ore, can be considered very safe to build upon. The caving in of a single mine, the breaking down of a pump, less activity in lead mining, or the scattering of the miners to richer camps may cause a falling off in the output of ore from which it would be very difficult to recover. That mining has on the whole been very profitable in this region is established from the fact that the country around has steadily and rapidly increased in wealth and population. Within the last few years three railroads, the Saint Louis and San Francisco, the Missouri Pacific, and the Kansas City, Fort Scott, and Gulf, have built branches through the ore fields to each of the three towns, Joplin, Webb City, and Galena. Joplin, with its good streets, gas and water works, machine shops and foundries, flour and woolen mills, lead and zinc furnaces, street cars, and extensive jobbing and retail houses, has been built almost entirely from the profits of mining.

Granby, 20 miles southeast of Joplin, presents a striking contrast. It is dependent on a single railroad, which owns much of the mining land; and the land is all leased or owned by the Granby Mining and Smelting Company. Lead ore has been extensively mined since 1856, and during the war the mines were worked for both armies. The zinc ore obtained is mainly calamine, but blende is also found. The mines are in general shallow, and less troubled with water, and the ores usually require less mechanical dressing than at other points in the lead region. The company receives from the men all of the lead and zinc ore, deducts the royalties paid to the railroad and its own royalties, and pays the miner on a sliding scale, based on the price of the metallic lead and the selling price of zinc ore, for the reason that it smelts the lead ore, and at present sells the zinc ore.

This mining point is noteworthy, as it is the only one producing large amounts of calamine. The calamine is naturally rich, not much contaminated with other materials, and occurs with the lead ore in shallow horizontal openings. It was first utilized in 1871, prior to which time laige amounts of it had been discovered and left in the ground or thrown aside. Since that time it has been extensively mined, and has added greatly to the prosperity of the mines. Calamine is by nature less rich than blende in the proportion of 53 to 67 per cent.; it is also much more difficult to clean when mixed with rock, on account of its lower specific gravity; but in proportion to the metal it contains it is more valuable than blende because it can be smelted more cheaply and the metal more perfectly extracted from it, and when mixed with blende in the furnace charge it makes it possible to get more metal out of the blende. It is also valuable on account of the superior softness and toughness of the metal obtained from it; but it will not bear transportation to a distance as well as blende, on account of its lower percentage of metal. This ore has been at times the principal supply of the Carondelet zinc works; large amounts of it have been shipped to La Salle and Peru, and in 1874 4,000 tons were shipped to Bethlehem, Pennsylvania, which yielded a little over 32 per cent. of metal on the weight of the raw ore. It is less favored by the zinc works in the neighborhood, because the freight upon it is heavier than the freight on ore from other points, and because furnaces working it cannot turn out as many pounds of metal a day as when working on blende, and the output of the works is reduced.

EASTERN ZINC WORKS.

Spelter furnaces.—The reduction works at Newark, Jersey City, Bergen Point, and Bethlehem employ the same general type of furnace, adapted to the use of anthracite coal. They all manufacture oxide of zinc as well as spelter. None of them can produce metal as cheaply as any of the western works, but they all produce a brand of metal very free from lead, which commands a continued sale. The furnace used differs from the ordinary Belgian furnace chiefly in the substitution of a shallow ashpit 16 to 18 inches deep, with luted ash-doors, into which a blast of air is admitted under the fire, in place of the high underground ashpits and tunnels of the latter. The grate is composed of flat perforated bars of cast iron, placed close together, so as to permit the use of pea coal. The method of cleaning the fire is as follows: At the back end of the grate, and on a level with it, there is a flat ledge of firebrick; the live coals from the top of the fire are pushed back on to this ledge, the cinders are barred up from the grate and scraped out at the fire-door; the fire is then drawn forward and spread over the cleaned bars, fresh coal is thrown in, and the blast is admitted, and in a very short time the furnace is brought to the required heat. By means of the blast and chimney dampers the fire is easily controlled, and the heat is regulated to suit the requirements of the different operations of smelting. Furnaces of fifty-six retorts are in general use. Nothing seems to be gained by any considerable increase in the number. If the furnace is charged twice in twenty-four hours, which is the usual practice, this is about as many as can be attended to properly by three men—one charger and one long shift and one short shift man; for if the operation of cleaning and charging is prolonged, the time left for reduction becomes too short to properly exhaust the charge. If the furnace is enlarged so as to employ two more men, the work of firing becomes excessive if there is only one fireplace; if there is a fireplace at each end, a cross wall between them adds little to the cost of construction, but it greatly strengthens the block and facilitates repairs; but at the same time it divides the block into four furnaces. Anthracite coal, with a blast, gives a good flame and sufficient heat in all parts of the furnace. It is customary to protect the lower retorts from the radiated heat of the fire by a row of thick tubes, called cannons, about the same size as the retorts, but open at both ends. Where the furnace is charged only once in twenty-four hours much time is lost, during which part of the furnace is not working; and the lower retorts are too long exposed to a strong heat under circumstances which make it very destructive to them. It may also be considered as proved that any considerable departure from the long established dimensions of the retorts—6½ to 7 inches internal diameter—is a mistake where the furnace is charged twice in twenty-four hours and the ore is sufficiently valuable to make close working desirable. It is worthy of note that the workmen everywhere desire larger retorts and twenty-four-hour charges, for the simple reason that their active working hours are reduced at the same time that the amount of metal on which they are paid premium is increased.

Oxide furnaces.—The oxide furnaces in use are also of the same general type. Each furnace has a rectangular horizontal cross-section, about 3½ feet wide by 6 feet deep, and is covered by a full center arch; 8 or 10 inches below the spring line of the arch is the grate, which is formed of flat cast-iron bars, 6 feet long, 6 inches broad, and an inch thick, perforated by tapering holes, 1 inch diameter below and one-quarter inch diameter at the top, set as closely together as the strength and stiffness of the iron will permit; these bars lie close together and rest on three or four bearers set crosswise into the side walls of the furnace. Below the grate is an ashpit 18 to 20 inches deep, closed in front by iron doors. The opening into the furnace is under an arch in the front wall; this doorway is sometimes closed by iron doors, but the simplest and best method of closing it is with a bank of moistened ashes piled up against it; for this purpose a shelf about 20 inches broad projects in front of the furnace on a level with the grate bars. The front opening is usually a semicircular arch the full width of the furnace. The ashpit is connected with an air flue coming from centrifugal fans, and provided with a damper, by which the blast is regulated. There is an opening in the arch of the furnace for the escape of the zinc oxide and other products of combustion; this opening either leads directly into the iron or brick flue running to the cooling apparatus, or into a short flue, from which the gases may be turned either into the oxide flue or into an open chimney, according to which of the two systems of working is adopted. It is customary to place two such furnaces end to end, and work them from opposite sides; and the end wall between them is sometimes omitted, a single opening through the arch answering for both furnaces. A row of such pairs of furnaces side by side is built, and the same air and oxide flue answers for the row.

The method of working the furnaces is as follows: One man attends to four or six adjoining furnaces and charges them alternately, one every hour. When opposite furnaces open into each other, these two furnaces are charged at the same time. When the time comes for cleaning out a furnace, the draft is shut off, the pile of ashes is removed from the front of the furnace and thrown to one side, to be used again. What is left in the furnace from the preceding charge is in the form of a more or less solid clinker, covering the whole surface of the grate; this is loosened and broken up with suitable bars, and is drawn out in front of the furnace. The bed coal is thrown in on the cleaned grate and spread evenly in a layer of about an inch deep, the front opening is partly closed with a loose piece of sheet iron, and a little air is admitted through the ashpit; the cinders and ashes of the preceding charge are thrown out of the way of the workman, and by the time this is done the bed coal has been sufficiently ignited from the heat retained in the sides and arch of the furnace to receive the charge. This consists of a mixture of crushed ore, with about half its weight of anthracite coal, as finely crushed as can be used without falling through the grate. The charge is spread over the fire and leveled carefully; the front of the furnace is closed with its bank of ashes, and more blast is let on. A charge remains in the furnace from four to six hours, according to the practice at different works. When the ore used is calamine, smithsonite, or franklinite, it is charged raw; when it is blende, it must be very carefully roasted beforehand. When franklinite is used, the hard clinkers remaining in the furnace are reserved for the manufacture of spiegeleisen, and are called the "residuum." The fine residues of the charge are mixed in with the succeeding charge; by this means the fire is kept open for a longer time for the penetration of the blast, and a thick crust of residuum is obtained, more suitable for treatment in a blast furnace. The ashes are removed from below the grate only once in 24 hours, and the charge is in all cases slightly moistened before being thrown into the furnace. As the charges are made alternately every hour, the heat in the conduits and all parts of the apparatus is kept very uniform, and sufficient to instantly burn any particles of coal drawn over with the gases, and no trouble is experienced from their effect on the oxide. The practice of some works in only turning the gases into the oxide flue when the zinc flame makes its appearance, seems an unnecessary precaution. An excess of air is always admitted, so that it is probably the active agent in oxidizing the zinc, and very little carbonic oxide would be found in the bag-room. It is very important that the men should watch the working of the furnace carefully, and by regulating the admission of the air, and by closing all blow-holes with a rake, should force the air to pass through the charge as uniformly as possible.

The apparatus for cooling the gases and oxide varies considerably in different works, but consists essentially in some combination of brick or iron flues, with towers or ascending pipes, with or without sheets or jets of water and steam chambers. Beyond it are exhaust fans, to draw the gases carrying the oxide from the furnace and send them through settling chambers to the bag-rooms. The gases, now cooled and carrying only light flakes of merchantable oxide, are distributed through the bag-rooms by iron branch pipes, along the tops or the bottoms of which are set rows of nipples close together, to which are attached cotton bags. These bags are often 40 or 50 feet long, and hang down from the branch pipes or are suspended vertically above them from the roof. Two hundred square feet of bag surface to one square foot of grate surface is a proportion found to work very well in practice. The bags are about two feet in diameter, and when suspended from the branch pipes the lower ends need not be closed if they are long enough to be given a half twist and rest on the floor, or on a slightly raised bench under them. An ingenious variation of this arrangement may be seen in the works of the Lone Elm Company, at Joplin, Missouri, for the collection of the white fumes from the lead slag eyes. There the lower ends of the bags are tied to nipples in the top of closed bins, into which the collected fume may be directly shaken, and from which it may be packed, when the lower ends of the bags are closed by a sliding gate. The bags thus form the only outlet from the furnaces. The cooled gases pass freely through the meshes of the cotton, and the finest flakes of oxide are arrested on the inside. These must be shaken down from time to time to keep the meshes open and to collect the oxide in the bottom of the bags. When the oxide, after collection, is kiln-dried to drive off 1 or 2 per cent. of moisture absorbed from the furnace gases, and bolted to remove cotton fibers and occasional specks of iron-rust and lumps of hardened oxide detached from the pipes, its quality is certainly improved, and it will keep better without caking; but this is not always considered necessary. As collected, the oxide is too light and feathery to be directly packed, and must be compressed by suitable machinery.

This oxide process is not new, and is generally well known, but it is probably the only valuable contribution America has made to the metallurgy of zinc. Its operations, though very simple, are not without their difficulties. Very slight and often not very obvious causes suddenly affect the color or body of the oxide; different ores require different treatment, and the heat conditions and amount of air admitted at different points of the apparatus seem to have almost as decided an effect on the quality of the oxide as has the character of the ore treated; all of the volatile constituents of the ore will be found in the oxide. Besides containing traces of sulphur, arsenic, antimony, and cadmium, commercial oxide frequently contains minute but weighable amounts of lead, iron, manganese, lime, magnesia, and ash, which often do not seriously affect its color. If the color is good, a small percentage of lead is supposed to add to the body of an oxide. There is good reason to infer that the unnatural color imparted to an oxide by these elements depends much less on the actual amount of them which it contains than upon the nature of the compounds into which they enter, some of these compounds being white, others possessing more or less coloring properties. Conditions of volatilization, oxidation, and condensation, therefore, strongly determine the color of the resulting oxide. Color being a purely physical property, it is also probable that, apart from the effect of extraneous coloring substances, the color of an oxide depends also on its physical texture, and sometimes results solely from physical causes. There must be a certain proportion between the volume of gas, the amount of oxide carried by, and the dimensions of the flues. Apparatus that will work very well with certain ores, or with a certain number of feet of grate surface, will not give equally good results with richer or poorer ores, or with more or less grate surface. In working some ores it is necessary to run as hot as is consistent with safety to the different portions of the apparatus; with others the best results are obtained by running cold. It is well to start with sufficient cross-section of flues, and with a reserve of power in blast and exhaust fans, and with large cooling and settling chambers, and numerous doors for cleaning them and admitting air. Water in the ashpits is in some cases found to be very useful in protecting the grate bars and equalizing the temperature. Considerable control can always be had over the heat by varying the weight either of coal or ore in the charge; both must also be regulated to suit the time the charge is to remain in the furnace. Lime or limestone is often added to the charge, and acts sometimes chemically in liberating the zinc from its combination with silica; at other times it is added to stiffen the charge and prevent it from running through or stopping up the grate bars.

In the works at Jersey City, Newark, and Bethlehem franklinite is now exclusively used for the manufacture of oxide, and the residuums are treated for the extraction of the iron and manganese in small cupola furnaces, about 20 feet high above the tuyeres and 6 feet wide above the boshes. Nearly all of the iron is obtained, but little more than half of the manganese. The operation is beset with many difficulties. The 3 or 4 per cent. of zinc oxide left in the residuum is very troublesome, and has heretofore prevented the use of large furnaces. The pipes for collecting the fumes from the tunnel-head require cleaning two or three times a week, and during the cleaning the furnace cools down and manganese goes into the slag; the spiegeleisen drops suddenly from as high as 22 per cent. often below 10 per cent. of manganese, and eight or ten hours are required to bring the furnace back again to its proper working condition. If the manganese could be got into the pig to the same extent as the iron is utilized, a ferro-manganese of 33 per cent. could be obtained.

The fumes collected from the spiegel furnaces and the impure oxide obtained from the flues and sweepings of the oxide works are usually made into metal in the ordinary spelter furnaces, but the latter is sometimes converted into good oxide by reburning.

CENTRAL ZINC WORKS.

Works in Illinois.—Of the works at La Salle and Peru, Illinois, only a general description can be given. They produce at present considerably more than half the metal made in this country. The works at La Salle were started about the year 1860; they belong to the Mathiessen & Hegeler Zinc Company, and have a capacity of from 28 to 30 tons of metal a day. The most striking feature about these works is the patented furnace employed. This furnace is in the neighborhood of 100 feet long and contains about 800 retorts, of the same general size and shape as in the old Belgian furnace, and set into the furnaces in the same general way, but only five rows high. The furnace is fired by gas produced by a blast in a producer outside of the furnace. The producer is set close to one end of the furnace, but on a lower level; is of square cross-section, and has an airtight iron ashpit raised from the ground, into which air is forced by a large iron fan. The front of the ashpit is closed by planed iron doors, which are raised by counterpoises when the fires are cleaned and held closely in place by suitable clamps when the air is admitted. The producer is covered by iron doors, which open half way across the top when the producer is being charged. The coal is mined under the works, and dumped directly into the producer from the mine cars. The gases are led hot into the end of the furnace, and are gradually burned as sufficient air is admitted. The air for combustion is brought from the opposite end of the furnace, through a flue running over the center of the furnace arch; from this flue lateral branches are taken off, at right angles, to both fronts of the furnace, and carried down to the floor level at such intervals as to admit four retorts in a horizontal row between successive air-flues. All these flues are external to the furnace, and the air is admitted into the combustion chamber through perforated fire-clay tubes, corresponding in size, position, and arrangement with the charged retorts. Dampers to regulate the supply of air are introduced at intervals in the flues; when once adjusted they do not require to be often changed. Contrary to what might be expected, the heat is tolerably uniform throughout the length of the furnace, but slightly less at the end remote from the producer, where the charge is modified to suit these conditions. The first furnace built was provided with stoves to heat the air by burning the gases escaping from the furnace. These stoves are a combination of iron and fire-clay pipes, through which the air passes, while the gases burn on the outside, and are about as large as are required for a 50-ton iron blast furnace. Later furnaces have not these stoves, but room is left for them in the furnace buildings. It would seem, therefore, that there is still a question as to their economy. Probably the same may be said of the whole furnace.

Except for the use of suspended retorts, several rows high, and some peculiarities in the producer, there is little essential difference between this furnace and the step-grate furnaces with blast, employed in Silesia. It certainly has many of the advantages due to the use of gas-firing, and special advantages due to mechanical devices for working it; but, on the other hand, without the effective heating of the blast and the utilization of the escaping heat of the furnace it cannot be considered an altogether successful contrivance, and the construction involves points which seem to render maintenance and repairs very expensive. Among the inventions to facilitate working may be mentioned: cars for cleaning and charging the retorts, cars with swinging ladles for drawing the metal, derrick-cars for taking out and replacing the retorts, all provided with suitable screens for protecting the workmen from the heat, and all moving on a track laid close to the furnace. Also two-story bins for the charge, to follow close behind the charging-car; a car carrying molds for casting the metal, and trays for the collection of the blue powder.

Of the roasting kilns there are many varieties. In most of them the ore gradually falls from the top of the kiln upon a succession of inclined shelves, meeting the hot air or furnace gas passing up through the kiln. The latest mechanical kiln has more points of novelty, and some good features. It is worked in connection with sulphuric acid chambers. This kiln is something like 75 feet long, and has five or six flat hearths, one above the other, with lateral cast-iron doors, not ordinarily used, and working doors at the ends. The ore is charged on the several hearths at one end of the furnace, and is carried to the opposite end by mechanical means. The handle of a rake is rapidly projected through one of the hearths and out of the working door at the opposite end of the furnace, where the head of the rake is quickly attached to it; the rake is then drawn back through the furnace by the reversal of the same machinery which projected the handle. When it reaches the discharging end the rake-head is detached, and is received on a car with decks corresponding to the hearths of the furnace, and carried back to the far end by the car moving around the furnace. There are as many handles and rake heads as there are hearths. The sliding doors are raised and lowered so as to admit as little false air into the kiln as possible. The form and dimensions of the rake teeth determine the amount of ore discharged by each draw through the furnace. The whole operation is quickly performed, and the doors are open only a few seconds at a time. Two sets of sulphuric acid chambers, each of a capacity of about 240,000 cubic feet, with all modern improvements, have recently been added to the works.

In the large rolling-mill of the company there are six pairs of rolls; and the same desire is shown here as elsewhere to supplement manual labor by machinery. With rapidly moving rolls, and three 8-hour shifts a day, the output is pushed to the utmost. The capacity of the mill is over 100,000 pounds of sheets in twenty-four hours. To keep these works running steadily, the company, which mines no ore, is obliged to always carry a large stock on hand, which often must represent several hundred thousand dollars of capital. The system of sampling and mixing the ore is good, as is also the preparation of the retort mixture of clay. The retorts are shaped by machinery, the clay being forced by a propeller-like screw through a die-plate and around a mandrel; a man below receives it in an adjustable mold, into which he allows it to be forced with all the pressure it will bear without bending; when it reaches the bottom he stops the machinery, cuts off the retort, and turns it over to another man, who stamps in the bottom and smooths up the retort. This process is said to give as good retorts as can be made by hand; but certainly not so good as those made in Belgium by hydraulic pressure in molds. The condensers are stamped out by a drop plunger of the required internal shape. Besides four large furnaces, this company has a number of common Belgian furnaces, which have, however, been altered from direct firing to gas-firing, by building a semi-detached fireplace against one side. In other respects also crude and obsolete constructions may be found working side by side with the latest perfected inventions; and it can scarcely be doubted that the preponderating influence of these works on the zinc industries of this country is due less to their economy in working, or the excellence of any of their furnaces, than to the peculiar advantages they have enjoyed in the past in the matter of cheap ores, their abundant capital made in the business, their extensive knowledge of the metal trade, and the monopoly they enjoyed for many years of the sheet-zinc market, during which time the price of sheets ruled about two cents a pound higher than the price of metal.

The Illinois Zinc Company, whose works are at Peru, across the river from La Salle, have the next largest works in the country, with a capacity of from 18 to 20 tons of metal a day. There are three gas furnaces in use, in addition to eight ordinary furnaces. The gas furnaces were built under license from the owners of Siemens's patents in this country, and present several marked improvements over the earlier designs of Dr. Siemens of several years ago. The bottom of the furnace chamber is a solid floor of brick, and the air and gas ports are raised above it, and come through the back wall of the furnace under the lower row of retorts. Another improvement is the placing of an auxiliary gas box with a simple two-way flap valve over the ordinary reversing butterfly valves, by means of which either set of regenerative chambers may be run on gas or air. By an occasional reversal deposits of soot in the gas chambers may be burned out, and to some extent deposits of oxide may be removed; but as the only escape for the zinc when it gets from the retorts into the combustion chamber is through the regenerators and valves into the chimney, the principal effect on the oxide must be to drive it from one place to another in the furnace. It is said, however, that with the recent improvements the trouble from oxide is not serious, and that the furnace never has to be shut down on purpose to clean the regenerators, and will run two years without needing repairs. The furnace is about 60 feet long, and contains about 144 retorts on a side, three rows high, 48 retorts in a row. The four regenerators extend the whole length of the furnace, are about 28 inches wide, and contain about 30,000 bricks. In these works the furnace is charged only once in twenty-four hours, and the retorts in the bottom row are considerably the largest, and have an elliptical shape. The charge is 17,000 pounds of calcined ore for an ore yielding 8,000 pounds.

The gas producers are of the ordinary type, and the management of the valves is the same as with any Siemens furnace. A rolling mill with three sets of rolls, driven by a large engine with great reserve of power, has been started within a year. The rolls, housings, and general equipment of the mill are of first-rate design and construction. For many reasons a separate engine for "breaking down" the ingots would seem to be preferable.

Works near Saint Louis.—There is another group of zinc works in the neighborhood of Saint Louis, using Illinois coal, and drawing their supply of ore from the southeastern and southwestern lead regions of Missouri. Of these works only two, the one at Collinsville, Illinois, and the Glendale Works at Carondelet, have run at all steadily for the past year or two. The Missouri Zinc Works and the Carondelet Zinc Works have stood idle for some time. Of these four works collectively, it may be said that they have passed through many vicissitudes; they have been repeatedly started up under different managements, and have always been among the first in the country to shut down when ores are high or metal low. There is nothing noteworthy in their general construction. Until quite recently they have been dependent upon a single road for their ore supplies, and the works on the Missouri side of the river have had to pay extravagant prices for fuel. Whether these two causes alone, or joined with the lack of sufficient capital, are enough to account for their irregular record, and to offset their natural advantages of location, it might be a matter of some difficulty to determine. Large retorts, large furnaces (for direct firing), and 24-hour charges, seem to have been the prevailing practice. It may be mentioned, for the benefit of any one thinking of repeating the experiment, that there are two nearly new blocks of two furnaces, each furnace containing 198 retorts, nine retorts high, with 22 retorts in a row, to be seen at the works of the Missouri Zinc Company.

WESTERN ZINC WORKS.

On the bituminous coal belt extending from Indian Territory through eastern Kansas into northern Missouri and Iowa, and on lines of railroad penetrating into the lead region of southwest Missouri, is located another group of works. The oldest of these is at Wier City, Cherokee county, Kansas, about 25 miles from Joplin on a branch of the Kansas City, Fort Scott, and Gulf railroad. The first furnaces were built in 1873, before railroad communication was established. Ore and coal were then exceedingly cheap, but the former had to be hauled from 25 to 35 miles in wagons, and came mainly from Jasper and Dade counties. The works were built on a stripped coal bank, in the open prairie, and four miles from any town. Skilled labor was hard to get and high-priced, and the class of men first employed was very turbulent and unsatisfactory. The works have undergone many changes, and it is only recently, under the present management, that they have assumed importance as producers. Ten miles from here, on the same coal field, at a point which has since become the town of Pittsburgh, R. & S. H. Lanyon started two furnaces in 1878; the number of furnaces has since been increased to eight, each furnace containing 98 retorts. In 1880 the partnership was dissolved, and Mr. S. H. Lanyon began the erection of new works alongside of the old one; he has now four furnaces similar to the foregoing. In 1882 W. & J. Lanyon put up two similar furnaces in the same immediate neighborhood, which are now running. The Granby Mining and Smelting Company in the same year began the erection of works, using the Siemens gas-firing furnace, at this place, and are now engaged in smelting. The town of Pittsburgh is 28 miles from Joplin, and on branches of both the Saint Louis and San Francisco and the Kansas City, Fort Scott, and Gulf railroads; it has now a population of about 3,000, and is the principal coal shipping station on the former railroad. The West Joplin Lead and Zinc Company has, within a year, built zinc works at Joplin, which are now running with a capacity of six furnaces containing 644 retorts. Within the same period the Southwestern Lead and Zinc Company have erected at Rich Hill, Bates county, Missouri, on the same coal belt, about 80 miles from Joplin, with which it has connection by two railroads, a Siemens gas furnace containing 288 retorts, which has been running some six months, and have just completed a block of direct-firing furnaces.

Economic conditions of zinc metallurgy.—This unusual activity in furnace building is likely to produce considerable uncertainty in the zinc market for some time to come. All of these works possess advantages of cheap coal (about 50 cents a ton for slack and $1 to $1.50 a ton for the run of the mine) and low freights on ore, $1 to $1.50 a ton according to the shipping point; living is cheap for their men, and the country around them is rapidly filling up with newcomers; foundries, boiler and machine shops at Joplin, Rich Hill, and Fort Scott supply castings at from 3 to 3½ cents a pound and machine work at reasonable rates; labor is abundant and wages moderate. There is little to be noted in the form of the direct-firing furnaces in use in this district. In the Lanyon furnaces the four lower rows of retorts are charged twice in 24 hours; the retorts of the upper rows, which are charged with blue powder, are both longer and wider than the lower ones; the back wall of the furnace being made thinner at the top than at the bottom, to admit of this arrangement, which commends itself to reason, as the blue powder is easier to reduce than ore and the charge is longer in the furnace. The furnaces are built with the ashpits above the ground and on a level with the rest of the works; a sloping bank of earth or cinder leads up to the furnace floor. The buildings are all of the simplest and lightest construction possible, scarcely more than sheds, and are huddled together, with little regard to their mutual relations. In such works, at present, it seems that metal can be made as cheaply as in any works in the country. Their first cost is very inconsiderable; the flat ledges of Coal Measure sandstone in the neighborhood furnish cheap and serviceable material for building foundations and ashpits; the peculiar mining systems of the district make small or second-hand engines, boilers, and crushing machinery comparatively inexpensive; cheap fuel renders economy in this direction unimportant; and cheap living causes ordinary yard labor to be easily obtainable at wages as low as prevail anywhere in the country. When the potteries are in operation, all refuse refractory material can be cheaply worked up into some sort of building material. The furnace walls are laid with the ordinary clay underlying the coal. The coke for the charge is jigged out of the cinders from the ashpits. The general mildness of the winters enables most of the work to be done in the open air. The potteries are heated by stoves, or by fires built in worn-out boilers. If the buildings do not blow up or burn down, as occasionally happens, the interest on capital is very insignificant. The works are usually owned by partners who do the work of salaried employés, buying the ore and selling the product, superintending the smelting operations, and occasionally taking a hand as mechanics, who consider as a profit what would only be the interest on their money and their wages at some other occupation. The furnaces, roughly constructed of inferior material, will not long sustain the heat required to exhaust the zinc from the cinder, and it is the accepted opinion that there is no economy in "butchering" the furnace for the sake of a small additional percentage of metal; it is preferred to increase the production of the furnace and reduce the smelting expenses of labor and fuel by increasing the charge of ore—in other words, to butcher the ore and save the furnace. Analyses of ores and cinders are entirely neglected.

But the most secure advantage these works have over those at a distance comes directly from the manner of buying the ore. It has been seen that ores are not sold on their contents of metal, and that the miners are absolutely ignorant of their value; ores differing 5 or 6 per cent. are often held at the same price. A personal knowledge of the ores of particular diggings, and their behavior and yield in the furnace, often enables these smelters, by a slight advance in price, to pick up desirable lots of ore and at the same time raise the price of all the ore held in the neighborhood. The smelters at a distance, buying in very much larger quantities, through agents who are ignorant of other branches of the business, are placed at an evident disadvantage. This system of personal supervision of all branches of the business by the owners of works is clearly applicable only to very small works; while labor-saving machinery and facilities for handling the ore can only attain the maximum economy when large amounts of material are to be handled—consequently when the works are large, and the machinery is constantly kept employed. On the other hand, under these favorable circumstances, in every prosperous owner of a mining lot and in every enterprising furnace brigadier is to be seen the possible proprietor of a new smelting works. It is from lack of sufficient capital and knowledge of the commercial part of the business to market their product advantageously that the weakness of such companies mainly arises. The accumulation of a few months' metal is sufficient to tie up all their capital and exhaust their available credit. Sales are made through commission men, with orders to sell the metal for what it will bring. Large consumers, knowing the condition of affairs, are careful to get the lowest bids before making purchases. Large metal houses, who might otherwise dispose of the whole product, are not disposed to have much to do with it; for no price above actual cost price is safe to buy the metal at in order to sell it again. Occasional good sales, or cheap lots of ore, give uncertain profits; and a slight rise in the price of metal is sufficient to "fire in" new furnaces. Under such circumstances no real advances in the metallurgy of zinc are to be expected.

Two companies controlling large bodies of mineral land—the Southwestern Lead and Zinc Company and the Granby Mining and Smelting Company—have been driven to undertake the smelting, in part, at least, of their own ores, in the hope of obtaining a certain sale for their ore product, which will enable them to pursue some definite policy in the management of their mines. The undertaking is not without its difficulties in the present state of the zinc industries. The strength of their position lies in their ability to supply their works with ore, without the risk of carrying a large stock on hand, and at the same time to develop their mines and increase the amount of their royalties and their profits from lead smelting.

Comparative merits of furnaces.—The advantages of a gas over a direct-firing furnace are briefly these:

1. A saving in fuel, which is plainly proportional to the extent to which the heating power of the gases escaping from the furnace is

utilized. For heating the air or gaseous fuel nothing is likely to supersede the Siemens regenerators.

2. A saving in wages, due to the simplification of the work and the less amount of labor required. The furnace can be built larger, without being above the reach of a man on the floor; and a man on a table exposed to the full heat of the furnace, with a man on the floor to wait on him, is no longer required. One set of men can fire for several furnaces at the same time.

3. A saving of metal and retorts; for the control of the heat is so perfect that the temperature of the furnace can be kept at the point needed to fully reduce the charge without running the risk of burning out the furnace or cutting down the retorts. But the full importance of such advantages, like the economy of building well and putting in the best devised labor-saving machinery, will only be realized when the cost of smelting at the different works affects their profits more directly than do their facilities for getting cheap ore and disposing their products to advantage.

General conclusions.—From the foregoing rapid survey of an extensive field these conclusions may safely be drawn:

1. That we are rapidly exhausting the richest portions of our known ore deposits.

2. That our methods of mining are reacting unfavorably on our furnace practice.

3. That the future of our zinc industries is uncertain and beset with many dangers.

When it is borne in mind that our production of spelter is less than one-seventh that of Europe, while the average yield of the ores we treat is nearly twice as great as the average yield of the whole of Europe and nearly three times as great as that of the ore treated in Silesia, whose metal rules the price of spelter in the world's market, it will be evident that many changes must take place before it can be said that we are making the most of our opportunities. It is not within the scope of this article to discuss the policy of the smelters towards the ore producers or towards each other, or the uses to which zinc is put, which determine the amount consumed or the price that can be paid for it; but it may be noted that, from the rapid extension of the use of galvanized iron and of telephone and telegraph lines and other applications of electricity, the market for zinc is rapidly extending, and that, except for purposes of roofing (which are almost unknown in this country, but absorb the bulk of the sheet zinc rolled in Europe, where the zinc comes into competition with tinned iron), there are few uses for zinc in which the consumption would be materially lessened by a considerable increase in its price; and that from the difficulties to be overcome in mining and smelting it seems probable that, relatively to other metals, zinc is at present undervalued. It is not to be desired that any smelting company, so long as it can buy ores profitably, should engage in mining, or should pay any more than it is obliged to for ore, or buy any quality of ore but what it finds most profitable. Nor is it to be expected that any mining company should change from a system which it finds sufficiently profitable, or employ its capital in any way but the one which yields the greatest profit. But it is very desirable that some record should be kept of present mining operations, and such knowledge gained of the mineral regions as will justify the employment of greater capital and render possible the introduction of better methods of mining and utilizing the ore. The geological surveys of Wisconsin and Missouri have done good work, but the fields covered by them are very extensive, and much more yet remains to be done. The huckstering of the ore and the metal, however profitable it may be to the persons engaged in it, is unfavorable to the mines and to the development of manufacturing industries. The fluctuations in price attendant on it are alike injurious to the producer and the consumer—more so, in fact, than would be a low price to the producer and a high one to the consumer. The remedy can only come gradually and with time.

QUICKSILVER.

Occurrence.—California has the only important quicksilver mines in the United States, or in fact on the American continent. With the exception of 50 flasks, made in Oregon in 1882, the total product of the country for that year came from the California mines named in the table of production.

Quicksilver is not found in quantity in the Rocky Mountain region, nor, indeed, in any of the country lying east of the Sierra. Trifling amounts of native quicksilver, the result of decomposition of coloradoite and other telluride ores, occur at the surface in quite a number of mines in Boulder county, Colorado. Quicksilver is also said to have been found in small amounts in San Juan county, in the same State, and in Rio Grande county, New Mexico, near Taos mountain pass; but these reports have not been confirmed by good authority. Selenide of mercury (tiemannite) occurs in Utah in limited amount, but has not been utilized. A deposit of cinnabar is now in process of formation at Steamboat Springs, Washoe county, Nevada; but its interest is rather geological than economic. Frequently red ochrous ores of iron are mistaken for cinnabar by prospectors and miners, and this may possibly explain many of the reported but unverified discoveries. Float cinnabar is sometimes found, like stream tin, without the original source of the ore in place being discovered.

Although very much has been written and published in a desultory manner on quicksilver no standard work has yet appeared, and information is only to be found scattered in technical papers and in various works on metallurgy. The investigation of the quicksilver deposits now being pursued by Mr. G. F. Becker, of the United States Geological Survey, is therefore regarded with much interest, as his report will embrace a full discussion of this important but hitherto rather neglected subject.

There are very many small claims in California, which, during the period of high prices for quicksilver, were actively worked, and which in the aggregate furnished a considerable output; but when prices ranged downward work in these small mines became unprofitable and was gradually discontinued; in fact, the production of the larger mines is more or less restricted by the state of the market, and were the demand greater a larger yield could be forced. At present the mines which are working are doing so on a small margin, and a variation of a few cents per pound in the price of quicksilver at once stimulates or restricts production. In the existing state of things the profits of the industry are very small, and not such as are likely to encourage prospecting for new deposits or further extensive development of the active mines. Thus the laws of demand and supply have placed the mining of quicksilver in a state of equilibrium, from which no sudden change may be looked for.

Cinnabar (red sulphide of mercury) is the chief ore mined, and is practically the only source. Native quicksilver is often found, but on the whole in trifling quantity, while metacinnabarite (black sulphide of mercury) occurs in a few mines.

Production.—The following statistics are furnished by Mr. J. B. Randol, manager of the famous New Almaden mine, who has made a careful and continuous study of the subject for a long series of years. The American flasks are invariably of 76½ pounds avoirdupois each.

Product of the quicksilver mines of California to the close of 1882.

Years.	New Almaden.	New Idria.	Redington.	Sulphur Bank.	Guadalupe.	Great Western.	Pope Valley.	Napa Consolidated.	St. John.	Altoona.	Oceanic.	Oakland.	California.	Great Eastern.	Sunderland.	Cloverdale.	Abbott.	Manhattan.	Various mines.*a*	Total yearly production of California mines.
	Flasks.	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Fl'ks.*	*Flasks.*	*Fl'ks.*	*Fl'ks.*	*Fl'ks.*	*Fl'ks.*	*Fl'ks.*	*Fl'ks.*	*Fl'ks.*	*Flasks.*	*Flasks.*	*Flasks.*
1850	7,723	Production from 1858 to 1866, 17,455 flasks—no yearly details obtainable—included in production of v rious mines.	....	....		....	....	....	....		....	....	....	....	....	....	....		....	7,723
1851	27,779		....	....		....	....	....	....		....	....	....	....	....	....	....		....	27,779
1852	15,901		....	....	Yearly production previous to 1875 not obtainable (estimated at 20,000 flasks), included in production of various mines.	....	....	....	....	Some was produced prior to 1875, but no record kept (estimated production previous to 1875 at 1,000 flasks), included in production of various mines.	....	....	....	....	....	....	....	Yearly production previous to 1876 not obtainable (estimated at 3,594 flasks), included in production of various mines.	4,099	20,000
1853	22,284		....	....		....	....	....	....		....	....	....	....	....	....	....		....	22,284
1854	30,004		....	....		....	....	....	....		....	....	....	....	....	....	....		....	30,004
1855	29,142		....	....		....	....	....	....		....	....	....	....	....	....	....		3,858	33,000
1856	27,138		....	....		....	....	....	....		....	....	....	....	....	....	....		2,862	30,000
1857	28,204		....	....		....	....	....	....		....	....	....	....	....	....	....		....	28,204
1858	25,761		....	....		....	....	....	....		....	....	....	....	....	....	....		5,239	31,000
1859	1,294		....	....		....	....	....	....		....	....	....	....	....	....	....		11,706	13,000
1860	7,061		....	....		....	....	....	....		....	....	....	....	....	....	....		2,939	10,000
1861	34,429		....	....		....	....	....	....		....	....	....	....	....	....	....		571	35,000
1862	39,671		444	....		....	....	....	....		....	....	....	....	....	....	....		1,885	42,000
1863	32,803		852	....		....	....	....	....		....	....	....	....	....	....	....		6,876	40,531
1864	42,489		1,914	....		....	800	....	....		....	....	....	....	....	....	....		2,286	47,489
1865	47,194		3,545	....		....	....	....	....		....	....	....	....	....	....	....		2,261	53,000
1866	35,150	6,525	2,254	....		....	....	....	....		....	....	....	....	....	....	....		2,621	46,550
1867	24,461	11,493	7,862	....		....	....	....	....		....	....	....	....	....	....	....		3,184	47,000
1868	25,628	12,180	8,686	....		....	1,122	....	....		....	....	....	....	....	....	....		112	47,728
1869	16,898	10,315	5,018	....		....	1,580	....	....		....	....	....	....	....	....	....		....	33,811
1870	14,423	9,888	4,546	....		....	1,220	....	....		....	....	....	....	....	....	....		....	30,077
1871	18,568	8,180	2,128	....		....	1,970	....	....		....	....	....	....	....	....	....		840	31,686
1872	18,574	8,171	3,046	....		....	1,830	....	....		....	....	....	....	....	....	....		....	31,621
1873	11,042	7,735	3,294	....		340	1,955	....	....		....	....	....	....	....	....	....		3,276	27,642
1874	9,084	6,911	6,678	573		1,122	1,645	....	1,743		....	....	....	....	....	....	....		....	27,756
1875	13,648	8,432	7,513	5,372	3,342	3,384	1,940	....	1,927	533	....	....	....	412	....	....	....		3,747	50,250
1876	20,549	7,272	9,183	8,367	7,381	4,322	300	573	1,683	1,979	2,358	2,150	965	387	1,570	1,028	1,436	976	2,595	75,074
1877	23,996	6,316	9,399	10,993	6,241	5,856	1,060	2,229	1,463	1,317	2,575	1,395	1,516	505	735	1,291	836	439	1,234	79,396
1878	15,852	5,138	6,686	9,465	9,072	4,963	1,075	3,049	....	1,534	1,679	1,615	1,640	1,366	472	116	....	....	158	63,880
1879	20,514	4,425	4,516	9,249	15,540	6,333	1,325	3,605	1,290	1,919	779	1,505	1,110	1,455	....	18	....	....	101	73,684
1880	23,465	3,209	2,139	10,706	6,670	6,442	275	4,416	492	245	....	166	422	1,279	....	....	....	....	....	59,926
1881	26,060	2,775	2,194	11,152	5,228	6,241	....	5,552	....	....	....	....	....	1,065	....	208	....	....	376	60,851
1882	28,070	1,953	2,171	5,014	1,138	5,179	(*b*)	6,842	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	2,124	(*b*)	(*b*)	(*b*)	(*b*)	241	52,732
Total	764,859	120,918	94,068	70,891	54,612	44,182	18,097	26,266	8,598	7,527	7,391	6,831	5,653	8,593	2,777	2,661	2,272	1,415	63,067	1,310,678

a The column of "various mines" includes the product of the Buckeye, Mt. Jackson, Bacon, Bella Union, American, Porter, Wall Street, Rattlesnake, Kentuck, and other mines. This column includes, in 1882, 50 flasks produced in Oregon. *b* Not in operation in 1882.

Product of the quicksilver mines of California in the first six months of 1883.

Mines.	January.	February.	March.	April.	May.	June.	Total.
	Flasks.	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*	*Flasks.*
New Almaden	2.497	2,150	2,230	1,756	2,344	2,214	13,191
Napa Consolidated	590	295	485	530	325	360	2,585
Great Western	390	364	305	294	293	400	2,046
Sulphur Bank	280	310	335	310	350	91	1,676
Redington	367	181	202	243	135	165	1,293
Great Eastern	262	156	162	142	164	184	1,070
New Idria	112	133	142	76	144	137	744
Various mines	84	11	14	3	13	10	135
Total	4,582	3,600	3,875	3,354	3,768	3,561	22,740

Consumption.—During the calendar year 1882 there were imported into New York 13,116 flasks, which, added to the domestic production of 52,732 flasks, made a total supply of 65,848 flasks. Of this quantity 19,451 flasks were exported to China, nearly the whole of which was consumed in the manufacture of vermilion. In addition to the imports from London at New York, 1,100 flasks were sent from California to the latter city by sea and 1,600 flasks by rail; making a total supply at New York of 15,816 flasks, of which the greater portion was made, or is to be made, into vermilion. Thus the manufacture of vermilion in China and in this country may be stated to have required a total of 31,451 flasks.

In addition to the 19,451 flasks sent to China, among the exports from San Francisco in 1882 by sea, were the following:

	Flasks.
To Mexico	9,742
Australia	1,690
New Zealand	105
South America	1,986
Central America	55
Various places	22
Total	13,600

All of this amount (13,600 flasks) is supposed to have been for amalgamation of gold and silver. Besides the exports above specified, 620 flasks were sent to Japan, of which the larger portion was for use in the Japan mint. Thus the consumption may be stated as follows:

	Flasks.
For making vermilion	31,451
For amalgamation etc (foreign)	14,220
Total	45,671

Thus leaving 20,177 flasks to be accounted for to make up the total of 65,848 flasks (consisting of the domestic product and imports at New York). Of these 20,177 flasks it is estimated that 3,000 flasks were held for increase of stock, and 17,177 flasks were consumed, say for amalgamation 16,677 flasks, and for mercurial preparations, mirrors, thermometers, scientific instruments, etc., 500 flasks.

Exports.—The following table shows the exports from San Francisco, both by sea and by rail, from the beginning of mining operations in 1850 to the close of 1882:

Exports of quicksilver from San Francisco by sea and rail.

	Flasks.
1850	6,467
1851	10,791
1852	21,458
1853	18,800
1854	20,963
1855	27,165
1856	23,740
1857	27,262
1858	24,412
1859	3,399
1860	9,488
1861	35,995
1862	23,747
1863	26,014
1864	36,927
1865	42,469
1866	30,287
1867	28,853
1868	44,506
1869	24,415
1870	14,240
1871	16,339
1872	16,780
1873	11,164
1874	11,750
1875	37,829
1876	49,046
1877	52,695
1878	41,877
1879	62,845
1880	46,294
1881	45,799
1882	40,417
Total	934,233

The following table gives the details of the exports by sea from San Francisco in 1882:

	Flasks.
To China	19,451
Mexico	9,742
Japan	620
Australia	1,690
New Zealand	105
South America	1,986
Central America	55
New York	1,100
Various places	22
Total	34,771

The total exports of quicksilver during recent years from all ports in the United States, as reported by the Bureau of Statistics, have been as follows:

Quicksilver of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Quantity.	Value.
	Pounds.	
1872	862, 694	$691, 637
1873	714, 783	626, 021
1874	501, 389	580, 521
1875	986, 469	1, 075, 796
1876	2, 711, 584	1, 740, 293
1877	3, 894, 311	1, 767, 266
1878	2, 552, 388	1, 230, 008
1879	3, 624, 827	1, 418, 331
1880	3, 574, 412	1, 360, 176
1881	2, 955, 948	1, 124, 955
1882	2, 485, 551	959, 128
Calendar year 1882	2, 627, 425	1, 004, 694

Foreign sources.—It has been seen from the foregoing statements that the yield of the California mines in 1882 (including 50 flasks produced in Oregon) was 52,732 flasks, of which the New Almaden mine yielded 28,070 flasks. The California mines not only lead in production those of any single foreign country, but furnish very nearly one-half the total of the present annual product of the world. The following table gives the production of the Idria mine in Austria, and of the Almaden mine in Spain, for a period corresponding to the history of the California mines. Besides these two great mines there is comparatively little quicksilver produced in foreign countries. Mr. Randol estimates the present yearly output of Italy and other foreign sources, besides the Almaden and Idria mines, at 2,000 flasks per annum. The figures in the accompanying table are given in flasks of 75 Spanish pounds each, equal to 34.507 kilograms, or 76.07 pounds avoirdupois.

Production of the Almaden mine (Spain) and the Idria mine (Austria) from 1850 *to close of* 1882.

Years.	Almaden (in periods of five years).	Idria.	Years.	Almaden (in periods of five years).	Idria.
	Flasks.	*Flasks.*		*Flasks.*	*Flasks.*
1850		4, 100	1870		10, 745
1851		4, 092	1871		10, 904
1852	101, 517	4, 085	1872	165, 608	11, 116
1853		4, 409	1873		10, 939
1854		4, 060	1874		10, 789
1855		4, 446	1875		10, 717
1856		5, 935	1876		10, 794
1857	110, 058	9, 189	1877	208, 200	11, 020
1858		4, 977	1878		10, 403
1859		8, 239	1879		12, 153
1860		4, 821	1880	41, 640	12, 356
1861		6, 493	1881	50, 353	11, 000
1862	122, 117	4, 712	1882	45, 921	11, 000
1863		5, 878			
1864		7, 263		998, 638	261, 834
1865		4, 908			
1866		5, 327			
1867	153, 224	7, 532			
1868		8, 253			
1869		9, 179			

The world's production of quicksilver from 1850 *to the close of* 1882.

Production in California for 33 years....	1,310,678	flasks, each of 76.50 pounds av'd.
Production in Spain for 33 years	998,638	flasks, each of 76.07 pounds av'd.
Production in Austria for 33 years.......	261,834	flasks, each of 76.07 pounds av'd.
Total	2,571,150	

Estimated present yearly production of Italy and other countries ....2,000 flasks.

Price of quicksilver.—In this country, quicksilver is almost invariably quoted at so much per pound; in London, the leading foreign market, quotations are by flasks. The accompanying table shows the remarkable fluctuations which have taken place in the value of quicksilver during the past thirty-three years:

Highest and lowest prices of quicksilver during the past thirty-three years.

Years.	Price in San Francisco, per pound.		Price in London, per flask.	
	Highest.	Lowest.	Highest.	Lowest.
			£ s. d.	£ s. d.
1850	$1 50	$1 10	15 00 0	13 2 6
1851	1 00	75	13 15 0	12 5 0
1852	80	72½	11 10 0	9 7 6
1853	72½	72½	8 15 0	8 2 6
1854	72½	72½	7 15 0	7 5 0
1855	72½	67½	6 17 6	6 10 0
1856	67½	67½	6 10 0	6 10 0
1857	70	60	6 10 0	6 10 0
1858	65	60	7 10 0	7 5 0
1859	1 00	65	7 5 0	7 00 0
1860	75	65	7 00 0	7 00 0
1861	65	45	7 00 0	7 00 0
1862	50	45	7 00 0	7 00 0
1863	60	50	7 00 0	7 00 0
1864	60	60	9 00 0	7 10 0
1865	60	60	8 00 0	7 17 6
1866	75	60	8 00 0	6 17 6
1867	60	60	7 00 0	6 16 0
1868	60	60	6 17 0	6 16 0
1869	60	60	6 17 0	6 16 0
1870	90	60	10 00 0	6 16 0
1871	90	75	12 00 0	9 00 0
1872	87½	85	13 00 0	10 00 0
1873	1 20	90	20 00 0	12 10 0
1874	1 55	1 20	26 00 0	19 00 0
1875	1 55	65	24 00 0	9 17 6
1876	70	45	12 00 0	7 17 6
1877	57½	40	9 10 0	7 2 6
1878	47	39	7 5 0	6 7 6
1879	45	33	8 15 0	5 17 6
1880	45	36	7 15 0	6 7 6
1881	41½	36¼	7 00 0	6 2 6
1882	38	35¾	6 5 0	5 15 0
Extreme range in thirty-three years	1 55	33	26 00 0	5 15 0

The highest and lowest prices at San Francisco from July 1, 1882, to May 1, 1883, were as follows:

Recent prices of quicksilver at San Francisco.

Months.	Highest.	Lowest.
1882.	*Cts. per lb.*	*Cts. per lb.*
July	37¼	37
August	37¾	37
September	37¾	37
October	37¼	36¾
November	37¼	36¾
December	36½	35¾
1883.		
January	35½	33¾
February	35⅝	35¼
March	36⅝	35¼
April	35¼	35¼

Assuming the mean between the highest quotation in 1882, 38 cents, and the lowest, 35¾ cents (36⅞ cents per pound), as the average price at San Francisco during that year, the total value of the domestic product for 1882 may be stated at $1,487,537. The value of the product of the first six months of 1883 is estimated at $613,213, assuming an average price of 35¼ cents per pound.

The California mines.—The following table shows the location, ownership, and capital stock of some of the leading California quicksilver mines:

Capital stock, etc., of leading quicksilver mining companies.

Name of company.	Location of mine.	Main office address.	Capital stock.	Number of shares.	Par value per share.
The Quicksilver Mining Company.	New Almaden, Santa Clara county.	New Almaden, California.	$10,000,000	*a*100,000	$100
Sulphur Bank Quicksilver Mining Company.	Lake county	San Francisco, California.	10,000,000	100,100	100
Redington Quicksilver Mining Company.	....do	....do	1,260,000	1,260	1,000
Great Western Quicksilver Mining Company.	....do	....do	5,000,000	50,000	100
Santa Clara Mining Association.	Santa Clara county.	....do	3,000,000	30,000	100
Napa Consolidated Quicksilver Mining Company.	Napa county	Boston, Massachusetts.	700,000	100,000	7
The New Idria Mining Company.	Fresno county.	San Francisco, California.			
Great Eastern Quicksilver Mining Company.	Sonoma county.	....do			

a Quotations: 57,000 shares preferred stock, $80 per share; 43,000 shares common stock, $40 per share.

All of the quicksilver mines now at work are owned by corporations, and none of importance are owned or operated by individuals. The claims are prospected for and located in a manner similar to that followed in gold and silver mining. If of value, they usually pass into the hands of companies. As there are no custom reduction works, and no system for the sale and purchase of ores, the smaller mines are at a disadvantage. Such claims sometimes have retorts, or simple furnaces, which cannot compete with the more elaborate plant of the larger companies.

The New Almaden mine is well equipped with pumping and hoisting machinery, designed for sinking to a depth of 2,000 feet from the surface. The Guadalupe and Redington mines have good machinery, but will require more power for deeper working. No pumping is yet required at the Napa Consolidated mine, but powerful machinery will be needed both for pumping and for hoisting if the mine is to be developed at greater depth. The New Almaden mine is the most extensive, and is worked through four shafts, of which the deepest is now 1,400 feet. There are about 33 miles of shafts, tunnels, drifts, and winzes in this mine. The other mines are worked through single shafts, that at the Guadalupe being about 800 feet in depth, and the remaining mines are opened by shallow shafts, and also by adits.

Method of mining.—In the main, quicksilver mining resembles gold and silver mining. The mode of stoping is generally overhand, but is varied by local circumstances. The common method is as follows: The vein having been exposed by drifting along the hanging wall by two levels about 100 feet vertically apart, a winze is sunk between these levels, partly for the purpose of prospecting the veins, and partly for affording ventilation during the subsequent stoping. The work of extraction then begins on the lower level, and the ore is taken out on that level from the hanging wall towards the foot wall, so far as its value is sufficient to warrant the cost of extraction and reduction. When so much of the ore has been taken out as can be conveniently mined from the level, stulls are put in. These consist of 14 by 14 inch timbers placed parallel to each other along the drift, and perpendicular to the dip of the vein, serving the double purpose of sustaining the hanging wall and supporting the platform from which the stoping is continued upwards. The stopes are worked outwards in all directions to the limits of the ore body, and stulls are put in wherever the requirements of the ground make them necessary. The ore as it is mined is thrown down through cribbed chutes of round timber to the level, and is then taken by handcars to the shaft and hoisted.

Furnaces.—For roasting coarse ores (*granza*), pieces from three to ten inches in diameter, shaft furnaces are used; and these are either continuous or intermittent in their operation, the majority being of the former type. The fine ores (*tierras*), from fine sand to three inches in size, were formerly made into adobes or sun-dried bricks, and were then roasted in intermittent furnaces. This mode of working has been superseded by the continuous shelf furnace of Messrs. Hütner and Scott, patented October 31, 1876, with improvements patented by Mr. J. B. Randol and Mr. H. J. Hütner, November 30, 1880. The capacity of these tierras furnaces ranges from 10 to 35 tons. They are in successful operation at New Almaden, the Sulphur Bank, and at the Napa Consolidated mine. The shaft furnaces for coarse ores at New Almaden, as well as all other known types of quicksilver furnaces, are described and illustrated in the testimony filed in the patent case of R. J. Knox *et al. versus* The

Quicksilver Mining Company, in the circuit court of the United States, California.

The fuel used in the furnaces is wood, coal, charcoal, and petroleum, in the order named. Petroleum is used only at Guadalupe, where its adoption is said to have been successful. The cost of roasting ore averages $1 per ton for fuel and labor; and the cost of roasting per flask of quicksilver produced depends of course upon the richness or leanness of the ores treated.

Mining men do not look for important improvements in the quicksilver furnaces; but there is a large field open for perfecting the condensers.

The following list comprises the more important furnaces working in June, 1883:

Principal quicksilver furnaces in California (June, 1883).

Name of works.	County.	Name of compan.	Main office address of company.	Number of furnaces.
New Almaden	Santa Clara.	The Quicksilver Mining Company.	New Almaden, California.	8
New Idria	Fresno	The New Idria Mining Company.	San Francisco, California.	3
Napa Consolidated	Napa	Napa Consolidated Quicksilver Mining Company.	Boston, Massachusetts	2
Sulphur Bank	Lake	Sulphur Bank Quicksilver Mining Company.	San Francisco, California.	7
Great Eastern	Sonoma	Great Eastern Quicksilver Mining Company.	do	2
Guadalupe	Santa Clara.	Santa Clara Mining Association.	do	4
Great Western	Lake	Great Western Quicksilver Mining Company.	328 Montgomery street, San Francisco, California.	4

Name of works.	County.	Total capacity of furnaces.	Number of furnaces in use.	Style of furnaces.
		Tons.		
New Almaden	Santa Clara.	*a*3, 000	8	1 intermittent, 2 shaft (continuous), 5 tierras (continuous).
New Idria	Fresno		1	All continuous shaft furnaces.
Napa Consolidated	Napa	*a*1, 500	2	Both shaft furnaces; one for fine and one for coarse ore.
Sulphur Bank	Lake	100	3	2 Knox & Osborn, 5 Almaden.
Great Eastern	Sonoma	18	2	Patera.
Guadalupe	Santa Clara.	75	0	Knox & Osborn.
Great Western	Lake	*a*2, 500	4	2 continuous Green & Halsey (for coarse ore), 1 Livermore (for fine ore), 1 Litchfield (for fine ore).

a Monthly

Labor.—About 1,200 men are directly employed in the quicksilver mines and furnaces of California, in addition to whom a large number are occupied as wood-choppers, teamsters, etc., working on contract. The leading nationalities of the miners and furnace-men may be stated in the following order: Mexicans, Cornishmen, Swedes, and Chinese, with comparatively few Americans. The Mexican miners, as in so many other instances, have developed a special fitness for this class of work, and their intelligence in finding ore amounts almost to an instinct. For the regular underground work of a mine, such as drilling, blasting, timbering, etc., the Cornishmen and Americans probably take the lead. Miners at day work are paid from $2 to $3 per shift of ten hours, and on contract work earn from $2.50 to $3 per shift of eight hours. The wages of furnace-men are $2 to $2.50 for shifts of ten and twelve hours. The New Idria mine gives employment to 120 men. Here the wages of white miners average $2.25 per day, the men boarding themselves. Blacksmiths and other mechanics and overseers are paid $4 per day. The Great Eastern mine employs 35 men, of whom about one-half are white and one-half Chinese. At this mine white miners are paid $2.50 per day, boarding themselves; and the Chinese $1.25. The Napa Consolidated employs from 60 to 70 men, at about the same wages. At the Sulphur Bank there are 90 men, of whom one-half are Chinese. Wages at this mine are the same as at the Great Eastern; and in all the mines above named mechanics and foremen are paid from $3.50 to $4 per day. The Great Western mine employs 25 men. White miners are paid $1.25 per day and board; Mexicans $2.50 and $3 per day and board. At New Almaden, where a force of 500 men is employed, the average daily wages are $2.50.

An estimate has recently been made from the working results of different mines, showing that for every flask of quicksilver produced nine days' actual labor (calculated as if done by one man) is required. This, at the low average of $2 per day, would make the amount paid for labor $18 (and probably upwards) for every flask manufactured, or between 23 and 24 cents per pound; which, at the present prices of quicksilver, does not allow a large margin for profit after accounting for the other expenses, such as supplies, fuel, powder, flasks, steel, transportation, etc.

Flasks.—The flasks in which quicksilver is marketed and conveyed to the gold and silver reduction works, etc., are made of wrought iron, and are sent to California from Pennsylvania. The average weight is 13 pounds. New flasks cost $1.15 each, and second-hand ones from 80 to 90 cents. They are quite uniform in dimensions, shape, and appearance, and no patented forms have come into use. In the regular type the flask is cylindrical, with a small conical top, and the extreme length inside is $11\frac{7}{8}$ inches. The mouth is 1 inch, tapering to $\frac{7}{8}$ inch at the neck. At the sides the inside length is $11\frac{1}{4}$ inches, and the inside diameter is $4\frac{3}{4}$ inches at the bottom, $4\frac{5}{8}$ inches at the middle, and $4\frac{3}{8}$ inches at the top. The flasks are $\frac{1}{2}$ inch thick at the top, $\frac{3}{8}$ inch at the bottom, and $\frac{3}{16}$ inch at the sides of the shell. For convenience in handling in transportation by stages and wagons, the flasks are sometimes inclosed in leather jackets provided with handles.

Vermilion.—Vermilion is an artificial sulphide of mercury. It is made on a large scale in the neighborhood of New York City, and dealers agree very closely in estimating the total quantity of vermilion made in the United States in 1882 at 700,000 pounds. The price at the close of 1882 was 45 cents per pound. The duty on quicksilver will have a tendency to advance the price of the domestic vermilion, which now sells at about 25 per cent. below the imported article. The foreign sources of supply from which vermilion comes to the United States are England, which furnishes the larger part; China, which, though manufacturing vermilion on an immense scale, does not send much to the United States; and Austria, from which comparatively small quantities are received. American vermilion is now said to be fully equal in every respect to the foreign, but it is often sold as "English" vermilion, as dealers claim, not to deceive as to its being made here, but as a distinctive name and brand for vermilion made by a certain process. Sometimes "Chinese" vermilion is made in this country. The quicksilver used by the manufacturers of vermilion is both from California and is imported, and sometimes reimported California quicksilver returns to this country after having made nearly the circuit of the world from San Francisco, via China, London, and thence to New York. No difference in the quality of quicksilver is perceptible, and the vermilion makers use either the domestic or the foreign indifferently. The proportion of pure vermilion is to that of the quicksilver from which it is made in the ratio of 112 pounds of the former to 100 pounds of the latter. The firms engaged in the manufacture of vermilion are: C. T. Raynolds & Co.; D. F. Tiemann & Co.; Sondheim, Alsberg & Co., and A. B. Ansbacher & Co., all of New York city.

NICKEL.

BY W. P. BLAKE.

THE ORES OF NICKEL.

Nickel, next to iron, is one of the most universally disseminated metals. It is found not only in all the metalliferous regions of the known world, but also in the meteoric masses which fall to the earth's surface from the regions of space. Tissandier found it in the meteoric dust falling through the atmosphere, collected on a large porcelain surface, (*a*) and its presence in the sun is revealed to us by the spectroscope. It thus enters into the composition of other worlds than ours, and probably pervades the solar system. But notwithstanding this universal distribution, and the apparent abundance of this element, it is only a few years since the metal was first separated from its impurities in commercial quantities and utilized in its pure state without alloy or contamination by sulphur, arsenic, or other elements with which it is universally combined in its natural state. It has never been found in a fine metallic condition.

Geographical distribution.—The geographical distribution of the ores of nickel in the United States is more general than is commonly supposed. They occur in moderate quantity, in close association with chrome ores, in the serpentine rocks from Canada to Maryland, and equally so with the chrome ores of the Pacific coast, notably in Oregon. Dr. T. Sterry Hunt long ago pointed out the general diffusion of nickel throughout the magnesian rocks of the Quebec group.(*b*) He directed attention to the fact that both chromium and nickel are almost always present in the serpentine rocks of the Green Mountain series in the same geological horizon as the serpentines of Canada and of Norway. He says, also, that the serpentines of Cornwall, the Vosges, Mount Rosa, and of many other regions agree in containing chromium and nickel, and these elements are also found in the Urschiefer, or primitive schists of Norway. Nickel is seldom or never absent from the serpentines, steatites, diallages, and actinolites of the Quebec group,(*c*) and is found also in the associated dolomites in traces and in very small quantities in the magnesites of Sutton and at Bolton, and in the Laurentian gneiss on the Assumption river.

The element is also found to be closely associated with iron terres-

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a Comptes Rendus, 83, 1876, 75.

b See Chemical and Geological Essays, p. 31; also, Reports of the Geological Survey of Canada.

c Geological Survey of Canada, pp. 506, 507.

tially as well as in meteorites. Leaving out of view the great masses of metallic iron of Greenland (of which the Ovifat mass containing nickel is a familiar example, and the meteoric origin of which is still in doubt), we find that a nickeliferous limonite occurs in Lincoln county, North Carolina, and that similar ore is found in Michigan, from which a superior nickeliferous iron has been made. The spathic iron ore of Antwerp, New York, also contains nickel in the form of millerite, and no doubt many other examples might be found of the close terrestial association of nickel and iron.

The ancient rocks of Michigan and the Lake Superior region are also found to contain many deposits of nickel, and several localities have been noted and partially explored, but none have yet been worked with commercial success.

Further evidence of the general diffusion of nickel, and of its abundance in the Lake Superior region, is found in the results of analyses of the refined copper of Lake Superior. Egleston has shown that it exists in the copper in small quantities.(*a*)

In New Mexico there are localities which it is said will furnish considerable quantities of 8 per cent. ore, and important localities are known to exist in Oregon, California, and in Nevada.

The most abundant ore of nickel is in the form of a mixture with pyrrhotite or magnetic iron pyrites, which is found more abundantly in the older crystalline rocks than in those of later formation. This form of nickel ore occurs in Canada, Vermont, Connecticut, in the highlands of the Hudson in New Jersey, and in Pennsylvania. It is abundant in Connecticut at Torrington and Litchfield, and in Pennsylvania at Lancaster Gap. These ores however seldom average over 2 per cent. of nickel as mined. Other nickel minerals of a higher percentage, but occurring in much smaller quantities, are found associated or occurring separately; as for example niccolite, containing about 44 per cent. of nickel and 56 per cent. of arsenic, at Chatham, Connecticut, together with breithauptite (nickel 31.43, antimony 68.57) and chathamite, containing nickel 9 to 10 per cent., with arsenic, sulphur, and iron. At Finksburg, Carroll county, Maryland, the species siegenite (cobalt pyrites) occurs with chalcopyrite, and it is cited as occurring also at Mine la Motte, Missouri. This species, which contains 29 to 30 per cent. of nickel, is found near Siegen, in Prussia, and in Sweden.

The presence of nickel in the serpentine rocks of Pennsylvania associated with chrome ores is well known by the beautiful green crusts on the massive chromite quarried at Wood's pit for the manufacture of bichromate of potash at Baltimore. These green crusts, known as "emerald nickel," consist chiefly of hydrous nickel carbonate, and are derived by infiltration from small granular nodules of nickel sulphide disseminated in the midst of a massive "violet talc" (kammererite)

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a Transactions American Institute of Mining Engineers, Vol. IX., p. 728.

accompanying the chromite. Similar coatings of emerald nickel occur upon the chrome ores of southern Oregon and probably have a similar origin. This ore of nickel, though rich in the metal and very desirable, is not abundant enough to work, and has not been utilized except for cabinet specimens.

The most available ore of nickel and the only one worked up to this date in the United States is the sulphide, occurring in connection with magnetic pyrites. Although the amount of nickel rarely exceeds 3 per cent., the quantity of ore is so large and available and the sulphide ore is so readily smelted or enriched in nickel by roasting and matting that it is the most economical ore to treat for nickel. Until the discovery of large deposits of nickel silicate ore in New Caledonia, the sulphureted ore was the chief source of nickel in Europe and America, and it still continues to be worked. This is an ore which occurs at many places along the lines of the older or Archæan rocks, being found with the beds of pyrrhotite from Canada southward. The principal localities are, however, in Connecticut and Pennsylvania. These, and some other localities, will now be briefly noticed.

PRINCIPAL LOCALITIES OF NICKEL ORE IN AMERICA.

Chatham, Connecticut.—The locality at Chatham, Connecticut, about six miles from Middletown, yields both nickel and cobalt in combination with arsenic and sulphur. The ore occurs in mica slate. It is not now worked, but it was one of the first places explored for metals in New England. As early as the year 1661 the inhabitants of Middletown made a grant to "our much-honored governor, Mr. John Winthrop, for the discovery of mines and minerals and for the setting up of such works as shall be useful for the improvement of them." It is probable that the governor hoped to find silver, being misled by the white, shining ore. Neither nickel nor cobalt had then been discovered. About one hundred years later, in 1762, Dr. John Sebastian Stephanney, a German, reopened the old works, and in 1770 associated John Knool and Gominus Eskelens with him, and worked the mine for cobalt. In 1781, January 1, President Stiles of Yale College wrote in his diary that Mr. Eskelens had visited him "full of his cobalt mine and China voyage. He some years ago bought the Governor's Ring, as it is called, or a mountain in the northwest corner of East Haddam, comprehending about 800 acres, or about a square mile area. Here he finds plenty of cobalt, which he manufactures into smalt, with which is made the beautiful blue of chinaware." Some twenty tons of cobalt ore appear to have been shipped to China from this locality. Nothing more appears to have been done for thirty years. In 1818 Mr. Seth Hunt, of New Hampshire, worked the mine for three years, and expended about $20,000. The ore was taken to Glastenbury and stamped by hand. He obtained, as he supposed, about 1,000 pounds of cobalt and shipped it to England, where it was found to be nickel, containing only a low percentage of cobalt. The difficulty in separating the nickel from the cobalt caused him to abandon the property. The mine was again reopened by Professor Charles U. Shepard in 1844, but with no greater success.

In 1853 an attempt was made to work the mine on a larger scale than before, and a company known as the "Chatham Cobalt Mining Company" was organized for the purpose. The assays made at the time upon the dressed ores show that they contained about 18 per cent. of nickel and cobalt, in nearly equal quantity, or 9 per cent. of each. The firm of William Coffin & Co., then operating in nickel at Camden, near Philadelphia, offered to take all the ore that could be produced, up to 200 tons annually, of that grade, and pay $200 per ton (of 2,240 pounds) for it on the wharf at Philadelphia. Cobalt at that time was worth 14 shillings sterling per pound, and nickel $1.70 per pound. According to a report by Mr. Simonin it appears that the average metallic contents of the ore as mined, before dressing, was 2.2 per cent. The property was examined and reported upon in 1855 by Prof. Jas. C. Booth, of the United States Mint, who found that the ore crushed and washed in a Bradford's ore separator yielded a product averaging about 20 per cent. of the oxides of nickel and cobalt in nearly equal parts. This company made a good display of the ores and products at the International Exhibition, New York, 1853. The second annual report of the company, by Dr. Francfort, the manager, though very complete as regards the amount of machinery and facilities for working brought together during the eighteen months after the organization, is silent as regards the production, which it may be assumed was comparatively insignificant. The enterprise was soon after abandoned. It is believed that a small quantity of nickel from this source reached the Mint.

Other localities in Connecticut.—There are small quantities of nickel at other places in the ancient schists of Connecticut. The principal localities, however, are at Torrington, where nickel ore was once mined on a considerable scale, most of it being sent to England, but the undertaking was an unprofitable one, and was not long continued. The Litchfield nickel mine is about 10 miles further south, and yielded ores similar to those obtained at Lancaster Gap, in Pennsylvania. Neither of these localities have been worked for many years. The mines are full of water, and an old furnace formerly used for smelting the ore is in ruins.

Orford, Quebec.—The sulphuret of nickel (millerite) is found in the township of Orford, Province of Quebec, Canada, and has been described by Professor Hunt,(*a*) and later by Mr. W. E. C. Eustis, of Boston.(*b*) It is disseminated through a mixture of green chrome garnet with calcspar and through the adjacent rock. The ore is very lean; 508 pounds run through the small blast furnace at the Massachusetts Institute of Tech

a Geology of Canada, 1863, p. 738.

b Transactions American Institute of Mining Engineers, Vol. VI., p. 209.

nology gave 8 pounds of matte, or alloy, containing 71.84 per cent. iron and 22.70 per cent. of nickel.

Thunder bay.—Mr. W. M. Courtis has directed attention to a nickel ore containing 4.50 per cent. of the metal, with some cobalt, from Silver Harbor, on the west side of Thunder bay, on the north shore of Lake Superior, and at other places inland.(*a*) The ore of Thunder bay is niccolite associated with native silver, and occurs in a vein traversing Huronian talcose slates. Another locality on Heron bay affords an ore containing silver and gold and 9 or 10 per cent. of cobalt and nickel.

Wallace mine.—Nickel ore occurs also on the north shore of Lake Huron, in Canada West, at the Wallace mine. Sir William Logan, the director of the geological survey of Canada in 1863, describes this ore as a fine steel-gray mixture, whose analysis, after deducting earthy matters derived from the gangue, gave, in 100 parts: Iron, 41.79; nickel, 13.93; arsenic, 6.02; sulphur, 38.16; copper, 0.10. Another sample specimen gave 8.26 per cent. of nickel. The nickel contains about three parts in a thousand of cobalt. This Wallace mine was originally opened and worked as a copper mine in the years 1848 and 1849. About three casks of nickel ore were taken out and shipped to a gentleman in New York, who had it smelted and a part of the product worked up into dish-covers, and sold the remainder for making nickel silver.(*b*) The ore occurs in quartzose and chloritic schists. A specimen analyzed by Messrs. Partz and Buck yielded 6.30 per cent. of nickel. A company was formed to work this property, but it did not succeed.

Mine la Motte, Missouri.—In Missouri the ancient Mine la Motte has furnished considerable ore, from which nickel is obtained in the form of matte, which is generally exported. Some of the earlier supplies of nickel at the Mint for the small nickel bronze coins were obtained from this source.

California.—Nickel ore occurs associated with chromite in Kern county, in this State, but this locality has hitherto furnished only samples.

Oregon.—A new deposit of nickel ore has recently been brought to notice, and is extremely interesting, inasmuch as the ore closely resembles the ores from New Caledonia. It is essentially a hydrated silicate of nickel oxide and contains from 20 to 30 per cent. of nickel oxide (in selected samples) and an average, perhaps, of 10 per cent., though the locality has not yet been sufficiently worked to determine satisfactorily what the ore will average in large quantities. The locality is in southern Oregon, in Douglas county, at Piney mountain, about 8 miles from Cañonville. It was discovered in 1881. It is described as corresponding exactly in its association and mode of occurrence with the description given by Professor Liverridge of the New Caledonia ores. These are found in serpentine with chromite and steatite. In Oregon the ore

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a Transactions American Institute of Mining Engineers, Vol. I., pp. 482 and 484.
b *Vide* report by Messrs. Partz and Buck, 1864.

is found in bunches and pocket-like accumulations in serpentine with chromite. Analyses have been made by Dr. Hood, who gives his results in comparison with the New Caledonia nickel ores as follows:

Analyses of Oregon nickel ores, compared with those of New Caledonia.

	Oregon ore, A.	Oregon ore, B.	Garnierite.	Noumeaite.
Silica	48.21	40.55	47.23	47.90
Iron and aluminum oxide	1.38	1.33	1.66	3.00
Nickel oxide	23.88	29.66	24.01	24.00
Magnesia	19.90	21.70	21.66	12.51
Water	6.63	7.00	5.26	12.73
	100.00	100.24	99.82	100.14

There is not properly any mineralogical distinction between garnierite and noumeaite. The ore is mainly a mechanical mixture or infiltration, penetrating and charging absorbent magnesian rock with greater or less amounts of nickel. The composition is not constant. The color varies from rich dark green to a pale whitish green, according to the amount of oxide of nickel absorbed. It is by some authorities referred to the old species pimelite, but it appears to contain more silica and less water than that species.

Nevada.—Dr. T. Sterry Hunt also cites a nickel ore from western Nevada,(*a*) describing it from a sample submitted to him in 1876 as a greenish, translucent, amorphous mineral with black stains, resembling chrysocolla in appearance. Analyses at the Massachusetts Institute of Technology gave oxide of nickel 3.23 per cent. and oxide of cobalt 3.88 per cent. This is probably the same kind of ore, and from the same locality, near Columbus, which yielded some ten tons, but much richer in nickel than the sample analyzed, shipped from San Francisco to Swansea in 1882.

Colorado.—Mr. F. F. Chisolm reports that nickel in small quantities, with its associated metal, cobalt, is found in many veins throughout the Rocky mountains; but hitherto mining for nickel exclusively has not been prosecuted, except at the Gem mine in Grape Creek cañon, Fremont county, Colorado. Here the metal occurs quite abundantly, and is associated with silver. Some tons of ore were mined and shipped to New Jersey for reduction, but the trial apparently was not successful, as work on the mine has been discontinued. Nickel occurs in the ore from some mines at Leadville in small quantities.

British Columbia.—Dr. James Blake has noted the occurrence of nickeliferous sand on Fraser river, British Columbia.(*b*)

Lancaster Gap, Pennsylvania.—But of all the localities cited the only

a Transactions American Institute of Mining Engineers, Vol. X., p. 23.
b *American Journal of Science*, Vol. III., vii., p. 238.

one which has exerted an important influence on the development of the metallurgy of nickel in the United States is that of Lancaster Gap, in Lancaster county, Pennsylvania. Mr. Joseph Wharton, of Philadelphia, leased the mine January 1, 1863, and finally purchased it May 6, 1867. He is now the only producer of metallic nickel in the United States.

The ore of Lancaster Gap is the nickeliferous pyrrhotite, containing in bulk from 1.50 to 2 per cent. of nickel. It is enriched at the mine by smelting into a matte containing 10 per cent. or more of the metal, and in this condition the nickel is taken to Camden, New Jersey, opposite Philadelphia, for extraction. There is associated with the pyrrhotite the mineral species millerite, in crusts and layers formed of a close aggregation of the slender crystals which give a velvet-like surface to the crusts when formed in cavities. Specimens several inches broad are frequently found, and from one-eighth to one-quarter of an inch in thickness.

Nickel ore from this mine was treated as early as 1850, though the mine had been previously worked for copper. Works for the extraction of nickel from the Lancaster and other ores were first started in Philadelphia, and in 1853 Messrs. F. M. Buck, E. W. Coffin, and others erected nickel works at Camden, supplying them with ore from the Gap mine. These were the same persons who proposed to work the Chatham ores. Mr. Wharton leased the Camden works May 13, 1863, and purchased them January 19, 1869. They were then greatly enlarged and extended.

A large portion of the metal produced at these works by Mr. Wharton has been used at the United States Mint for the subsidiary small coins, and a considerable amount has been exported. Since the development of nickeling by galvanism a large part of the product has been put into the form of nickel salts and anodes.

FOREIGN LOCALITIES.

Sweden.—Nickeliferous magnetic pyrites is found abundantly in Sweden, but in general is too poor in the metal to pay for working. The principal works for the extraction of nickel are at Klefra, in Jönköping (Småland), and of Sagmyra, in Dalécarlie. The product is an alloy of nickel and copper. The product in 1876 amounted to 790 quintals of nickel speiss, 1,035 quintals of concentrated matte, and 220 quintals of nickel of high grade.(*a*)

There is also an establishment for the manufacture of cobalt—the Gladhammars Grufro-Aktiebolag (the Gladhammar Mining Company). The mines yielding cobalt ore containing nickel are near the city of Vesterrik, and have been worked since the commencement of the sixteenth century for iron and copper, but since the beginning of the present century for the cobalt. The richest ores, containing 10 per cent. and over of cobalt, are exported, while the lower grades have recently been

a Sidenbladh, Exposé Statistique, p. 324.

treated by smelting for enrichment. The production of rich ore in 1876 amounted to 287 tons, exported chiefly to England, and 1,042 tons of poor ore.

In 1878 this company employed 16 workmen; wages from 2 francs 10 centimes to 2 francs 80 centimes per day. They are lodged gratuitously in houses constructed by the company. The taxes for the year amounted to 160 francs (about $30).

Saxony.—The clay slate and mica schist district near Schneeberg contains over 150 lodes, yielding nickel, cobalt, bismuth, and arsenic within a zone six miles in length and about two miles in width. The mines and works date from 1642, and employed in 1873 1,200 miners and smelters.(*a*)

New Caledonia.—A very important discovery of high-grade ores of nickel was made shortly before the International Exhibition in 1876, in the French penal colony of Noumea. This ore, as found near to the sea coast, is chiefly silicate of the oxide of nickel, free from arsenic, cobalt, or other injurious elements. It is easily worked by the wet or dry methods, and is known as noumeaite or garnierite.(*b*) The percentage of nickel is variable. Analyses have already been given (page 404).

According to Messrs. Christofle and Bouilhet (*c*) the ores from New Caledonia as they reached Europe in 1876, contained on an average 18 per cent. of protoxide of nickel, and had the following average composition:

Water	22
Silica	38
Peroxide of iron	07
Protoxide of nickel	18
Magnesia	15
	100

The same authorities gave at the same time an analysis of the metallic nickel obtained from these ores by the wet method and fusion:

Nickel	97.75
Silicium	.54
Carbon	1.25
Manganese	.36
	99.90

The New Caledonia mines are owned chiefly by a French company, and are worked at a small cost, in part by convict labor. Being near the coast, the ores can be conveniently shipped and cheaply transported to any part of the world. It is fair to assume, however, that like most

a Report on the Metallurgicial Exhibits at the Vienna Exhibition, by Messrs. Maw and Dredge.

b The mineral garnierite was discovered by Garnier in 1865, and noticed in 1867, (Bull. Soc. G. H., XXIV., p. 448), and was described by Professor Liversidge in July, 1874, (Jour. Chem. Soc., II., xii., 613), whose analysis showed the presence of about 24 per cent. of nickel oxide.

c Comptes Rendus, 83, 1876, p. 29.

oxidized ores, they are most abundant at and for a short distance below the surface; and that during the first few years of working the mineral will probably be yielded more rapidly and cheaply than it can be obtained afterwards.

The influence of the ores from New Caledonia is already felt in the nickel markets, not alone in cheapening the production of nickel and nickel salts and alloys, but also in the improvement of the quality of the alloys of nickel, making them more ductile, tractable, and in every way superior to the alloys made from impure nickel. The use of these clean ores dates from about 1876. The ores were shown in great abundance at the International Exhibition at Paris in 1878, together with many examples of the greatly improved alloys derived from them. The composition varied greatly, ranging from a few per cent. of nickel to over 20 per cent. There was for a time an oversupply, shiploads arriving at the French and British ports faster than required. The ore was already largely used at Christofle's new establishment. He early perceived the great advantages which this new docile ore from the French penal colony offered. He enlarged his works and in reality erected new works on a grand scale at St. Denis, near Paris, and generously invited the members of the international jury to inspect them. This establishment then had a capacity of production of 400 kilograms of nickel daily, say 240,000 pounds annually, but were producing only half of that quantity. Both the wet and dry methods are employed. The richest selected and washed ore is melted direct with carbonate of soda in crucibles, giving metallic nickel, which is granulated in water. The wet process consists in digesting the ore with acids, precipitating the iron first and then the nickel as oxide, which is washed, dried, reduced to sponge, and finally fused with copper to make copper bronze for use in making German silver. This firm had in 1878 a large stock of New Caledonia ore stored away, about 2,000 tons of 10 per cent. ore, valued at 500,000 francs.

Spain.—An ore resembling that from New Caledonia is reported by M. Meissonnier to exist in the province of Malaga, Spain. It is said to carry 8.96 per cent. of nickel and no cobalt.(*a*) It is referred to the species pimelite.

New South Wales.—Nickel ores do not appear to be abundant in New South Wales. Professor Liversidge reports(*b*) a massive variety of copper-nickel of a copper-red color partly incrusted with pale green nickel hydrate, from near Bathurst. Some has also been found on the Peel river.

PRODUCTION AND VALUE.

Price.—The price of metallic nickel in the market has been subject to considerable fluctuations, depending upon the variable demand and sup-

a Comptes Rendus, 83, 1876, p. 229.
b Minerals of New South Wales, p. 57.

ply. The metal is to be viewed as a new material, a new gift to the industrial arts, with an unknown number of applications before it. The discovery of the cheap and effective methods of depositing nickel from solution by electricity at once created a new outlet for a large quantity annually—a quantity which like the silver used in electro-plating is forever lost to the arts, not being capable of being economically regained, as is usually the case with alloys and objects made of solid metals. The demands for coinage also have not only been large, but have been sudden and transient, and have been the chief disturbers of the average market price of the metal. The production of nickel has always been comparatively limited, inasmuch as the consumption has been uncertain and not firmly established by a long-continued use of the metal in the arts.

Although the localities are numerous and wide-spread, the ores are not very rich and abundant; and it appears certain that the production of this metal will always require tedious and expensive processes, such as to make the item of labor an important one in the costs of production. This will always give the metal a high value as compared with iron or copper, and makes it on this account, as on others, well adapted to use as money, it being so largely a representative of labor performed.

According to Wharton,(*a*) the extremes in the price of nickel in England since the metal attained commercial importance up to about the year 1877 were from 4*s.* to 16*s.* per pound—say $1 to $4 per pound—the former rarely touched and the latter but once for a short time in 1873. In the year 1861 nickel was quoted at from $1.15 to $1.20 per pound. In 1864 it was quoted at 8*s.* in England and in 1867 in France at 1,500 to 1,700 francs per 100 kilograms, or 7½ to 8½ francs per pound. The present price in England, in 1883, is quoted in a memorial to Congress at the equivalent of 70 cents per pound.

Mr. J. M. Merrick, in his excellent article upon nickel in Johnston's Cyclopedia, gives a tabular statement showing the range of price of nickel per pound in large lots for a series of years from 1870 to 1876, as follows:

Price of nickel from 1870 *to* 1876.

	Price per pound (gold).
1870	$1 25
1871	1 50
1872	2 25
1873	3 25
1874	2 80
1875	3 00

The following figures give, in continuation of the preceding, the average market price of nickel in the United States from 1875 to January 1, 1883, a period of seven years:

a Sources and Prices of Nickel, p. 29.

Price of nickel from 1876 *to* 1883.

Years.	Price.
1876	$2 60 gold.
1877	2 00 to $1 20 currency.
1878	1 20 to 1 00 currency.
1879	1 15 to 1 10 currency.
1880	1 10 currency.
1881	1 10 currency.
1882	1 10 currency.

The market price at the end of the year 1882 was $1.10 per pound, and in May, 1883, about $1 per pound wholesale. Reductions or discounts are made by foreign makers to their large customers in the United States, the amount of which in each case is not known.

The extreme prices in the United States for ten years prior to 1877 were, according to Mr. Wharton, about $1.40 and $2.80 gold for large contracts. The nickel then made contained about 5 per cent. more impurities than the best since made, which contains 98 per cent. or over of pure nickel. In the years 1874, 1875, and 1876 the German Government paid an average price of about 10*s*. 6*d*., say $2.62 gold, per pound for the nickel in the planchets for coining. The extraordinary demand for the metal from this source carried the price for a time abnormally high, to $3.50 per pound. During that period the German Government consumed in coinage over 800,000 pounds of nickel (380,748 kilograms up to January 6, 1877, not including waste), purchased as planchets ready for stamping.

The relative value of nickel and silver, taking 54*d*. per ounce for standard silver, or 58⅝*d*. for fine and 5*s*. per pound for nickel, is as 1 to 14.18.

Production in the United States.—Before the year 1864 the whole amount of pure nickel made in the United States was not over 100,000 pounds avoirdupois.(*a*) Since then, to May, 1867, the Camden works turned out 105,000 pounds, and they were at that time producing at the rate of 150,000 pounds annually.

The total production of nickel from the Gap mine to the end of the year 1882 is estimated at about 4,000,000 pounds. It is not now being worked, having been shut down since January, 1883, and there is now, therefore, no production to record for the first portion of the year 1883.

The production of pure grain metallic nickel in the United States for seven years past, from 1876 to 1882 inclusive, aggregates 1,466,765 pounds, an annual average of 209,538 pounds, as shown in the following table:

a Letter of Mr. Jos. Wharton to Professor Dana, Dana's Mineralogy, p. 59.

Annual production of nickel in the United States since 1876 (pure grain nickel).

	Pounds.
1876	201,367
1877	188,211
1878	150,890
1879	145,120
1880	233,893
1881	265,668
1882—nickel	277,034
50 per cent. alloy, nickel therein	4,582
Total for seven years	1,466 765

The consumption of nickel in this country for the first six months of 1883 is hard to fix with accuracy, but it may be estimated at not less than 150,000 pounds.

Production in Europe.—The annual production of nickel in Europe in 1873 was estimated by Messrs. Maw and Dredge, the reporters on the metallurgical exhibits at the Vienna Exhibition, to be but about 500,000 pounds, and in America 200,000 pounds. The greatest producers of nickel in Germany at that time were the Saxon Cobalt Company of Oberschlema and Pfannenstiel, near Schneeberg in the Saxon Erzgebirge, which turned out over 10,000 pounds of pure metal.

The production of nickel ores and speiss in the principal countries at the time of the International Exhibition in Paris, 1867, was, as nearly as could be ascertained from the official reports, as follows:(a)

	Tons.
England (ores)	1,745
Austria (ores)	600
Prussia (ores)	220
Nassau (speiss)	52
Saxony (speiss)	15
Italy (speiss)	7
United States (ores)	2,350
Sweden and Norway (speiss)	150

The total annual product of metallic nickel in all countries was estimated in 1877 to be about 1,200,000 pounds, or 550,000 kilos. Mr. Wharton's establishment at Camden then supplied about 200,000 pounds, or one-sixth of the entire product.

IMPORTATIONS OF NICKEL.

The importations of nickel have varied greatly from year to year for the past five years, as shown by the annexed table. The steady increase in the amount of nickel oxide and alloy of nickel with copper from 8,518 pounds in the year 1878 to 177,822 pounds in 1882 is noticeable, and is due to the fact that a large part of the nickel imported is now entered as "alloy," while containing as high as 95 per cent. of

a Rapports du Jury International, *Métaux divers*. By M. E. Petitgand, t. V., p. 671.

nickel and only 5 per cent. of copper, being nearly as pure as the nickel of commerce made a few years ago before the discovery of the Noumean ores. A compound of 50 parts of nickel and 50 parts of copper was then commercially known as nickel alloy. At present nickel is made, or can be made, commercially pure, carrying only 1 or 2 per cent., or even less, of impurity.

Nickel, nickel alloy, etc. (including both entries for immediate consumption and withdrawals from warehouse for consumption), imported into the United States during the fiscal years specified.(a)

Years.	Metallic nickel.		Nickel oxide and alloy of nickel with copper.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
1878	7,486.50	$8,837	8,518	$7,847
1879	10,496.50	7,829	8,317.75	5,570
1880	38,276	25,758	61,869	40,311
1881	17,933	14,503	135,744	107,627
1882	22,906	17,924	177,822	125,736
Total	97,098	74,851	392,270.75	287,091

There were no importations of nickel ore at the port of New York during the fiscal year 1882.

The so-called "nickel alloy" is made for the American market by the Vivians, of Swansea, England.

USES OF NICKEL.

German silver and nickel plating.—The use of nickel in the industrial arts has rapidly extended. At first known only in the state of an impure alloy, it could not be used for many purposes for which, since it has been produced in a pure condition, it is found especially well adapted.

The first chief demand was for making the alloy known as nickel-silver or German silver, a substitute for the more expensive metal. This alloy, possessing great strength and whiteness, found a large and rapidly extending consumption as a substitute for silver spoons and forks and for silverware generally, especially when the new art of electro-plating was developed by Spencer, Smee, and others. The nickel-silver was specially well adapted to receive and hold the deposit of silver, and it is to this day the most desirable alloy for plating. It has been greatly improved in quality since nickel has been produced with less arsenic and sulphur and fewer metals in combination with it as impurities. The "nickel-silver" alloy is now largely manufactured in the form of ingots, sheets, and wire, at the large copper and brass

a Home consumption and imports, Bureau of Statistics, 1880, p. 114; and 1883, p. 50.

manufactories of the Naugatuck valley, Connecticut, for the supply of the manufacturers of spoons, forks, plated ware, and other articles.

The consumption of nickel for electro-nickeling is very large. It has been estimated in connection with the litigation of patentees for processes of depositing nickel from its solutions that in 1882 as much as 1,000,000 gallons of solution were in use, distributed amongst thousands of nickel-platers. One company, the United Nickel Company, admitted that the royalties received under its patent amounted to not less than $175,000 per annum.

A great demand for nickel arises from its use for small or subsidiary coins. It forms white, clean alloys, well adapted to the purpose, and nickel coins have to a great extent replaced the old-fashioned cumbrous copper coins.

Nickel coinage.—Tentative efforts to produce satisfactory alloys and to arouse the attention of the public to the adaptation of nickel for coins were made by Dr. Feuchtwanger, in New York, in the year 1837, and he actually issued many small one-cent and three-cent pieces made of a nickel alloy, the exact composition of which he was careful not to state, but called it "Feuchtwanger's composition." Switzerland commenced using nickel-alloy coins in 1850; the United States in 1857, though sample coins, one-cent pieces, had been made by Prof. James C. Booth at Philadelphia in 1853, the various experimental alloys made by him containing from 5 parts of nickel and 95 of copper to as high as 30 of nickel and 70 of copper. In 1856 Professor Booth recommended to the Government the adoption of the nickel cent, and in 1857 it was regularly issued from the Mint. The alloy adopted by the law consisted of 12 parts of nickel and 88 parts of copper. In 1860 Belgium adopted an alloy of the same proportions for small coins. In 1863 the issue of three-cent nickel commenced from the United States Mint, and in the following year the five-cent coin appeared. Belgium, the German Empire, and other countries have issued nickel-alloy coins in large quantities.

The following table shows the denomination, composition, weight, and size of the coins of nickel alloy issued by the United States:

Composition, weight, and size of United States nickel coins.

Denomination.	Composition.	Weight.	Size.
One-cent piece	12 per cent. nickel, 88 per cent. copper	72 grains	$\frac{15}{20}$ inch.
Three-cent piece	25 per cent. nickel, 75 per cent. copper	30 grains	14$\frac{1}{2}$-20 inch.
Five-cent piece	25 per cent. nickel, 75 per cent. copper	77.16 grains	21$\frac{10}{50}$ millimeters.

The extent of the nickel-bronze coinage of the United States for each year since the adoption of nickel alloy for the one-cent piece in 1857 to the end of the year 1882 is shown in the following table, prepared at the request of Mr. Williams, by Hon. H. Burchard, Director of the Mint Bureau, and Mr. Snowden, Superintendent of the United States Mint at Philadelphia. The table shows also the annual consumption of pure nickel in forming the alloy, amounting in the aggregate to 8,687,550.89 troy ounces. The consumption for the year 1882 was 344,553.71 ounces.

Nickel coinage of the United States.

Calendar years.	One-cent nickel coins.		Three-cent nickel coins.		Five-cent nickel coins.		Pure nickel consumed.
	Pieces.	Value.	Pieces.	Value.	Pieces.	Value.	
							Troy ozs.
1857	17, 432, 410	$174, 324 10					313, 931. 92
1858	24, 600, 000	246, 000 00					443, 731. 22
1859	36, 400, 000	364, 000 00					637, 687, 87
1860	20, 566, 000	205, 660 00					391, 199. 20
1861	10, 100, 000	101, 000 00					181, 076. 48
1862	28, 375, 000	283, 750 00					505, 320. 42
1863	49, 840, 000	498, 400 00					895, 878. 04
1864	13, 170, 000	131, 700 00					237, 049. 00
1865			11, 382, 000	$341, 460 00			165, 955. 08
1866			4, 801, 000	144, 030 00	14, 742, 500	$737, 125 00	674, 553. 54
1867			3, 915, 000	117, 450 00	30, 909, 500	1, 545, 475 00	1, 307, 978. 08
1868			3, 252, 000	97, 560 00	28, 817, 000	1, 440, 850 00	1, 213, 242. 65
1869			1, 604, 000	48, 120 00	16, 395, 000	819, 750 00	688, 617. 22
1870			1, 335, 000	40, 050 00	4, 806, 000	240, 300 00	215, 171. 62
1871			604, 000	18, 120 00	561, 000	28, 050 00	32, 591. 00
1872			862, 000	25, 860 00	6, 036, 000	301, 800 00	215, 303. 32
1873			1, 173, 000	35, 190 00	4, 550, 000	227, 500 00	110, 057. 07
1874			790, 000	23, 700 00	3, 538, 000	176, 900 00	76, 772. 51
1875			228, 000	6, 840 00	2, 097, 000	104, 850 00	21, 135. 36
1876			162, 000	4, 860 00	2, 530, 000	126, 500 00	2, 688. 42
1877							
1878			2, 350	70 50	2, 350	117 50	132. 90
1879			41, 200	1, 236 00	29, 100	1, 455 00	1, 821. 78
1880			24, 955	748 65	19, 955	997 75	1, 197. 32
1881			1, 080, 575	32, 417 25	72, 375	3, 618 75	10, 505. 16
1882			25, 300	759 00	11, 476, 600	573, 830 00	344, 553. 71
Total to December 31, 1882	200, 483, 410	2, 004, 834 10	31, 282, 380	938, 471 40	126, 582, 380	6, 329, 119 00	8, 687, 550 89

It will be noted that the alloy was changed in 1865 to 25 parts of nickel and 75 parts of copper, which is the composition of the five-cent piece now in circulation. Up to June 30, 1876, the United States had alone issued of the five-cent nickel to the extent of $6,716,129 in value. In the German Empire the total nickel coinage amounted in January, 1877, to about $9,880,000 (United States currency) in value, and in Belgium, in 1876, to 6,598,865.80 francs in value.(*a*)

The amount of pure nickel used in the coinage, as shown by the statement, does not represent a net consumption, as the one-cent nickel pieces received by the Treasury or exchanged for other coin at the Mint are not reissued, but are melted from time to time and are recoined into five-cent pieces. There has also been a small recoinage of mutilated and worn copper-nickel coins of the denomination of three and of five cents. About $500,000 worth of one-cent nickel coins have been received at the Mint. All of this coinage will be eventually withdrawn from circulation and will be remelted into coins of other denominations.

Mr. Joseph Wharton, who has given great attention to the subject of nickel-alloy coinage, in his exhaustive review of the whole subject,(*b*) ar-

a Small Money and Nickel Alloy Coinage, Wharton, p. 38.

b Small Money and Nickel Alloy Coinage, 8vo, pp. 50, July, 1877, Philadelphia.

rives at the conclusion that the quantity of small or subsidiary coins needed in different countries will be found to vary between 25 cents and 50 cents per capita of population. He makes also an estimate of the profit to the people of the introduction of such coins. Assuming that all the token coins of 5 cents, 3 or 2 cents, and 1 cent are of the standard alloy, one-quarter nickel and three-quarters copper, and that the weights are about 1 gramme for each 1 cent (making, however, the 1-cent coin weigh one and a half grammes, as one gramme is too small a coin), for each million of population the quantity of coins needed of all denominations from 5 cents to 1 cent would be about as follows:

Mr. Wharton's estimate of the nickel required for subsidiary coinage.

Denomination of coins.	Total number.	Weight of each.	Total weight.	Total value.
		Grams.	*Kilograms.*	
Five cents	6,000,000	5	30,000	$300,000
Two cents	4,000,000	3	12,000	80,000
One cent	6,000,000	1½	9,000	60,000
Total pieces	16,000,000	....	51,000	440,000

To this total weight about 6 per cent. should be added to cover the loss of weight in the manufacture, showing the total quantity of metal required to be about 54,000 kilograms, one-fourth of which, or 13,500 kilograms, is nickel, and the remainder copper. Taking the cost of nickel to be, say, $3.30 per kilogram, equal to about 6*s.* per pound, English, and the copper at 50 cents per kilogram, and the cost of manufacture, exclusive of waste of material, at not over 60 cents per kilogram, he shows a total net profit of 77.9 per cent. on the issue value, as below:

Mr. Wharton's estimate of the net profit to be derived from nickel coinage.

Issue value, 16,000,000 pieces, weighing 51,000 kilograms			$440,000
Cost of nickel, 13,500 kilograms, at $3.30	$44,550		
Cost of copper, 40,500 kilograms, at 50 cents	20,250		
		$64,800	
Add, for cost of manufacture, 54,000 kilograms, at 60 cents		32,400	
			97,200
Total net profit (77.9 per cent. of issue value)			342,800

The first supplies of nickel for the Mint were obtained from the sulphureted and oxidized ores of Mine la Motte, Missouri, and some years afterward from the Lancaster Gap mine. Very little was obtained from the arsenical ores of Chatham and from the Litchfield locality in Connecticut. For several years a large amount of the refined nickel was obtained in the English market, but of late years the greater portion used at the Mint has been from the refinery of Mr. Joseph Wharton, at Camden.

The Mexican Government has recently ordered a large supply of nickel coins, to the aggregate value of $4,000,000, and these coins are being manufactured under contract by a firm in New York and in Mexico. The nickel is said to be supplied from England by the successors of Sir Josiah Maron, and to be made from New Caledonia ore.

METALLURGY OF NICKEL.

The recognition of nickel as an element dates no further back than the year 1751, when the Swedish mineralogist so far separated it from its combinations as to ascertain some of its properties and justify him in describing it as an element. It had before that time been found as a troublesome residue, but was supposed to be a mixture of cobalt and copper with arsenic. According to Bergman, Hierne was the first to write of "kupfer-nickel," in a work upon minerals published in Sweden, in the year 1694. It was not only obscure, but was troublesome and thought to be destructive of copper.

Being generally in close association with cobalt, this troublesome substance was left as a residue or by-product when cobalt ores were treated to obtain the oxide of cobalt for staining glass or producing a blue color on porcelain. The nickel was found concentrated in the cobalt speiss left in the pots when smalt was manufactured. This speiss contained other metals, such as copper and iron, besides sulphur and arsenic. The nickel was not therefore in a pure state, and for a long time its valuable properties were unknown, although the impure alloy was largely utilized to make the alloy commonly known as "German silver," "*argent de Berlin*," *maillechort*," or "nickel-silver." The impure nickel, or nickel-bronze, thus carried with it into the nickel-silver all its noxious associates, and the quality of the product was impaired, being often hard, brittle, and intractable. Even 1 per cent. or less of arsenic was sufficient to greatly modify the physical properties of the nickel or the alloys made from it. It was difficult to free the nickel from such small quantities of impurity. It resulted that nickel was for a long series of years unknown, commercially, in a state of purity.

The scientific chemists, however, succeeded in preparing small samples of the metal sufficient to experiment with and to determine its true physical properties. The results were at first somewhat contradictory, as we should expect from our present knowledge of the sensitiveness of the metal to minute quantities of either carbon or hydrogen in combination, very much as iron is affected and its properties modified by mere traces of some of the elements. For example, Richter found that nickel oxide, strongly ignited in an earthen crucible with carbon, gave the metal in a perfectly malleable, ductile condition. When so prepared it could be hammered cold or hot into plates $\frac{1}{100}$ of an inch in thickness, and could be drawn into wire $\frac{1}{56}$ of an inch in diameter. The malleability of the nickel was found to be impaired by carbon or manganese. Another experimenter, Tupputi, found that nickel reduced in the presence of carbon, in a covered charcoal crucible, and under glass, formed more or less nickel-graphite, absorbed a portion of carbon, and became less ductile than zinc. The metal so produced was brittle when cold, and was as fusible as cast iron, while the metal obtained by Richter was difficult of fusion. He also noted that nickel could be welded, but Touste found that it welded imperfectly.(*a*) Deville recognized the useful physical properties of both cobalt and nickel, such as malleability, ductility, and great tenacity. He showed that these metals could be worked at a forge with the same facility as iron; that they were susceptible of being employed in the same manner, and that they were less oxidable. These facts are important to any review of the progress of the metallurgy of nickel, particularly as it will presently be shown that the metal in a state of purity was first commercially wrought into useful objects in the United States.

The influence of nickel in its alloy with iron has been brought into special notice by reason of the mingling of these two metals in various proportions in meteorites. The occurrence together of iron ore and nickel terrestrially has already been noticed. At the New York Exhibition in 1853 the nickeliferous ores and iron, in addition to those from North Carolina, were from Marquette, Michigan, and were exhibited by Mr. Philip Thurber, of Detroit. The percentage of nickel was small, but it is stated that the forging iron made from this ore by the Catalan forge process had some remarkable properties; it contained nickel, but the percentage is not stated. It had a silvery white appearance and received and retained a high polish.(*b*) It has been noted by Faraday that iron alloyed with 3 per cent. of nickel has similar properties. This subject has been to a certain extent investigated by M. Boussingault, whose results did not fully sustain those of Faraday. He found that steel with from 5 to 10 or 15 per cent. of nickel added would in some cases rust as freely under water as steel without nickel. He also noted that some meteorites rust much more rapidly than others. Nickel does not in all cases prevent rusting. A notable exception was found with the alloy of 63 parts of steel with 37 of nickel corresponding to the composition of the supposed meteoric mass of Santa Catarina in Brazil, which resists oxidation in a remarkable degree.

The relations of nickel to carbon have been studied experimentally by the same authority. It appears that nickel does not readily absorb carbon and acquire steel-like properties. But the extreme toughness of most meteoric iron is well known. This fact, and the excellence of the iron made from the nickeliferous limonite of Michigan, are very suggestive and important to the producers and consumers of forging irons.

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a Vide Gmelius's Chemistry, V., 361.
b Progress of Science and Mechanism.

Another example of association of nickel ore and iron ore is found at Antwerp, New York, and the list of examples of such association could, no doubt, be greatly extended.

An interesting contribution to the chemistry of nickel has been made by Margaret S. Cheney and Ellen Swallow Richards, of the Massachusetts Institute of Technology,(a) who describe a new and ready method for the estimation of nickel in pyrrhotites and mattes. In the course of a systematic series of tests it was found that phosphate of nickel is completely soluble, while phosphate of iron is almost insoluble, in acetic acid in the presence of an excess of phosphate of soda. The process for the separation of the metals in analysis is based on this fact.

Messrs. Eustis and Howe, of Boston, have published a method of separating nickel and other metals by suspending iron bars in nickel-bearing slag.(b) The nickel is described as rapidly accumulating on the iron and finally running down and trickling from the ends of the bars.

Garnier, of Paris, points out the fact that pure nickel has great capacity for the absorption of oxygen. The pure metal, fused with access of air and poured, absorbs enough oxygen to make it brittle. If fused in a reducing atmosphere it is malleable, but the same metal carried to a red heat with access of air can be pulverized under the hammer. This can be corrected by the addition of metallic manganese, but as the corrective effects of this disappear with repeated fusions, M. Garnier prefers to use phosphorus, and finds that an addition of 3 thousandths leaves the nickel soft and very malleable. His method of introducing the phosphorus is to first make an alloy of nickel containing about 6 per cent. of phosphorus. This is then added in the proper proportions.(c)

The refining of nickel and cobalt was commenced in the United States, at Philadelphia, as early as the year 1846 by Prof. James C. Booth, of Philadelphia. Ores from the Lancaster Gap mine, and some from other sources, were worked there by Professor Booth and his associates. Later, as already mentioned, Mr. Joseph Wharton purchased the works and established the nickel industry at Camden, where it has since been carried forward, using chiefly the sulphureted ore of Lancaster Gap, previously described. This ore, which contains from 1½ to 2 per cent. of nickel, is enriched at the mine by a preliminary smelting into a matte containing 10 per cent. or more of the metal. For a long time the ordinary nickel of commerce was produced and was used chiefly at the United States Mint for the subsidiary small coins. Mr. Wharton, not being content with the production of impure nickel, early commenced experimenting to determine whether nickel could not be produced in a pure and malleable condition, susceptible of being worked in nearly the same manner as iron, and of being applied in the manufacture of various ob-

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a *American Journal of Science*, XIV., September, 1877.
b Transactions of the American Institute of Mining Engineers, February, 1882.
c Comptes Rendus, 91, 1881, p. 331.

jects requiring strength of material and a substance that cannot be easily oxidized. One of his earliest experiments was to take the somewhat spongy mass got by reduction of the oxide of nickel, and, after heating it to full redness, to work it under a steam-hammer into a bar.

In 1873, Mr. Wharton sent to the Vienna Exhibition a sample of nickel in the form of axles and axle bearings, and at the Exhibition in Philadelphia, in 1876, he exhibited a remarkable series of objects made of *wrought nickel*, such as bars, rods, a cube, a horseshoe magnet and magnetic needles of forged nickel. These did not excite the interest to which they were entitled as a remarkable advance in the working of this little-known metal. The exhibit did not cause much comment, and it was not specially described or reported upon, except by the judges who reported the exhibit to the Commission as worthy of an award in the following terms: "A fine collection of nickel ores from Lancaster county, Pennsylvania, with nickel matte, metallic nickel in grains and cubes, and manufactured nickel, both cast and wrought; nickel magnets and magnetic needles, cast cobalt, electro-plating with nickel and cobalt, and salts and oxides of both these metals; the whole showing a remarkable degree of progress in their metallurgical treatment."(*a*)

Some of the same objects formed of wrought nickel were sent over to Paris two years later, and were exhibited in the American section in 1878. There, as in Philadelphia, they did not at first excite any surprise, or receive any special attention. Very few persons realized what the objects really were, and that they were very different from *alloys* of nickel. In fact, very few chemists had ever seen *nickel*. Pure nickel was a rarity, a curiosity, just as samples of indium or thallium are to-day. It was not strange, therefore, that the expert chemists and metallurgists of Europe on the international jury showed some incredulity and surprise when whole ingots and forged bars of metal and numerous finished articles of pure wrought nickel, without alloy, were offered for their inspection. These articles, not differing greatly in their appearance from the higher grades of nickel alloys, or from electro-nickeled objects, were at first passed by without comment. No previous exhibition had been so rich in exhibits of the use of nickel and in the products from them. The influx of the pure carbonated and oxidized ores from New Caledonia had greatly stimulated the nickel industry in Europe, and had improved the quality of the alloys of nickel. New companies had been formed to manufacture nickel-silver and to produce nickel from these superior ores, at a lower cost than had before been possible. Christofle, of Paris, had just erected extensive works at St. Denis, and had made a most brilliant display of his products in one of the main avenues of the Exposition. The Vivians, of Swansea, and other exhibitors had large cases filled with beautiful objects of hollow and solid ware made of nickel-silver. Amid these various exhibits of striking *tours de force*, the modest little show-case from the United States with examples of manufactures

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a Reports and Awards, Group 1, 640, p. 470.

of pure wrought nickel, not alloy, could hardly be expected to excite attention and win the golden award, which was most cheerfully accorded as soon as the fact was demonstrated by analysis that the objects were really of the pure metal. Some of the objects shown at that exhibition have retained their brilliant polish and luster unimpaired to this time, without being rubbed or cleaned. These notable advances in the metallurgy of nickel, made with the lean and sulphureted ores of Lancaster Gap, prepared the way for greater advances.

Dr. Fleitmann, of Iserlohn, Westphalia, Prussia, who was for a time engaged at the works in Camden, has improved and cheapened the operation of refining nickel and toughening it, and has reduced the liability to the presence of blow-holes in castings by adding to the molten charge, in the pot, when ready to pour, a very small quantity of magnesium. This is immediately decomposed, magnesia is formed, and graphite is separated. It would seem that the magnesium decomposes the occluded carbonic oxide, or reduces it to a minimum. The magnesium must be added with great care, and in small portions, as it unites explosively with the charge. It is stirred in. About one ounce of magnesium is sufficient for 60 pounds of nickel. Three-quarters of an ounce to 54 pounds of metal has been used with success by Mr. Wharton. The nickel from the ore at Lancaster Gap seems not to require as much as the foreign metal. It is to be noted that complete malleability of nickel was obtained at Wharton's works in Camden, before Fleitmann's invention or process, but this last is more rapid and better than the old method. Nickel so treated with magnesium has been rolled into sheets as thin as paper. The metal becomes remarkably tough and malleable, and may be rolled into sheets and drawn into wire. Cast plates can be successfully rolled. The cast plates, such as are made for anodes, after reheating, are rolled down to the desired thickness. It is found that it is a great improvement to the nickel anode plates to roll them down. They dissolve with greater uniformity in the bath, and do not crumble away in the wasteful and annoying manner of cast anodes.

Expensive works for rolling nickel have been recently erected at Camden, containing among other machinery two trains of 40-inch rolls 18 inches in diameter, with annealing ovens and their adjuncts, and a 90-horse-power engine. At present this mill as well as the works for producing the metal, and the mine, also, are shut down, and have been since January 1, 1883. The largest sheet yet rolled at Camden was 72 inches long and 24 inches wide, of pure nickel.

Dr. Fleitmann has also succeeded in welding sheet nickel upon iron and upon steel plates, so as to coat them equally on each face with a layer of nickel. The quantity preferred by weight is $\frac{8}{10}$ iron and $\frac{2}{10}$ nickel, one-tenth of nickel being placed on each surface. To secure union, the iron or steel must be perfectly flat and clean. A pile is made with outer facings of sheet iron to protect the nickel from scaling. When the whole is heated to the proper degree, it is passed through the rolls. The two metals become so firmly united that they may afterwards be rolled down two or three together, or separately, to the thinness desired. At the recent meeting of the Institute of Mining Engineers at Boston a full series of examples of forging and rolling nickel was shown. Samples of rolled metal were exhibited cut from sheets made at the Camden works. These consisted of one sample No. 20 gauge, 10 per cent. nickel; one sample No. 22 gauge, 10 per cent. nickel; one sample showing edge of sheet. These were all examples of nickel upon iron. There was also shown a thin sheet of pure nickel annealed.

The physical properties of the two metals, iron and nickel, are so nearly the same that they work well together, and they adhere tenaciously. The nickel surface cannot be removed or regained in the scrap and waste except by dissolving out the iron core by dilute sulphuric acid. In the earlier experiments the ingots or cast plates were beaten under the hammer; this produced a great deal of scale and waste, as with iron, but this is now avoided, partly by the device of a thin covering of sheet iron, which is afterwards dissolved off. Dr. Fleitmann claims to have produced steel wire similarly coated, and proposes to make nickeled boiler plates.

The applications in the arts of such nickeled iron sheets will readily suggest themselves. Up to this time the most direct uses seem to be in making hollow ware, particularly culinary vessels. The manufacture of such ware has already begun at Schwerte by Dr. Fleitmann, and a great variety of vessels, such as saucepans and kettles, have been turned out, some of them of pure sheet nickel. They are all very beautiful in appearance, resembling highly-finished platinum vessels more than ordinary ware. When planished and buffed off, the surface becomes like a mirror and will answer the purpose of one. The vessels already sent to this country as samples are made of nickeled iron, and show the facility with which the compound sheet metal may be stamped, spun up, and polished. This ware is far superior to tinned iron or tinned copper for cooking in. Experiments have shown that it is not poisonous. The nickel is not only less liable to corrosion, but is harder, will last longer, and cannot be melted off by overheating. The ware is lighter and stronger than tin or copper ware; is susceptible of a high polish, and is not easily tarnished. It is well adapted to the manufacture of dishes, salvers, and covers for the table. The coating of nickel applied by welding is stronger and tougher than that deposited by electrolysis, and appears to be less liable to scale off. The electrically deposited metal is in some cases very brittle, and no doubt contains sufficient hydrogen to essentially modify the physical characters of the coating.

This new application of nickel constitutes practically a new industry of great importance. It increases the consumption of nickel and will stimulate its production, and by giving a steady demand will no doubt lead to a more uniform and constant supply.

COBALT.

By F. W. Taylor.

Occurrences.—Cobalt in the United States is found associated with the ores of nickel, sometimes with those of copper. At Silver Islet the mineral macfarlanite, found with the silver ores, yields a small percentage of cobalt. In Missouri, at Mine la Motte and at the Saint Joe lead mines, nickel and cobalt-bearing minerals are found associated with the galena, the nickel in the form of millerite, with a small amount of cobalt, and the cobalt as siegenite, in brilliant octahedral crystals. At the Gap mine in Lancaster county, Pennsylvania, cobalt is found replacing part of the iron in the pyrrhotite; the percentage is exceedingly small, and the ore could not be worked for cobalt alone. Smaltite occurs in Gunnison county, Colorado, at the mines of the Sterling Mining Company, an analysis by Dr. M. W. Iles showing 11.59 per cent. of cobalt. Some of the copper ores of western Nevada are also reported to contain cobalt; and it is found in traces in many of the iron ores of Pennsylvania and Virginia. The speiss formed in smelting certain Utah lead ores also contains appreciable quantities of cobalt. Other occurrences of cobalt minerals are cited in the preceding paper on nickel, by Prof. W. P. Blake.

No American ore is worked for cobalt alone, the small amount produced being obtained as a by-product in the reduction of the nickel ores of the Gap mine. These ores are smelted to a matte at the mine, which is further treated at the Camden Nickel Works, and the small amount of cobalt obtained is worked up into oxide. At Mine la Motte the cobalt is obtained in a matte produced in smelting the lead ores, the matte being shipped to England and Germany for reduction.

Domestic manufactures.—The production of cobalt oxide in the United States is very limited, and, so far as can be learned, no other preparation of the metal is produced. Until recently, all that was used was imported, and now the oxide is only produced incidentally in the reduction of the nickel ores of the Gap mine in Pennsylvania.

Small amounts of the carbonate, chloride, and nitrate are produced in this country by chemical manufacturers, the crude material, in the form of oxide, being obtained from abroad. The principal cobalt preparations imported are the oxide, smalt, and zaffre. The last is generally an impure oxide, produced by simply roasting the ore. Smalt is the ground product of a fusion of the oxide (or of zaffre) with quartz sand and potash.

Imports.—It is difficult to get at the exact amount of cobalt preparations imported, as in many cases the weights of packages are not given. The following table gives the number of packages and some of the weights of packages entered at the port of New York in the years 1881 and 1882, and up to May 9, 1883, as published by the *Oil, Paint, and Drug Reporter*, of New York city:

Reported imports of cobalt and cobalt preparations at New York.

	1881.		1882.		1883, to May 9.	
	Packages.	Pounds.	Packages.	Pounds.	Packages.	Pounds.
Cobalt, metallic	85	9,984	40	4,444		
Do			33	(a)		
Cobalt oxide	18	3,001	21	4,249	11	3,050
Do	20	(a)	16	(a)	9	(a)
Smalt	20	2,205	33	7,429		
Do	100	(a)	32	(a)	60	(a)
Zaffre	5	555	15	1,901		
Do	12	(a)	3	(a)	5	(a)

a Weight not given.

If the average weight of the packages for each year be taken, and that weight be assumed the weight of the unweighed packages, the probable amounts imported through the port of New York were as follows:

Estimated amounts of cobalt and cobalt preparations imported at New York.

	1881.	1882.	1883, to May 9.
	Pounds.	*Pounds.*	*Pounds.*
Cobalt, metallic	9,979	8,103	
Cobalt oxide	6,334	7,485	5,540
Smalt	13,224	14,495	13,380
Zaffre	1,887	2,280	633

In the Annual Report of the Chief of the Bureau of Statistics for the year ending June 30, 1882, the importation of cobalt oxide is stated as follows:

Imports of cobalt oxide during the fiscal years 1881 *and* 1882.

	1881.		1882.	
	Pounds.	Value.	Pounds.	Value.
Cobalt oxide	21,844	$13,837	17,758	$12,764

It is very probable that the amounts of oxide, smalt, and possibly zaffre, are combined in this statement, as the value per pound would be for 1881 63 cents, and for 1882 71 cents, while the quotation of oxide for the year 1882 was $2.65. Smalt is quoted in two grades, the first at 13 cents, the second at 8 cents per pound, and no distinction is made as to grade or class in the reports mentioned. Chemically pure metallic cobalt is quoted in New York at $14 per pound retail. The probabilities are that only a small percentage of the amount given was pure metal, and no figures can be had as to its value.

Production in 1882.—The home production of cobalt oxide, as already stated, is very limited, the production of the Camden works for the year 1882 amounting to 11,653 pounds, valued at a little less than $3 per pound wholesale. The production of the Saint Joe mines has not been ascertained. The value of the nickel and cobalt in the matte from Mine la Motte for the year 1882 was $12,500, but the proportion of cobalt to nickel is not stated.

Utilization.—The uses of cobalt and its compounds are limited. In the metallic form cobalt is used chiefly for experimental purposes. Experiments have been made in England on the substitution of cobalt for nickel in electro plating, and, it is said, with some success. The demand for the oxide, smalt, and zaffre comes from the glass manufacturers and potters, the oxide and smalt being largely used in the manufacture of blue glass, and more extensively by potters to correct the yellow tint of the ware, as well as in the production of blue ware and in ornamentation. Smalt was formerly used in the manufacture of paper to neutralize the yellow tint, and in blue ruling, but its extreme hardness proved a serious drawback to its use for that purpose.

MANGANESE.

By David T. Day.

Sources.—Manganese is found in deposits of various oxides extending through the Atlantic States from Maryland to Georgia. The mines furnishing the most valuable ores at present are located in the "Etowah region" in Bartow county, Georgia. From 500 to 1,000 tons are here mined annually, and while this is less than is produced in Virginia the higher percentage of manganese in the Georgia ore makes it a more important feature of the total supply. The deposits in Virginia rank next in importance. The mines are numerous and furnish a total of from 2,000 to 3,000 tons. One mine alone in Augusta county yields 1,500 tons annually. These two sources are the only ones which enter into the manganese industry to any extent. The information concerning them was furnished by Mr. C. L. Oudesluys. There are large deposits of ore at Warminster, on the estate of Mr. Philip Cabell, in Nelson county; and also in Rockingham and Campbell counties. Near Harper's Ferry, in Jefferson county, West Virginia, there is a mine which was formerly worked, and ore is again met with in the northwestern part of this State. There are deposits in North Carolina, but of such hard quality that it is not profitable to work them. Greenville, South Carolina, has furnished a small quantity to the trade; but the quality, like that of the Virginia ore, is too poor to render it of much value. The same is true of more extensive deposits in Tennessee, where, in spite of a few exceptionally rich veins, the ore falls below the average.

The ores of manganese have been observed at many different places on the Pacific coast, the heaviest deposits yet discovered, or at least opened up, being on Red Rock, a small island in the Bay of San Francisco, 10 miles north of the city. Information regarding this occurrence is furnished by Mr. C. G. Yale. This island contains 27 acres, and rises to a height of 250 feet above the water. The ore, which is of the gray variety (pyrolusite), occurs in large masses, distributed through a black, flinty gangue, a heavy belt of which extends for seven or eight hundred feet across the island. The exploratory work here consists of a tunnel, which intersects the ore channel at the depth of 200 feet, and several drifts run and pits sunk on it higher up. This work was done in 1866, at which time over 200 tons of ore carrying 70 per cent. binoxide were extracted and sent to New York with a view to testing its commercial value. As this lot sold for less than freight and commissions, the work of ore-extraction was discontinued and has not since been resumed. The cost of taking out the ore and delivering it in San Francisco amounted at that time to $10 per ton. As this is twice as much as the same service would now cost, and there is likely to grow up some demand for manganese for local uses, there is a probability of this mine again being worked at an early day.

Many other occurrences of pyrolusite, said to be in workable quantities, are reported but not utilized, in the Far West. In the Mammoth district, Nye county, Nevada, occurs a large deposit of the tungstate of manganese.

Character of the ores.—The three prominent ores of manganese are: 1, black oxide, or pyrolusite (MnO_2); 2, braunite, or brown oxide of manganese (Mn_2O_3); 3, manganiferous iron ore. It is very rarely, if ever, the case that the ore is found in a state of purity approaching the composition of a definite mineral. It is usually a mixture of black and brown oxides of manganese and ferrous and ferric oxides of iron, in varying proportions, and the commercial name given is intended to designate the predominating feature of the ore. If, as is sometimes the case with Georgia ore, the amount of manganese reaches the neighborhood of 80 per cent., and the substance shows some crystalline form and is soft, it is called by the proper mineralogical name, "pyrolusite." But ordinary ore containing less than 75 per cent. of MnO_2 is called "black oxide" of manganese. If, however, the amount of manganese dioxide runs as low as 20 to 30 per cent., and oxide of iron becomes the dominant ore, it is called "manganiferous iron ore." Black oxide is the only manganese ore mined in this country, and if the manganese dioxide in it falls much below 60 per cent. it is not worth bringing to the market. It may be said that the Virginia ore usually contains about 60 per cent., while Georgia ore runs from 66 to 70 per cent. The manganiferous iron ore found in the United States usually contains phosphorus, sometimes to the extent of one to two per cent. Even five one-hundredths of one per cent. of phosphorus renders steel "cold short" (that is, brittle when cold), and this more than counterbalances the beneficial effect of adding manganese in the manner stated later in this notice. A few other substances are always present in the ores, as is shown by the following table of analyses of samples from the places named:

Analyses of black oxide of manganese.

	Georgia ore.	Ore from Campbell county, Virginia.
Water	1.17	1.05
Silica	4.00	21.76
Manganese dioxide	66.40	57.60
Ferric oxide	10.08	9.93
Barium sulphate	0.29	1.05
Calcium carbonate	trace	0.85
Oxides of manganese other than dioxide	18.06	7.76
Total	100.00	100.00

Quantity mined.—The total quantity of manganese ores mined in 1882 was very nearly 3,500 long tons (of 2,240 pounds). Its spot value at the mines is from $11 to $20 per long ton, according to the percentage of manganese. The cost of mining is from $5 to $10 per ton.

Utilization.—The chief use of manganese ores is as a ready and easily available source of oxygen. For this reason the *dioxide* is the only valuable constituent, because it can be made to give up its oxygen by several means. Advantage is taken of this oxidizing power of the dioxide in the preparation of chlorine and bromine. It is extremely difficult to separate these elements from other elements with which they are ordinarily in combination. It is a simple matter, however, to obtain hydrochloric acid, and when manganese dioxide is added to this, its oxygen unites with the hydrogen, forming water, and leaves part of the chlorine free. As it is very difficult to transport chlorine in its ordinary gaseous state, it is passed over slaked lime, and thus made into "bleaching powder," which is a mixture of chloride and hypochlorite of calcium. Bromine is made by a similar process, but as it is a liquid it is not necessary to convert it into a substance analogous to bleaching powder. These processes, which consume probably three-quarters of the manganese mined in this country, are carried on at several places near Pomeroy, on the Ohio river, and at a few other points in the United States. When manganese ore richer than 70 per cent. is obtained, it is usually found profitable to send it to England for the manufacture of bleaching powder, and a small proportion of the yearly supply is thus annually exported. This is the only case of the exportation of manganese. Manganese ore is also used as an oxidizing agent in boiling linseed oil and varnish. When linseed oil is boiled with powdered manganese dioxide, the oil takes up a certain amount of oxygen and becomes thick, drying rapidly. It is doubtful whether the manganese dioxide does more in this case than to expose a greater surface of the oil to the oxidizing effect of the air, for the mineral does not appear to lose its efficiency after continued use. Manganese dioxide is also used in the preparation of oxygen, but only when mixed with chlorate of potassium; because manganese dioxide requires a very high temperature when heated alone before it will give up its oxygen. When heated with potassium chlorate the latter yields its oxygen at a comparatively low temperature, the dioxide serving only to distribute the heat through the mass.

So far as can be ascertained, these are the only uses for which the native ores of the United States are at present available. There are two or three uses into which the manganese itself enters; but, for these, foreign ores are used altogether. Considerable quantities of manganiferous iron ore are imported, principally from Carthagena, Spain. The ore is brought as ballast in sailing vessels and steamers coming to American ports in search of cargoes. Probably the largest amount comes to Baltimore, but some is also received in Philadelphia and New York. The following table gives the importations of manganiferous iron ore received in Baltimore during 1882. The percentage of manganese is also stated:

Imports of manganiferous iron ore at the port of Baltimore, 1882.

Date of arrival.	Amount.	Metallic manganese.
	Tons.	*Per cent.*
April 27	800	17.10
April 28	800	5.93
July 18	2,800	10.28
July 22	800	3.77
August 16	2,000	12.66
August 30	2,000	15.75
September 4	900	15.85
October 10	2,000	15.83
November 28 (in bond)	4,000	
December — (in bond)	1,000	
Total	17,100	

The imported ore contains an average of about 20 per cent. manganese dioxide, so the ore which enters this country is about equal to that mined here. This form of ore is all used in making a superior variety of steel. It has been found that when a small quantity of manganese—less than 3 per cent. of the steel to be melted—is added to steel in the melting-pot, inferior steel may be raised to a high grade, and is made capable of welding with iron. This was discovered in 1829 by Mr. Josiah Marshall Heath, who proposed the addition of manganese dioxide with enough charcoal for its reduction to the steel to be melted.(*a*)

This method of improving steel has since been introduced into the Bessemer process; but instead of adding manganese dioxide itself, an iron ore containing considerable manganese is used as the starting point. Nearly all the manganiferous ore imported is sent directly west to the Pittsburgh region, particularly to the Edgar Thompson Steel Works.

Small quantities of very pure manganese dioxide are imported from Nova Scotia for use in neutralizing the green tint imparted to flint glass by minute traces of iron. The Nova Scotia ore is remarkably free from iron, and hence its value in the glass industry. Sulphate and chloride of manganese and potassium permanganate are the only other salts which have thus far found any industrial application in the American arts. Permanganate is imported in small quantity from Germany, and is worth from 50 to 70 cents per pound in this country. It is safe to prophesy that in the near future another salt of manganese, manganese borate, will be largely used in the United States, as it already is in Germany, Austria, and France, for boiling with linseed oil and fine varnishes. According to the most experienced varnish manufacturers, manganese borate offers an aid in making dryers, superior to that of any other substances.

Since the greater quantity of imported manganese ore comes directly to Baltimore, and moreover because of the convenience offered to Southern producers of selling ore through Baltimore agents, that city has come to be regarded as the headquarters of the manganese industry, although very little of the ore is actually consumed there.

a J. S. Jeans, "Steel, its History, Manufacture, Properties, and Uses," 1880, p. 27.

CHROMIUM.

By David T. Day.

Sources.—Until the past few years the source of all the chromium produced in this country was the chrome iron ore found quite abundantly in the Green Spring valley, in Maryland. The important mines of this region are at Bare Hills, Soldiers' Delight, and Owing's Mills, in Baltimore county. Cecil and Harford counties have also furnished chrome iron ore, principally in the small crystalline form called sand ore. Lump ore is also obtained. The mines at Owing's mills alone have yielded in all probably 5,000 tons. But this entire source has been practically abandoned, not from exhaustion of the mines, but because richer ore can be obtained from regions to be mentioned. As the cost of grinding and decomposing the ore is the same for rich and for poor grades, the rich ores are naturally preferred. Moreover, the higher the percentage of chromium in the ore the easier is its decomposition and the less is the waste involved. An objectionable feature of the sand ore is that it contains silica in considerable quantity, and this forms silicate of potassium with the potash used, thus causing loss of alkali.

Quite recently a new deposit of chrome ore has been discovered in Jackson county, North Carolina. It promises to be of better quality than any other in the Eastern States.

Russia and Turkey have also supplied ore to the American market, and continue to do so in small amounts. But practically all the chrome ore used in this country at present comes from California, particularly from the neighborhood of San Luis Obispo.

The following information regarding the occurrence and mining of chromic iron ore in California is furnished by Mr. C. G. Yale: "This is a plentiful ore in many parts of the State. The only deposits from which much ore has as yet been extracted are located in San Luis Obispo, Napa, Sonoma, Del Norte, and Placer counties. From some of these counties the shipments were several years ago considerable. Latterly, however, the business proving unprofitable, has dwindled to small proportions. The chromic iron found in this State is of good quality, carrying from 40 to 60 per cent. of the oxide, and commanding full prices in Baltimore, where the most of it was sent, some having been sent also to England. The mines near San Luis Obispo, five miles from the town, on the line of the San Luis Obispo and Santa Maria railroad, are the most prominent. Some three years since, chrome iron was found about seven miles east of Iowa Hill, Placer county. The ore, which of good quality, is found in irregular masses, disconnected and imbedded in the country rock, and varying in weight from a few pounds to several hundred tons. Since this discovery, the mining and shipping of chrome ore from Placer county is becoming an important industry. Shipments are made from Auburn regularly, the ore coming from points on the Forest Hill and Georgetown divides; a great deal also is being shipped from Colfax, being brought over from what is known as Brimstone plains, a few miles above Iowa Hill. Smiley Bros. are the principal shippers from the latter point. Chrome deposits not yet opened are known to exist in other places in the county."

Character of ores.—The character of chrome ore is practically the same whatever the source, although it varies in the amount of chromium oxide contained, between 40 and 50 per cent. Its composition may be expressed by the formula Cr_2O_3FeO; but part of the chromium may be replaced by iron, or the iron may be partly replaced by magnesium. Aluminum is also sometimes present, and silica often accompanies the sand ore as an impurity.

Amount mined.—About 2,500 net tons were obtained from California during 1882. The price paid in Baltimore is $40 per ton, with slight variations according to percentage of chromium oxide.

Utilization.—All the chrome iron ore used in the United States at present is made into potassium bichromate by Messrs. Jesse Tyson & Sons, Baltimore, with the exception of a very small quantity of sand ore which is used in making chrome steel at the Brooklyn Chrome Steel Works. The amount so used does not exceed 1 per cent. of the chrome ore mined. Bichromate of potassium is, then, the one salt of chromium from which all the others are obtained. The wholesale price of bichromate in 1882 was 15½ cents per pound. By far the greatest proportion of this salt is used in calico printing; the bichromate being dissolved in water and then deposited on the cloth in the desired color by suitable reagents. It is also made into the pigments chrome yellow and chrome green. A small quantity is used in electric batteries. Besides the bichromate made in Baltimore about 35 per cent. of the whole amount used is imported from Scotland, under a duty of 3½ cents per pound. In 1882 the amount imported was 1,972,221 pounds. Formerly American chrome ore was exported to England, but latterly the English supply has come from Russia.

No chrome ore in any quantity has thus far been worked up outside of Baltimore; but about two years ago Messrs. Harrison Bros., of Philadelphia, established a branch of their color works, called the Kalion Works, where they have undertaken the decomposition of chrome ore, and it is believed they are still continuing the work.

Baltimore has for a long time enjoyed a monopoly in the manufacture of bichromate, not, however, without many efforts on the part of manufacturers in other cities to obtain a footing in the trade. In the past eleven years no less than fifteen attempts have been made to establish works for decomposing chrome ore in other cities, particularly in Philadelphia, New York, and Boston.(a) Not only thousands, but tens and even hundreds of thousands of dollars have been thrown away in these attempts to accomplish what is put down in the text books as a comparatively simple operation. Factories have been built, and arrangements made for grinding and decomposing the ore, but in very few cases has the experiment lasted long enough to result in the production of a single pound of bichromate. It is an extremely difficult matter to carry on this manufacture so well as to produce bichromate at 15½ cents per pound. But by long experience and methods of decomposition known only to themselves, Messrs. Tyson & Sons have been able to maintain a successful business and to compete with the two other manufactories in Scotland and France.

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a There has been some talk of establishing works for the manufacture of bichromate in California; but, as has been pointed out by Mr. H. G. Hanks, the State mineralogist, the necessity of importing potash would be a most serious obstacle to commercial success, while the substitution of other alkalies (such as soda or lime) is not considered practicable.—A. W., jr.

TUNGSTEN.

BY DAVID T. DAY.

Sources.—The element tungsten has the general characteristics of a metal, but it is also capable of acting as a non-metallic element and can form an acid—tungstic acid. It is in this role that it is always found in nature, as the tungstic acid salt of iron, manganese, calcium, or lead. These tungstates are rare. The most abundant is wolfram, a mixture of tungstates of iron and manganese in varying proportions. The tungstate of iron may replace the manganese almost entirely, when the mineral receives the name ferberite; or the manganese may replace all the iron, giving the mineral hübnerite. Besides these, scheelite, the tungstate of calcium; scheelitine, tungstate of lead; and wolfram ocher, the anhydrous acid itself, are found in small quantities. Wolfram is found in the United States at Charles Lake's mine, Munroe, Connecticut; at Trumbull, in the same State; and at Blue Hill bay, Maine, on Camdage farm. Although the deposits are never very extensive, an attempt has been made to work the mines in these localities, but the ore has not proved rich enough, and at present no wolfram is mined in the United States. Wolfram also occurs at the Flowe mine, in Mecklenburg county, North Carolina; in Missouri near Mine la Motte, in Saint Francis county, near the Saint Francis river; and in the Mammoth mining district, Nevada.

Value.—Wolfram usually contains from 35 to 55 per cent. tungstic acid, and is worth about 10 cents per pound, or \$80 to \$100 per ton, in Germany. It is subject to an import duty of 20 per cent ad valorem. The price has been rising slowly during the past year or two, not however from any marked increase in the demand. Metallic tungsten is worth 60 to 80 cents per pound in Liverpool.

Utilization.—Tungsten holds a peculiarly uncertain position from an industrial standpoint. It has been recommended for use in many widely different industries; but thus far it has not gained extensive application, principally for two reasons: it has proved either too expensive or it has failed to yield the advantages claimed for it in particular cases. Under the former may be mentioned the projected scheme of saturating inflammable fabrics with a solution of tungstate of soda to render them proof against fire; but experiments have usually drifted off to alum or some other cheap substance. Tungstate of soda is one of the many substances proposed for the prevention of boiler incrustations. Soluble tungstates are used to a limited extent in calico printing. By far the most important application of tungsten that has ever been proposed is in the manufacture of steel for certain special purposes. An extended treatise on this subject will be found in the work by J. S. Jeans,(a) of which the following is a summary.

It was shown by the Duc de Luynes, in 1844, that a feature in the so-called damask steel was that it contained tungsten. Later, in 1860, F. A. Bernoulli made a series of experiments at the Royal Iron Foundry, in Berlin, on the alloys of iron and tungsten, which led him to the following conclusions: 1. By mixing tungstic oxide with turnings of gray cast iron and fusing them, the tungsten is reduced to the metallic state and cast steel is formed. 2. The carbon of the cast iron, and particularly that portion which is mechanically mixed with the iron, is consumed in reducing the oxide of tungsten, and metallic tungsten appears partly to take the place of the carbon in the steel.

There has been much dispute as to the real advantage of this replacement of carbon by tungsten. Mayer of Loeben, Styria, is assigned the credit of having first applied tungsten to the manufacture of steel on the large scale, and owing to the success which he attained tungsten steel has been declared to be of the highest quality in respect to fineness of grain, uniformity of structure, hardness, toughness, strength, and durability; but numerous adverse opinions have followed the experiments of others. Tungsten, like carbon, appears to diminish the ductility of iron; though by melting tungsten and iron it is possible to obtain steel much harder than with carbon alone, without the danger of incurring at the same time an excessive fragility when cold or difficulties of working while hot.

For uses which require an especial degree of hardness, a steel rich in tungsten, called "special" steel, is frequently employed. Thus a fine Sheffield steel for lathe tools contained, according to an analysis made in the laboratory of the Stockholm School of Mines, 9.3 per cent. of tungsten, 0.7 per cent. silicon, and only 0.6 per cent. carbon. This steel, which is used without being tempered for turning cylinders of cast iron, is of sufficient hardness to scratch glass and yet is not fragile, for great difficulty is experienced in breaking a ¾-inch bar.

The hardness communicated to iron by tungsten is not increased by tempering. Steel rich in tungsten cannot be hardened without breaking. It can only be worked cold by grinding, on account of its excessive hardness; by working hot with caution the desired form may be given to it, but steel rich in tungsten must be managed with great care to prevent its cracking, and it must be treated several times in succession before the desired form is attained. After the form is obtained by hammering hot, the steel should be hammered with quick light blows nearly cold before it is allowed to cool gradually.

In order to produce tungsten steel it is necessary in the first place to rid the wolfram of the impurities which it contains. According to Jacob it must in the first place be roasted, then treated by diluted acid, and finally washed with water; in this manner the sulphur and arsenic are

a "Steel, its History, Manufacture, and Uses," London, 1880.

eliminated. After being dried the residuum is raised to a strong heat in crucibles lined with damp charcoal, the tungstic acid is reduced to the metallic state, and a compound is formed containing iron and manganese. The product thus obtained is of a dark color and great density. From 5 to 25 per cent. is added to the steel, according to the proportion of tungsten desired.

To produce Bessemer steel containing tungsten Le Guen adds to the molten metal, when the operation is finished, some pig containing tungsten, also in the liquid state. This pig is prepared from a mixture of 90 per cent. wolfram and 10 per cent. of lime with tar. According to Le Guen, the tungsten increases the hardness of the metal, and up to a certain point its tenacity also. If, on the other hand, the proportion of tungsten becomes rather high, the strength diminishes.

Mushet has obtained a patent for producing tungsten steel by mixing finely pulverized wolfram with an equal weight of melted pitch, after which the mixture is run out on a dry stone slab, and is added in certain proportions to crucible steel. Mushet's "special" steel made in this way is remarkable for its hardness and strength. This class of steel is manufactured in Germany at the works of Wund & Co., at Buckaw, near Magdeburg, in Prussia; and in Hanover at Uslar on Solling. The magnets used at Siemens' telegraphic works in Berlin are also said to be made at Moabit of this steel. Its qualities are very different from those of ordinary steel, as although when annealed it is so hard as to resist the best files, it becomes soft when chilled, and presents an exterior full of cracks, for which reasons it must not be hardened. At a red heat it is malleable and is easily worked, but all tools made of it must be brought into shape by the hammer at once, and finished if necessary under the grindstone, as the file will not touch it afterwards. Tools of tungsten steel in use for planing and other machines at the Engine Works of Knoevenagel, in Hanover, are reported to stand longer than those made of the best Sheffield cast steel.

A species of steel invented by H. A. Levallois, of Paris, has been patented in England. This is said to be an alloy containing tungsten and nickel in various proportions, and it is claimed to be less liable to oxidize or rust than ordinary steel.

C. W. L. Bierman, of Hanover, manufactures alloys of cast iron and steel containing from 20 to 50 per cent. of tungsten, and from 1½ to 6 per cent. of manganese, in ingots, which are sold for mixing with (and so introducing any desired percentage of tungsten into) iron or steel.

Experiments with tungsten steel have been made at Park's works, and at several establishments in Pittsburgh, but as yet it has not assumed industrial proportions in the United States. It does not seem probable that it will become a rival of chrome steel.

TIN.

Occurrence.—Stream or wood tin (cassiterite) is known to occur in very many scattered localities throughout the United States where areas of granitic and gneissoid rocks are exposed. Stannite (tin pyrites) has not been found in any quantity, though occasionally reported. In southern California a large number (said to be upwards of 500) of tin claims have been located in the Temescal range, San Bernardino county, a few of which have been irregularly worked, one mine only, the Cajaica, having been developed to any extent. An analysis of the Temescal ore, made by Dr. F. A. Genth, gave the following results:

Silicic acid	9.82
Tungstic acid	.22
Oxide of tin	76.15
Oxide of copper	.27
Oxides of iron and manganese, lime and alumina	13.54
	100.00

Litigation has interfered with the working of some of the more promising Temescal mines, and thus far the results have been disappointing. In January, a strike of tin ore, said to be rich, was reported as having been made a few miles from San Diego, California, and during the winter tin ore is said to have been discovered near Fort McKavett, Texas. A number of localities have been reported in Dakota, and in Montana and Idaho, among the placer mines. In the latter Territory stream tin has been found in the bed of the Jordan river, Owyhee county. Frequent reports have been circulated of the discovery of tin ore in the mountains of Colorado, and especially in the San Juan range, but analysis of the specimens shows the absence of any tin. Tin ore also occurs near Bangor, in Maine, and in other portions of the State. Possibly in about half the States and Territories of the Union tin ore in small quantities has been discovered, but these occurrences are usually only of mineralogical interest.

The Broad Arrow mines.—The most important occurrence of tin in the United States recently noted is that at the Broad Arrow mines, two miles from Ashland, Clay county, Alabama. Mr. G. W. Gesner, the owner, reports that these mines consist of four open quarries in the hillside, 35, 40, 45, and 55 feet in depth. The ore occurs both in lodes and as stream tin. The country rock is micaceous and talcose schist.

The ore itself is disseminated in gneiss, which forms seams from ten to twenty feet thick in the country rock, and having a northeast and southwest strike. A horizontal section given by Mr. Gesner from west to east across the strike of the seam is as follows:

Granite, highly feldspathic.
Tin-bearing gneiss.
Micaceous and talcose schists.
Tin-bearing gneiss.
Country rock, containing molybdenite.
Tin-bearing gneiss.
Country rock.
Tin-bearing gneiss.
Country rock.
Tin-bearing gneiss.
Country rock.
Main vein of gneiss containing the largest tin contents and best ore.
Massive white quartz with limonite, etc.

The section shows in a space of 800 feet six parallel, nearly vertical, belts of stanniferous gneiss. The tin-stuff ranges from a trace up to 2 per cent., averaging $1\frac{1}{2}$ per cent.; and is said to be readily concentrated. Certain massive ores in pebble-like pieces have been found on and in the richest gneiss. They have rather more than one-half the specific gravity of Durango tinstone; and yield an alloy of tin and iron very readily in the test crucible. This alloy is easily fused, and is said to reach 45 per cent. of the contents of the ore and to resemble the general character of the impure pigs from tin ores charged with iron. The ore is reported to exist in very considerable quantity, and to be free from all traces of arsenic and sulphur. It worked very kindly in the assay and test furnace. Cassiterite is also found in the stream which crosses the lodes, but associated with titanic and iron compounds, which render its reduction troublesome.

No hoisting or pumping machinery is at present required. Reduction works have been erected near the quarries, the distance from the latter to the works being only from 100 to 400 feet. They consist of one light 40-stamp mill; one 5-stamp mill for crushing slags; one rock-breaker; one 15-horse power engine, one table, two jigs, four schlich vats, four settlers, and one tin blast furnace of the Altenberg pattern. The present plan was designed to produce from gneiss ore of $1\frac{1}{2}$ per cent. tin oxide some 500 pounds of crude pig tin per day. The ore is so easily handled that the cost of stamping is light. The concentrated ore is to be smelted in lots of 1,000 pounds.

Regular work began at the Broad Arrow mines March 1, 1883. The reduction works were built during the winter and spring, and were first tried March 20. The force employed has averaged four men at the quarries and seven at the works. It cannot be said that the results obtained up to July 1 were commercially successful. Mr. Gesner attributes this to two leading causes, one of which is the difficulty of sorting from so large a formation ores rich enough to repay working; and the other is the frequent appearance of titanium in the tin oxide, seriously interfering with reduction. It is expected that when the employés become more familiar with the appearance of the ores and are able to make a proper selection, and when the concentrating apparatus is perfected, operations will proceed more successfully. In the mean time the works have been utilized in milling the low-grade gold ores from the quartz reef next to the tin-bearing gneiss.

No metallic tin was reported to this office as having been produced in the United States in 1882. It seems probable that when some of the known localities shall have acquired proper transportation facilities, and when prospecting for tin is regularly prosecuted, tin mining in this country may reach a stage of considerable importance. At present comparatively few persons are acquainted with the appearance of native tinstone; and its occurrence has doubtless often been overlooked by prospectors in search for gold and silver ores.

Foreign sources.—Our importations of tin in its various forms come chiefly by way of England. The bulk of the product of the world is from the Straits, a large quantity of excellent tin being produced in the islands of Banca and Billiton; Australia, Tasmania, and Cornwall. Bolivia also furnishes a small supply. Immense deposits of tin ore are said to exist in the states of Durango and Chihuahua, Mexico, which have been worked only on an insignificant scale heretofore; but these in the near future are expected to yield largely.

The total output of the world during recent years has been reported as follows:

	Gross tons.
1878	35,597
1879	37,539
1880	36,294
1881	38,123

Duty on tin.—The new tariff fixes the duty on "iron or steel sheets, or plates, or taggers iron, coated with tin or lead, or with a mixture of which these metals is [*sic*] a component part, by the dipping or any other process, and commercially known as tin plates, terne plates, and taggers tin," at 1 cent per pound. Tin ore, bars, blocks, or pigs, and grain or granulated tin are on the free list. Manufactures, articles, or wares not specially enumerated or provided for, composed wholly or in part of tin, are subject to a duty of 45 per centum ad valorem.

Imports and exports.—The following tables show the foreign commerce of the United States in tin during recent years:

Tin in bars, blocks, and pigs imported into the United States during the fiscal years specified (specie values).

Years.	Free of duty.		Dutiable.	
	Quantity.	Value.	Quantity.	Value.
	Cwts.		Cwts.	
1872	(a)	(a)	118, 856	$3, 418, 042
1873	91, 166	$2, 914, 481	11, 693	363, 393
1874	114, 952	3, 180, 769	(b)	(b)
1875	102, 561	2, 327, 212	(b)	(b)
1876	93, 095	1, 816, 289	(b)	(b)
1877	98, 933	1, 793, 613	(b)	(b)
1878	129, 662	2, 183, 034	(b)	(b)
1879	143, 512	2, 312, 297	(b)	(b)
1880	284, 960	6, 223, 176	(b)	(b)
1881	170, 880	3, 971, 718	(b)	(b)
1882	186, 616	4, 953, 538	(b)	(b)
Calendar year 1882.	211, 934	5, 836, 082	(b)	(b)

a Included in dutiable. b Included in free of duty.

Tin plates and other manufactures of tin imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

Years.	Tin plates.		Value of other manufactures.
	Quantity.	Value.	
	Cwts.		
1872	1, 754, 667	$12, 312, 428	$79, 233
1873	1, 718, 620	14, 993, 650	85, 129
1874	1, 511, 776	12, 992, 923	71, 779
1875	1, 702, 350	12, 956, 647	81, 706
1876	1, 770, 631	10, 005, 799	92, 514
1877	1, 987, 578	9, 750, 327	39, 332
1878	2, 185, 905	9, 929, 498	58, 498
1879	2, 469, 081	10, 147, 460	54, 107
1880	3, 385, 740	17, 223, 266	62, 808
1881	3, 303, 639	14, 149, 387	70, 855
1882	3, 936, 869	16, 599, 264	88, 371
Calendar year 1882.	4, 279, 738	17, 975, 161	107, 182

Tin exported from the United States during the fiscal years specified.

Years.	Foreign.							Domestic manufactures.
	Bars, blocks, or pigs.				Plates (dutiable).		Other manufactures (dutiable)	
	Free of duty.		Dutiable.					
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	Value.
	Cwts.		Cwts.		Cwts.			
1872	(a)	(b)	309	$8, 372	5, 043	$36, 095	$1, 333	$67, 241
1873	1, 517	$62, 122	16	495	7, 178	63, 419	3, 932	69, 865
1874	140	4, 124	(c)	(c)	7, 850	63, 557	245	62, 973
1875	23	907	(c)	(c)	4, 734	37, 349	3, 500	48, 194
1876	801	19, 988	(c)	(c)	4, 930	32, 932	4, 265	48, 144
1877	158	2, 809	(c)	(c)	8, 091	44, 416	2, 654	87, 057
1878	523	8, 402	(c)	(c)	15, 827	74, 897	3, 924	116, 274
1879	2, 572	43, 780	(c)	(c)	6, 899	31, 992	5, 610	103, 467
1880	4, 116	82, 594	(c)	(c)	6, 958	36, 319	1, 016	144, 185
1881	8, 645	196, 511	(c)	(c)	11, 287	60, 104	2, 280	198, 524
1882	23, 144	597, 479	(c)	(c)	19, 974	87, 498	61	198, 608
Calander year 1882	2, 122	58, 613	(c)	(c)	23, 703	103, 732	151	202, 740

a Included in dutiable. b No data. c Included in free of duty.

ANTIMONY.

The ore of this metal occurs abundantly in California and Nevada, as well as in other parts of the Pacific division. The heaviest deposits so far as known exist at the Bonshay & Temple mine, in San Emidio cañon, Kern county, California, and at a point twelve miles south of Battle Mountain, a station on the Central Pacific railroad in Humboldt county, Nevada. At the latter place the ore occurs in two parallel veins, about 100 feet apart and cropping out strongly for the distance of a mile or more. These veins are nearly vertical and stand between regular, well-defined walls. From one of them, which carries a stratum two feet thick of solid sulphuret of antimony (stibnite), several hundred tons of ore have been extracted. Some of this was reduced in the small works put up at Battle Mountain Station, and some lots were shipped to San Francisco and New York, but the bulk of it was left on the dump at the mine. An analysis of an average sample of this ore, rough dressed, gave the following result:

Moisture	2.82
Alumina	1.58
Silica	12.62
Antimony	62.28
Bismuth	6.63
Sulphur	19.31
Oxygen (calculated)	4.06
	99.30

While this ore carries from three to fifteen ounces of silver per ton, it is entirely free from lead and copper, a feature that greatly facilitates its reduction to a regulus by the most inexpensive and simple process. Some of the metal disposed of in the New York market is said to have given entire satisfaction, though not quite free from sulphur. Mining the ore at this point costs $2 per ton; freight to San Francisco, $10 per ton; hauling to the railroad $4 per ton; to England, via Cape Horn, $15 per ton; value of ore in England, $50 to $60 per ton; regulus, 12 cents per pound. After being worked in a small way for several years commencing in 1871, operations were suspended at this mine, nor has much been done there since, the bulk of the ore being of too low grade to warrant further attempts at handling it.

The lode San Emidio is represented to be much larger than at the Battle Mountain mine, being from 30 to 40 feet thick and containing immense quantities of ore, some of it very rich, the mass of it, however, of rather low grade. A good deal of money was expended there in

1876 in the erection of a furnace, building roads and making other improvements; but the enterprise having failed to prove remunerative, work was soon after suspended and has so remained since. The principal obstacle in the way of success here was the cost of transporting supplies to and the ore and metal from the mine, which is situated high up in the mountains and a long way from the railroad. A similar enterprise attended with not unlike results was inaugurated about the same time at the Stayton mines in San Benito county, California. Two furnaces were put up here and other improvements made at considerable cost, but the undertaking, though well managed, had to be given up after a few years' trial, the cost of production and transportation to available markets being too great to leave any margin for profits. And yet the ore of this locality would in most countries be considered high grade, having averaged about 40 per cent. metallic antimony.

Under the impression that they would be able to obtain an adequate supply of antimonial ores cheaply, Messrs. Starr & Mathison, of San Francisco, erected in that city several years since works for the reduction of this class of ores. Although these works were of limited capacity and the metal produced was equal to the best imported, the proprietors after struggling along for a few years were obliged to close the works, having been unable to get enough ore of suitable grade to keep them running. As they had to market the product of their works in New York, they were unable to smelt ore carrying less than 55 or 60 per cent. metal. The consumption of antimony on the Pacific coast is inconsiderable, amounting perhaps to not more than 25 or 30 tons per year; not much is used except in the manufacture of type, britannia ware, and babbitt metal.

The shipments of antimony ore from San Francisco to England amounted in 1882 to $5,850. The Southern Pacific railroad carried east during the same period, 60,130 pounds of metallic antimony, shipped from San Francisco and Oakland.

Antimony occurs as a sulphide, and probably in other forms, associated with silver, lead, copper, etc., in many veins and deposits of ores of the latter metals throughout the Rocky Mountain region, but as yet has not been found in sufficient quantity to become commercially valuable. In the Wood River county, Idaho, it occurs in association with the argentiferous lead ores, as is very generally the case in the silver-lead districts of the Far West. The distance from reduction works and the high cost of transportation will prevent the successful working of any but the richest and most accessible deposits.

BISMUTH.

Bismuth ores occur in many of the States and Territories of the Far West. One deposit of some importance is reported from Utah. Carbonate of bismuth has been found near Phœnix, Arizona. The usual ore is the sulphide. This ore is found in small quantities as a sulphide in a large proportion of the refractory ores of the Rocky mountains, and in considerable quantities in certain veins in Boulder and La Plata counties, Colorado. The Bismuth Queen lode, about five miles north of Golden, Colorado, shows a vein of bismuth ore varying from 2 to 8 inches in width, in which the metal occurs in the forms of bismutite and bismuthinite, carrying in some cases 80 per cent. metal. Small quantities have been smelted for experimental purposes, with highly satisfactory results. Tetradymite (telluride of bismuth) has recently been identified in Arizona.

The production of metallic bismuth in the United States has thus far been of no importance. The ores, which in small quantities at least are widely distributed in this country, give promise that in the future the production of bismuth may become a regular industry. The metallurgical processes for the extraction of the metal from its various ores are quite simple.

ARSENIC.

Arsenic is widely disseminated throughout the ores of the Rocky mountains, occurring principally in combination with iron forming the mineral mispickel. In Gunnison county, Colorado, it occurs in combination with cobalt and iron, probably as the mineral lollingite. On the Pacific coast the mispickel is frequently auriferous, and is treated by the chlorination and leaching process for the extraction of its gold contents. Mispickel is also found, in more or less quantity, in almost every portion of the United States; and is often mistaken by farmers for silver ore.

Large quantities of arsenic pass off in the fumes from roasting and smelting furnaces and are lost, no attempt being made to save the volatile elements in the ores. Arsenious acid occurs quite frequently in fragile white crystals in the dust chambers of smelters, forming beautiful specimens for cabinets.

PLATINUM.

American occurrences.—Platinum, either comparatively pure, but more commonly alloyed to a considerable extent with iridium, osmium, or other metals of the same group, is found in small quantities in many of the gold placer regions of the Far West and Pacific coast, notably in California; and also occurs associated with placer gold in Virginia, North Carolina, Georgia, and other Southern States. A nugget of platinum found near Plattsburgh, New York, weighing 104.4 grains, is described in the *American Journal of Science*, III., xxi., p. 123, 1881.

Platinum usually appears in the form of small rounded and flattened grains. The occurrence of platinum in the United States thus far has been a matter of scientific interest rather than of any economic importance. Small quantities have from time to time been saved from the sluices of hydraulic mines, but were merely kept as a matter of curiosity. In 1877, 1878, and 1879, an irregular search was made for it in view of the then existing and prospective demand for the metal for incandescent electric lighting, and samples were obtained from many points, but many of the localities reported in the Southern States, as well as elsewhere, failed to afford specimens when specifically tested. No platinum in place, that is as ore in a lode, has as yet been discovered; its occurrence being confined, as above stated, to the placer deposits. A vein of platinum is reported to have been recently discovered near Hailey, in the Wood River country, Idaho, and small shipments of the ore have been made to the smelting works at Omaha. Although this find is called a vein, in the absence of definite particulars it is reasonable to assume that the metal is found in the usual form of stream platinum.

It is quite probable that in the future the production of platinum in the United States may become a regular industry; though from the indications which have been observed it does not appear likely that it will ever reach any very considerable importance. The quantity of American platinum marketed in 1882 was about 200 troy ounces. There are no regular quotations for the domestic metal. One manufacturer reports that the crude, unrefined American platinum which he has handled ran as low as .520 in fineness, as against .850 for the average crude Russian.

The method of mining is analogous to that of placer gold, with the exception that the apparatus for saving platinum depends upon gravity alone, and not upon gravity and amalgamation. The plant required for manufacturing platinum is simple and inexpensive, and the art has been developed to a high extent in this country. The best crucibles, etc., are made by hammering plate of the greatest possible density into shape. It is said that the cheaper spinning process which is sometimes employed has the effect of opening the texture of the metal and rendering utensils so made short-lived and unsatisfactory.

Imports.—The supplies of platinum consumed in the United States are derived from the Ural mines, where it is found in placers. The Russian platinum, however, mostly comes through French, English, and German laboratories, where the native grains are worked into merchantable metal. During the fiscal year ending June 30, 1882, unmanufactured platinum (wire or rod and sheet or plate) to the value of $304,290, and manufactured platinum (consisting of three or four large stills for rectification of sulphuric acid) worth $32,360 were imported, and during the same period manufactured platinum articles (consisting mainly of used-up stills sent to Europe for repair, or of scrap-metal) were exported to the value of $19,244. Very little native Russian grain platinum is imported. The price of Russian unmanufactured platinum in New York at the close of 1882 was $6 per troy ounce. The terms "manufactured" and "unmanufactured" are used in accordance with an old ruling of the Treasury Department drawing the line between dutiable and free entries. "Vases, retorts, and other apparatus, vessels, and parts thereof, for chemical uses," are now on the free list.

IRIDIUM.

By F. W. Clarke.

The chief source of iridium is the mineral iridosmine, which occurs in very hard, shining, metallic grains in many placer deposits, associated with gold. The ore consists mainly of the rare metals iridium and osmium, together with smaller quantities of rhodium and ruthenium. Platinum and palladium also are sometimes present. The chief commercial sources of iridosmine are in the Ural mountains; but it occurs also in Brazil, and a considerable amount is brought from California and Oregon. Being as heavy as gold, it accumulates with the latter in the placer washings, and is easily recovered and saved. The harder grains are used in tipping gold pens, and the other portions are converted into iridium oxide. The latter substance serves for a permanent black pigment in decorating fine porcelain.

When iridosmine, which is practically infusible, is heated to whiteness in contact with phosphorus, fusion takes place. The fused product, heated with lime, loses phosphorus, and a subphosphide of iridium is left. At the same time osmium is eliminated by volatilization as oxide. This so-called fused iridium is now manufactured under Holland's patent by the American Iridium Company, of Cincinnati. It is steel-white in color, harder than steel or even agate, is practically infusible in any furnace, is insoluble in the strongest acids, and incapable of rusting. These properties are likely to create a demand for iridium, which is now being introduced into commerce for a variety of purposes. It is not only used for gold pens and for the points of stylographs, but also for the knife edges of fine balances, for the tips of rubber-turning tools, for wire draw-plates, etc. Recently Prof. W. L. Dudley, of Cincinnati, has succeeded in electroplating with iridium, and has obtained excellent results.

To a considerable extent iridium is alloyed with the platinum used for chemical purposes, inasmuch as it gives the latter metal increased rigidity and hardness. The standard meters of the International Commission on Weights and Measures consist of ninety parts of platinum to ten of iridium.

Crude iridosmine is now worth from $2 to $5 per troy ounce, according to purity. "Fused iridium" sells at about $10, pure iridium (refined only abroad) at about $20.

ALUMINUM.

By R. L. Packard.

Soon after Deville succeeded, more than twenty-five years ago, in obtaining aluminum on the large scale from its chloride by the use of sodium, on the principle introduced by Wöhler, various methods were suggested for obtaining the metal by substituting other reducing agents for sodium, and by means of electrolysis. These attempts were scattered through the years 1856, 1857, and 1858. Since then, excepting an occasional effort in the direction of electroplating, the industry, if it may be called so, has remained substantially as Deville's experiments left it. The other processes have not been practically successful, and the inherent cost of the sodium method appears to have been a serious obstacle to the use of aluminum in the arts.

Some revival of interest in the production of this metal has recently arisen in England, where it is stated a process has been invented by which aluminum can be produced so cheaply as to make practicable its speedy application to the purposes for which its properties peculiarly adapt it. The descriptions of this process, unfortunately, as given in the journals, do not warrant such an inference. According to these accounts, it consists in obtaining alumina from alum or bauxite, then converting the alumina into aluminum chloride, and finally reducing the metal by sodium. The steps of the process, if the description given in the papers is correct, are substantially identical with those described by Deville in his book, "De l'Aluminium," Paris, 1858, and the expensive sodium is the reducing agent.

The retail price of aluminum is reported at $1.25 per troy ounce. The quantity of the metal sold in this country in 1882 was inconsiderable. Its use is confined to the manufacture of light weights, parts of mathematical instruments, and similar articles.

MOLYBDENUM.

Molybdenum as the mineral molybdenite (sulphide) occurs crystalized in veins about 4 miles north of Pitkin and near Rock creek, Gunnison county, Colorado. The quantity is probably sufficient to render these veins valuable in the future. As molybdate of lead it is said to occur in Leadville in small quantity, and to be very abundant in Utah. Molybdenite occurs at Blue Hill bay, Maine; and at Westmoreland, New Hampshire. Many other localities have been reported. Salts of molybdenum are used to a certain extent in chemical operations, but the supply is quite limited.

TELLURIUM.

Though not very abundant, tellurium can hardly be called a rare metal in the United States. It has been found at several localities in California and reported elsewhere on the Pacific coast. The principal occurrences of tellurium in this region, so far as discovery has gone, are at the Melones mine on Carson Hill, in Calaveras county, and at the Rawhide and Golden Rule mines, in Tuolumne county, California, where it is found in combination with gold, silver, sulphur, etc., many large and exceedingly rich samples of the telluride of gold having been taken out of these mines. Tellurium has also been found under like conditions in Utah, but the extent and value of the deposits there remain undetermined.

Tellurium ores are of frequent occurrence in Boulder county, Colorado, where they form the characteristic ores of the district, and, in smaller quantities at Bonanza, Saguache county; the Hotchkiss mine, Hinsdale county; in La Plata county, and also at two different points in Montana, where the species is nagyagite. The tellurium of the Rocky Mountain region occurs combined with gold, silver, lead, and possibly mercury, forming the minerals petzite, with a composition of tellurium 32.68, gold 25.60, and silver 41.86; sylvanite, with a composition of tellurium 55.8, gold 28.5, silver 15.7; hessite, containing tellurium 37.2, silver 62.8; nagyagite, containing tellurium 32.2, sulphur 3.0, lead 54.0, gold 9.0; altaite, tellurium 38.3, lead 61.7, containing both silver and gold; calaverite, tellurium 55.89, gold 40.70, silver 3.52; and probably as coloradoite, a telluride of mercury. Tellurium also occurs native in fine crystals in the telluride mines of Boulder county, Colorado. The most frequently occurring of the tellurium minerals are petzite and sylvanite, of which large quantities are shipped to the Boston and Colorado smelter at Denver.

A telluride of bismuth occurs in Fluvanna county, Virginia.

Tellurium is not extracted from its ores in any portion of the United States in quantity, and has no value either as the metal or in the various compounds beyond its gold or silver contents, except as a curiosity. The metal can readily be obtained in small quantities, and possesses a specific gravity of from 2 to 2.5, and a hardness of from 6.1 to 6.3. Its color is tin-white.

URANIUM.

Uranium in the form of the mineral pitchblende (uraninite or gummite) occurs in Jefferson and Gilpin counties, Colorado. In Jefferson county thin seams of it have been found, but the mineral is in too small quantity to be economically valuable. In sinking the shaft on the Wood lode at Central City, Colorado, in 1872, a lenticular mass of pitchblende was cut through and quite a large quantity of it was thrown away before its character and value were known. Afterward the remainder, amounting in all to three tons, was extracted under lease by Richard Pearse, esq., of the Boston and Colorado smelter, and was sold in England at an average price of $1.50 per pound. The mineral was quite pure, and averaged 70 per cent. of the proto-sesquioxide of uranium.

Uranium is used in considerable quantities in chemical operations and in porcelain painting, affording a yellow or black color, according to the process of baking. The principal supply is obtained from the mines at Joachimstal, Bohemia, and is quite limited.

VANADIUM.

Vanadium, in combination with lead, forming the minerals dechenite and descloizite, occurs sparingly in the Evening Star and some other mines in Leadville, Colorado, and in orange-red crystals in the ores from the Merritt mine, in the Socorro mountains, 4 miles west of Socorro, New Mexico. These minerals are not utilized, though vanadic salts are extremely valuable, and are used principally as a mordant in the manufacture of the finest silks.

STRUCTURAL MATERIALS.

BUILDING STONE.

Census statistics.—The division of the Tenth Census charged with the collection of statistics of building stone obtained returns from 1,525 quarries in the United States, having an invested capital of $25,414,497, and producing during the year ending May 31, 1880, 115,380,133 cubic feet of stone, valued at $18,365,055. In value of total product, the leading States rank as follows: Ohio, Pennsylvania, Vermont, Massachusetts, Illinois, New York, Maine, and Connecticut; each of these States producing upwards of $1,000,000 worth of stone. Vermont, Illinois, Ohio, Iowa, Indiana, New York, and Missouri, in the order named, produce the most marble and limestone; Ohio, New York, Connecticut, and Pennsylvania, the greater part of the sandstone; Massachusetts and Maine quarry the most granite and other siliceous crystalline rocks; while Pennsylvania leads in product of slate. Following is an abstract from the census returns:

General statement of the operations of the building-stone quarries in the United States in the census year 1880.

	Totals by kinds of rock.				Totals for the United States.
	Marble and limestone. (*a*)	Sandstone.	Crystalline siliceous rocks.	Slate.	
Number of quarries	616	502	313	94	1, 525
Capital invested	$10, 565, 497	$6, 229, 600	$5, 291, 250	$3, 328, 150	$25, 414, 487
Product in census year—cubic feet	65, 523, 965	24, 776, 930	20, 506, 568	4, 572, 670	115, 380, 133
Value of product in census year	$6, 856, 681	$4, 780, 391	$5, 188, 998	$1, 529, 985	$18, 356, 055
Number of quarrying machines	190	40	64	45	339
Number of hoisting machines	709	634	763	184	2, 290
Number of dressing machines	499	95	322	392	1, 308
Value of explosives	$61, 408	$27, 571	$70, 397	$32, 799	$192, 175
Greatest number of laborers employed	15, 646	9, 567	11, 477	3, 033	39, 723
Males above 16 years of age	15, 363	9, 428	11, 340	2, 814	38, 945
Number of horses	4, 439	2, 091	1, 258	271	8, 059
Number of mules	586	140	105	20	851
Number of oxen	163	277	652	4	1, 096
Number of wagons	1, 571	1, 023	981	110	3, 685
Number of vessels	111	73	81	....	265
Number of cars	368	72	144	72	651
Number of locomotives	2	2	1	....	5

a With "Marble and limestone" is included one quarry of serpentine rocks.

Statistics of the building-stone quarries of the United States in the census year 1880, by kinds of rocks and by States and Territories.

States and Territories.	Number of quarries.	Capital invested.	Product in census year.	Value of product in census year.
MARBLE AND LIMESTONE. (*a*)			*Cubic feet.*	
Illinois	38	$2,101,200	13,013,139	$1,320,742
Indiana	65	539,660	8,102,115	593,375
Iowa	128	552,775	10,772,283	666,554
Kansas	17	59,700	1,340,346	131,570
Kentucky	19	143,250	1,724,675	92,216
Maryland	3	142,435	70,617	65,929
Massachusetts	4	284,500	99,425	230,495
Michigan	4	61,050	97,800	26,085
Minnesota	33	159,575	2,816,298	201,593
Missouri	27	242,350	4,419,300	421,211
Nebraska	1	5,000	330,000	15,000
New York	55	508,620	2,836,025	431,439
Ohio	119	872,102	11,098,583	669,723
Pennsylvania	24	592,160	3,339,722	240,934
Tennessee	13	131,700	792,621	192,695
Vermont	18	3,886,000	1,192,100	1,340,050
Virginia	2	35,000	20,000	27,750
Wisconsin	46	248,420	3,458,916	189,320
Total	616	10,565,497	65,523,965	6,856,681
SANDSTONE.				
Colorado	3	2,000	108,750	9,000
Connecticut	6	1,167,500	988,200	680,200
Dakota	1	3,500	38,400	12,000
Illinois	5	18,800	308,060	21,830
Indiana	5	73,900	311,712	40,400
Iowa	3	4,000	157,500	4,200
Kansas	2	14,000	66,000	11,000
Massachusetts	15	95,800	729,980	144,294
Michigan	5	13,650	550,260	53,080
Minnesota	5	113,600	324,000	41,150
Missouri	5	51,200	194,000	81,960
New Jersey	20	210,100	2,384,791	400,420
New York	181	510,775	2,980,353	724,556
Ohio	126	3,294,700	8,574,726	1,871,924
Pennsylvania	95	560,825	6,229,110	627,943
Washington	1	1,500	14,000	2,000
West Virginia	10	55,350	294,700	16,689
Wisconsin	14	38,400	522,388	37,745
Total	502	6,229,600	24,776,930	4,780,391
CRYSTALLINE SILICEOUS ROCKS.				
California	2	100,000	413,000	172,450
Colorado	3	11,500	554,040	41,400
Connecticut	32	563,060	2,539,200	407,225
Delaware	3	4,800	45,900	12,300
Georgia	2	60,000	278,960	64,480
Maine	68	1,625,500	2,203,670	1,175,286
Maryland	7	106,000	1,182,500	224,000
Massachusetts	92	1,217,150	4,623,125	1,329,315
Minnesota	3	11,050	28,815	13,075
Missouri	2	35,000	86,300	110,000
New Hampshire	39	128,800	1,920,340	303,066
New Jersey	2	10,500	820,000	99,000
New York	3	16,000	42,400	10,000
Pennsylvania	15	243,590	3,028,222	211,454
Rhode Island	17	476,000	1,352,900	623,000
Vermont	12	50,140	187,140	59,675
Virginia	10	631,250	1,181,556	331,928
Washington	1	1,000	18,500	1,044
Total	313	5,291,250	20,506,568	5,188,998

a With "Marble and limestone" is included one quarry of serpentine rocks.

Statistics of the building-stone quarries of the United States, etc.—Continued.

States and Territories.	Number of quarries.	Capital invested.	Product in census year.	Value of product in census year.
SLATE.				
			Squares.	
Georgia	1	$600	1,000	$4,500
Maine	6	660,000	26,200	84,800
Maryland	7	59,500	12,280	56,700
Massachusetts	2	19,400	1,550	7,000
New Jersey	3	11,300	4,683	15,000
New York	12	45,050	19,850	95,500
Pennsylvania	30	1,681,400	271,313	863,877
Vermont	31	795,900	108,891	352,608
Virginia	2	55,000	11,500	51,000
Total	94	3,328,150	457,267	1,529,985
			Cubic feet.	
Total United States	1,525	25,414,497	115,380,133	18,356,055

In these tables the data are strictly confined to quarries of building stone and do not include the many and important quarries of limestone for flux and for lime-burning, and quarries of various minerals used in the technic arts.

Present status.—It should be observed that the figures quoted are mainly based on reports from quarries above the standard production fixed by the census authorities, that is, quarries which during the census year yielded stone to the value of $1,000 or upwards. A few reports from smaller establishments were, however, included. As there are a very large number of small and irregularly worked quarries, which, though individually insignificant, in the aggregate furnish a large output, it is safe to assume that the value of the product stated ($18,356,055) is considerably within the truth. A fair estimate, founded on the actual returns quoted, would place the present annual product of the building-stone quarries at certainly not less and probably slightly more than $21,000,000. The product fluctuates slightly from year to year according to the general prosperity of the country, and the consequent impetus given to the building industry. The quarries give employment during the busy season to some 40,000 men.

Imports and exports.—The imports of marble and other stone, rough and manufactured, including statuary marble, and a considerable proportion of dressed stone, and stone worked into objects of art, average about $1,000,000 annually. The exports of rough stone of domestic production amount to between $150,000 and $200,000 per annum. Manufactured stone articles made in the United States are exported in quantities having a fluctuating value, but reach nearly $500,000. The re-exports of foreign stone are unimportant in amount. The following tables show the extent of the foreign commerce of the United States in this branch from 1872 to the close of 1882;

Value of marble and stone and manufactures of marble and stone imported into the United States during the fiscal years specified (specie values).

	Value.
1872	$1,041,053
1873	1,099,280
1874	1,246,692
1875	1,335,695
1876	1,216,796
1877	865,133
1878	746,956
1879	689,288
1880	888,874
1881	927,752
1882	930,071
Calendar year 1882	1,048,661

Marble and stone of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Rough—value.	Manufactured—value.
1872	$156,976	$165,311
1873	96,735	189,795
1874	126,669	168,977
1875	125,968	254,356
1876	95,480	236,255
1877	131,716	917,937
1878	142,661	597,356
1879	143,457	430,848
1880	199,051	453,912
1881	220,362	409,433
1882	180,774	433,656
Calendar year 1882	184,365	472,426

Marble and stone, and manufactures of marble and stone, of foreign production, exported from the United States during the fiscal years specified.

	Value.
1872	$1,929
1873	4,571
1874	1,928
1875	3,428
1876	13,371
1877	8,475
1878	3,448
1879	6,364
1880	6,816
1881	709
1882	4,848
Calendar year 1882	4,269

BUILDING STONE IN THE ROCKY MOUNTAIN DIVISION. (*a*)

Building stones of almost every description are found abundantly and of the greatest value throughout the Rocky mountains, running through all the varieties of granites, sandstones, marbles, and volcanic rocks.

a The forthcoming census report on the quarrying industry will contain a detailed account of the building stones of the Eastern States.

In Montana and Wyoming but little has been quarried, but the Colorado quarries have been opened to a considerable extent, and thousands of tons have been used in the construction of public and private buildings.

Of the quarries of Jefferson county, Colorado, Capt. Edw. L. Berthoud, of Golden, says: "The 'Hogback,' an inclined, wedge-shaped outlier of the Rocky mountains, which is continuous from the Spanish peaks into Wyoming Territory, and composed of cretaceous and Jura-Trias formations, is an inexhaustible source of fine building stone, with two separate parts formed wholly of limestone. From this natural quarry an infinite variety of color, hardness, and quality is obtainable. We have from it, first, gypsum, white, or banded, or clouded; second, dark red sandstone; third, superb salmon-colored sandstone, a specialty of the famed Morrison quarries; fourth, yellow sandstone, hard and fine; fifth, white and cream-colored, easy to manufacture, either by cutting, sawing, or polishing—hardening by exposure; sixth, green and brown sandstones, soft when quarried, easily worked and polished, but hardening when thoroughly dried and exposed; none of these several qualities split on exposure to frost; seventh, red-banded calcareous sandstone, of red, yellow, and white alternate bands, very ornamental for polished work, such as table-tops, mantel-pieces, etc. Westward from the Hogback a vast variety of granites, mica slates, mica schists, hornblende rock, felspathic rock, syenite, and porphyry abound everywhere, and have been largely used for foundations, bridge structures, etc. Some of the granite dikes will afford red crystalline rock, which is susceptible of a high polish and would be fine material for ornamental work. Graphic granite occurs near Bergen's ranch and in Clear Creek cañon; it is of light straw or cream color and takes a fine, durable polish."

One quarry at Morrison produces a superb red freestone which has been used in the following buildings in Denver: the Union Depot, Tabor Opera House, First National Bank, Colorado National Bank, Daniels & Fisher's block, and in many others. The quarries at Morrison also produce green, brown, and white freestone; and dark gray, light gray, brown, red, pink, and greenish granites of excellent quality.

The marbles of Colorado are of several varieties and of excellent quality. A beautiful variety of breccia occurs in Boulder county, white marble in Chaffee county, apple-green and clouded marbles in Park county, and various kinds at the head of Rock creek, Gunnison county.

A favorite building stone, used to a large extent in Denver, is the fine pink lava from Castle Rock, Douglas county, and large quantities of this stone are shipped annually over the Denver and Rio Grande railroad.

Excellent marbles are found in Montana, but scarcely any is quarried. New Mexico also contains some fine building stones, but none are utilized to any extent.

BUILDING STONE ON THE PACIFIC COAST.

Stone suitable for building and similar uses is abundant in all the Pacific States and Territories. Besides mountains of granite and immense beds of sandstone, there occurs in many parts of the country a species of steatite well adapted for building purposes, being light, fireproof, very durable, and easily quarried and dressed. Much use is made of this stone in the localities in which it abounds, more especially in sections of the distant interior where lumber is scarce. Neither stone nor brick is much employed for building in these Western regions, lumber being almost everywhere cheap, and climate and convenience favoring its extensive use. Even in the larger cities more than three-fourths of the structures of every kind consist of wood; many of them, however, have brick or stone foundations.

Granite.—Large quantities of granite are used in San Francisco, and some of the other large towns, for curbing the sidewalks and street-crossings. This stone is extensively quarried at Folsom and Natoma, in Placer county, California, and at Rocklin and Penryn, situated on the Central Pacific railroad, 22 and 28 miles, respectively, from the city of Sacramento. The granite at these places is of excellent quality, that obtained at Rocklin and Penryn being considered especially good. As the deposits here are very extensive and the rock splits evenly, it is possible to break out blocks of large dimensions, some more than 100 feet long, 50 wide, and 10 thick having been quarried out and afterwards broken up into smaller pieces.

The Penryn granite works are some 28 miles east from Sacramento, on the line of the Central Pacific railroad. The first of the several quarries from which the stone is procured was opened in 1864 by the present owner, Mr. G. Griffith, whose establishment is the most complete on the coast. His quarries cover some 680 acres at Penryn and Rocklin, the latter point being six or eight miles distant from the former in a due westerly direction. The cutting and polishing works, located near Penryn, and the principal quarries, are extensive. They consist of various buildings and sheds, filled with machinery employed in cutting and polishing the granite. Here 200 men find constant employment, and the force is frequently much greater. The chief superiority and predominating excellence of Penryn granite consist in the fact that it does not change color by exposure, and that it contains no iron. These advantages give to the Penryn granite a superiority when used for monuments, tombstones, or when placed in any position where it will be exposed to the elements. The predominating shades of Penryn granite are blue, gray, and black, the last named very much resembling the celebrated black granite found in Egypt, and exceedingly beautiful when highly polished.

Granite quarries are worked at a great many other places in California and elsewhere on the coast.

Marble.—Carbonate of lime in nearly all its forms is abundant on the Pacific coast and in the adjacent Territories, especially as limestone. Marbles in great quantity and in every variety are found in California, the following localities being noted for their fine beds:

Near the town of Columbia, Tuolumne county, where the deposit is of great thickness, masses weighing as much as 600 tons have been blasted out, and single blocks weighing 13,000 pounds have been quarried and dressed. For sawing the stone into slabs and other required forms a water-power mill of large capacity has been put up at the quarry, from which a good deal of marble has since been taken out and sold, the most of it having been used for building purposes in San Francisco. In color this marble is much diversified, some portions being an unclouded white, while others are tinted with blue or gray, or a blending of hues of many kinds. It is all fine-grained and extremely hard.

Four miles from the town of Suisun, Solano county, where the stone in its rough state has exactly the appearance of rosin, it occurs in heavy beds, blocks measuring 800 or 900 cubic feet having been broken out here. A great deal of marble has been taken from this quarry, the unique tints of the material and its fine grain recommending it for many ornamental uses.

On the McCloud river, near Copper City, Shasta county, a pure white marble is found, fit for all kinds of delicate work, even for statuary. Being in a remote and sparsely settled region, not much has been done with this bed, though it is said to be very extensive.

At Indian Diggings, El Dorado county; above Downieville, in Sierra county; at Susanville, in Lassen county; and in Placer county near the line of the Central Pacific railroad, occur heavy beds of marble of almost every color and degree of fineness, though none of them have been extensively worked. The deposit at Indian Diggings, opened in 1857, the first ever worked in the State, is of the clouded variety, and has been much employed for monuments and like purposes. In this bed, which is over 100 feet thick, there occurs a grotto nearly 700 feet long and from 20 to 80 feet high.

While there has always been a great demand for marble in California, only the more common kinds obtained from the quarries opened in the State have been largely used, the finer varieties having been imported, mostly from Italy. Much of the stone in California is of excellent quality, being a pure white or beautifully variegated, and susceptible of the highest polish. It is probable that none equal to the Carrara has yet been met with in the State, but from the quality of some already found near the surface it is thought that marble equal to the best foreign will be obtained when the deposits come to be worked to greater depths. In addition to the kinds already mentioned, there are handsome specimens of the Cipolin, white with shadings and streaks of green, and the Porton or Genoese yellow; also, what is termed Ruin marble, a yellowish stone with broken brownish lines resembling the ruins of fortifications, castles, and other artificial structures.

What has tended to prevent a larger use of the domestic product has been the cost of transportation, which from almost any of the quarries to San Francisco has been greater than from Italy to that point. Through the construction of railroads into the interior the transportation of marble is likely to soon be so cheapened that the principal supply will thereafter be obtained from home sources.

It does not appear that much, if any, marble has as yet been found in the State of Nevada, nor is this stone so abundant in any other part of the Pacific coast as in California. Enough of the carbonate of lime occurs everywhere, however, in other forms, to make all the lime required for local purposes, Oregon alone forming an exception.

Sandstone.—A handsome fine-grained sandstone of a greenish-gray color is quarried on Angel island in the bay of San Francisco. A brown sandstone, obtained near Haywood's, Alameda county, California, is much used in the cemeteries as bases for monuments, for constructing vaults, etc. A bed of sandstone of a pinkish color, streaked with wavy lines of brown and purple, occurs near the Merced river, in Mariposa county, which, being very beautiful and durable, would be likely to come into large use were the locality more accessible.

Slate.—While slate is very common stone on the Pacific coast, the fissile variety suitable for roofing has been found only in a few localities; one of these being near Copperopolis, Calaveras county, California, where a stone of a very good quality is found in abundance. A bed of similar slate was opened over 20 years ago in Amador county, California, and worked for a short time, when the enterprise was abandoned, there being little demand for it when gotten out, asphaltum, tin, and shingles continuing as before to be preferred for roofing purposes.

"*Trachyte.*"—In various parts of the western mining region an igneous rock, generally known as "trachyte," is found. It is usually of a pinkish-gray color, and affords convenient and most desirable stone for building purposes, being soft when first taken from the quarry, but gradually indurating on exposure to the atmosphere. This hardening property, however, is sometimes claimed on slight grounds. The stone is durable and resists a high degree of heat.

BRICK, TILE, ETC.

These come rather under the head of manufactures than mineral industries; for the value of the raw material is very small compared with the labor and supplies expended in making from them marketable commodities. The making of common brick, firebrick, pressed brick, tile, drain pipe, etc., employs a force of nearly 70,000 persons; and the value of the product is now in the neighborhood of $34,000,000 per annum. In total product Pennsylvania takes the lead with nearly $5,000,000; followed by New York with $4,000,000; Ohio, $3,500,000; Illinois,

$3,000,000; Indiana, $2,000,000; and New Jersey, Missouri, and Massachusetts, each of which produces between $1,000,000 and $2,000,000 worth of these products. New York leads in production of common brick; Pennsylvania in firebrick and pressed brick; Indiana in tile; and Ohio in drain pipe. The following table is an abstract from the returns of the tenth census:

Operations of the brick and tile establishments of the United States during the census year 1880.

Number of establishments	5,631
Capital invested	$27,673,616
Labor:	
Average number of hands employed	66,355
Males above 16 years	59,032
Females above 15 years	268
Children and youths	7,055
Total amount paid in wages in census year	$13,443,532
Materials:	
Wood, cords	1,157,522
Value of all other materials	$5,750,303
Total value of all materials	$9,774,834
Products:	
Common brick	3,822,362,000
Firebrick	163,184,000
Pressed brick	210,815,000
Value of tile	$2,944,239
Value of drain pipe	$1,765,428
Value of all other products	$729,926
Total value of all products	$32,833,587

LIME.

Domestic production.—Lime for mortar and other building purposes is burnt to a greater or less extent in every State in the Union. It is difficult, or almost impossible, to obtain accurate statistics of production, inasmuch as the manufacture is in a great number of small hands, and only a small proportion of the product passes through the main channels of transportation. The production is estimated to be between 30,000,000 and 32,000,000 barrels, of 200 pounds each, worth 65 to 75 cents per barrel, spot value. This gives a total valuation to the production of $21,700,000—assuming the means of the above figures. The lime product presupposes the quarrying of about 6,000,000 tons of limestone. Of this total product of lime it is estimated by several authorities that 1,500,000 barrels come from Rockland, Maine, and from 800,000 to 1,000,000 barrels from New York State.

Imports and exports.—The imports of lime for the fiscal year 1882 amounted only to $36,846. The exports of lime for the calendar year 1882 are grouped with those of cement, both amounting to 70,439 barrels, valued at $105,090. The following tables show the exports during recent years. The new tariff rate on lime is 10 per cent. ad valorem.

Lime and cement of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Quantity.	Value.
	Barrels.	
1872	39,686	$69,218
1873	27,873	52,848
1874	41,349	69,080
1875	64,087	98,630
1876	53,827	77,568
1877	78,341	97,923
1878	82,507	98,334
1879	60,657	74,097
1880	41,989	52,584
1881	57,555	83,598
1882	67,030	100,169
Calendar year 1882	70,439	105,090

Lime in the Rocky Mountain division.—Limestone occurs everywhere throughout the Rocky Mountain region in great quantity and purity. In every town where the local demand warrants it, limekilns are erected and excellent lime produced upon the spot. No record can be obtained of the production, because of the numerous small producers.

The kilns at Morrison, Colorado, produce great quantities of lime of the best quality, which is used in Denver and in the mountain towns. In 1882 Morrison shipped 274,000 bushels of lime to various points in Colorado, and of gray or cement lime 6,500 perches. The entire Rocky Mountain country is supplied with lime of domestic manufacture exclusively.

Lime on the Pacific coast.—Common limestone, though an abundant rock in most parts of the extreme West, occurs sparingly in Oregon and perhaps also in Washington Territory. The receipts of lime at San Francisco for the nine years ending with 1882 were as follows, the whole being the product of California:

	Barrels.
1874	143,513
1875	182,631
1876	174,758
1877	155,113
1878	144,072
1879	104,405
1880	133,097
1881	123,779
1882	133,306

During this period, the prices of lime in San Francisco have varied from $1.50 to $1.75 per barrel, the present price being $1.60. While lime is burned in various parts of the State, about one-third of the California product is made near the town of Santa Cruz, where a highly crystalline limestone occurs in great abundance.

CEMENT.

Kinds.—Nearly all the cement produced in this country is made from natural cement rock. The Rosendale and Louisville cements, which form the great bulk of the production, are natural cements. Portland cement, most of which is imported, comparatively little being made here, is an artificial cement. Besides this, which forms by far the greater part of the importations, we import Roman (a natural cement), Keene's, Lafarge, selenitic, lime of Teil, and other varieties.

Production in 1882.—The total cement product of the country in 1882 is estimated by the best authorities at from 3,000,000 to 3,500,000 barrels. Probably the mean of these (or 3,250,000 barrels) is very near the true production. Of this, 85,000 barrels, of 400 pounds each, is estimated to be the production of artificial, or Portland cement. The average value of this is about $2.25 per barrel, at the works. A barrel of natural cement weighs 300 pounds and has an average value at the works of $1.10. Estimated on this basis, the total value of the cement production for the year 1882 was $3,672,750.

Manufacturing centers.—The principal centers of production of American cement are:

First. Ulster county, New York, at Rosendale and in the valley of Rondout creek, where the material for this cement is found in abundance. From the name of the principal producing center of this district, the name Rosendale is given to all natural cement produced in this neighborhood, as well as to all that made from materials obtained here, although prepared for use at other points, as Troy, Brooklyn, and Cohoes. The rock used for this purpose is the lowest stratum of the Lower Helderberg group, and the topmost member of the Niagara group. The production of Ulster county is estimated to be between 1,500,000 and 1,600,000 barrels, while that of all New York State is placed at about 2,000,000 barrels of 300 pounds each, the spot value of which is about $1.10 per barrel. The following are analyses of two of the Rosendale cements, which although consisting essentially of the silicates of lime, magnesia, and alumina, differ materially in their relative proportions:

Analyses of Rosendale cements.

	"Lawrence" Rosendale manufactured by the Rosendale Cement Company.	"Hoffman" Rosendale manufactured by the Lawrence Cement Company.
Silica	22.77	17.17
Lime	34.54	48.28
Magnesia	21.85	19.13
Oxide of iron and alumina	10.43	10.80
Manganese oxide	.37	....
Soda	2.28	Trace.
Potash	1.35	Trace.
Carbonic acid	2.84	3.38
Phosphoric acid	.19	....
Sulphuric acid	1.44	1.20
Water	1.59	....
	99.65	99.96

Besides the natural (Rosendale) cements manufactured in this locality, a small amount of Portland cement is made here.

The second cement-producing locality, in point of importance, is in Kentucky and Indiana, in the neighborhood of the falls of the Ohio. The product is known as Louisville cement, from the principal center of its production. This is also a natural cement.

Both natural and artificial cements are manufactured to a considerable extent at Allentown, Pennsylvania. Cement is also reported as being manufactured at the following points in the eastern States, in greater or less quantity: Akron and Buffalo, New York; Sandusky, Ohio; Utica, Illinois; Kensington, Connecticut; Cumberland and Round Top, Maryland; Shepherdstown, West Virginia; James River, Virginia; Rockland, Maine; in western Pennsylvania, and at South Bend, Indiana, where small amounts of Portland cement are produced.

Imports.—Our main supply of Portland and other artificial cements is imported from abroad. There are many varieties of imported Portland differing among themselves in the proportions of their constituents, and in their characteristics of tenacity, strength, and hydraulic qualities. Generally speaking, imported Portland cement is manufactured from 60 per cent. of chalk, 30 per cent. of alumina free of organic matter, and 10 per cent. of silica. Until within a few years all our supply of Portland cement came from England. Recently, however, German importations have assumed great importance, and bid fair to hold a large proportion of the market in the near future. This material is also imported in considerable quantity from Sweden and other Scandinavian countries, and from France. The following is, in brief, a history of the importation from different countries: From 1871 to 1876, practically all importations were from England. From 1876 to 1880, the importations were largely from England, with a gradual encroachment from Germany; while in 1882 the importations from England formed one-half the total amount brought to this country. Three-fourths of the other half were from Germany, while the remaining one-eighth came from Sweden, France, and the Netherlands.

The following table gives the total importations during the fiscal years named:

Imports of cement.

Years.	Quantities.	Values.
	Barrels.	
1878.....	92,000	$184,086
1879.....	106,000	213,719
1880.....	187,000	373,263
1881.....	221,000	441,512
1882.....	*a* 337,793	675,587

The values given are based on manufacturers' prices; 40 per cent. should be added to bring them up to the prices in this country. The

a The number of barrels in 1882 is estimated from the valuation.

new tariff rate on building cements of all kinds is 20 per centum ad valorem.

Roman cement has been imported almost entirely from Glasgow and London. Of late years the importation of this cement has largely decreased. Lime of Teil is imported mainly from France. The importation of this, Keene's, and other cements is comparatively trifling.

Special qualities.—Portland, Rosendale, and Louisville cements are used primarily for work under water and in all cases where great strength and tenacity are required, as in the foundations of heavy buildings, sea-walls, light-houses, bridges, sewers, etc. Portland is used very extensively, also, for cellar floors, sidewalks, and the manufacture of artificial stone. In general, it may safely be said that imported Portland possesses a higher degree of tenacity and greater resistance to crushing than other cements, although there may be some American Portland which equals it in these qualities. The great difference in price between the imported and the American Portland on the one hand and the natural American cements on the other illustrates this difference in quality. Roman cement is characterized by setting much more quickly than Portland or American cements, and is hence used for such purposes as repairing leaks and such minor uses. Keene's is used for the manufacture of imitation marbles, ceilings, cornices, etc. Lime of Teil seems to be of very limited application, and is used mainly in admixture with Portland cements.

While the amount of the importations is increasing with great rapidity, the amount of cement of domestic manufacture is increasing doubtless in an equal ratio. This increased demand, which is largely in excess of the increase in building, is explained by manufacturers and importers as being due to the fact that cement is rapidly replacing lime mortar for ordinary uses of building, especially in large and expensive structures.

CEMENT IN THE ROCKY MOUNTAIN DIVISION.

In 1881 it was accidentally discovered that the lime burned from one of the limestone beds near Cañon City, Colorado, possessed hydraulic properties, and experiments were begun by Mr. N. M. Megrue, of Cañon, with a view to the manufacture of first-class cement. These experiments were continued with but slight success on a large scale. In 1882 works were erected at Denver, and every effort was made to secure the most favorable results. During 1882 about 100 barrels of excellent cement were made, and this was freely tested in various ways, the material satisfactorily standing every test.

Only a small proportion of the rock burned acted satisfactorily, over 90 per cent. being useless for all hydraulic purposes. These experiments have been continued until finally complete success has been achieved. In the first week in May, 1883, the first entire kiln of cement was turned out, and the company are now satisfied of their ability to produce a cement almost equal to the best Portland.

The works and experiments have cost nearly $30,000, and the capacity is now 100 barrels of 400 pounds net per day. The relative cost of the various brands of cement in Denver is as follows:

Portland, per barrel of 375 pounds net	$7 00 to $7 50
Louisville, per barrel, 265 pounds net	4 00
Denver, per barrel, 400 pounds net	6 00

This will make the Denver and Louisville cements cost the same price, 1½ cents per pound.

The Denver Cement Company expect to fully supply the State of Colorado, and the Territories of Wyoming, Utah, and New Mexico with a material which will make excellent and durable pavements and fulfill all the requirements of the best cement.

The Cañon City Iron, Paint, and Cement Company manufactured in 1882 2,000 barrels of cement (each 300 pounds net), but its quality has not been ascertained. For the first six months of 1883 the make was 385 barrels. This cement is sold retail at $4 per barrel.

The source of supply for both companies is the same—the Upper Silurian limestones in the Hogback near Cañon City. In the same locality occur beds of infusorial lime and white silica.

CEMENT ON THE PACIFIC COAST.

Fully twenty years ago a bed of hydraulic limestone was opened up about one mile south from the town of Vallejo, Solano county, California, and kilns for burning and a mill for grinding it were erected near the town of Benicia. The rock occurs in seams never more than four or five feet thick, inclosed in a metamorphic sandstone. The belt containing it extends west across the Strait of Carquinez and to the northwest for a distance of ten or twelve miles, in which direction it spreads out over a breadth of several miles. Only at a few points along this belt, however, does the limestone occur in any considerable quantity. The company engaged in beneficiating this rock pay 50 cents per ton for the privilege of taking it out and appropriating it wherever found, paying from $3 to $5 per ton for it delivered at their works, which have capacity to turn out about 100 barrels daily. Owing to heavy importations of this commodity these works have not always been run to their full capacity.

Several years since a bed of limestone suitable for making Roman cement was discovered in the town of Santa Cruz; but the deposit, though apparently extensive, has not as yet been much utilized.

In Oregon, and also in Washington Territory, hydraulic limestone of good quality has been found and works put up for manufacturing it into cement. The discovery of similar limestone elsewhere on the coast has been reported.

The consumption of cement in California is large, much being used in laying the foundations of buildings, for the manufacture of artificial stone, the construction of street-cable roads, dry docks, etc. The importations at the port of San Francisco during the past nine years have been as follows:

Imports of cement at San Francisco.

	Barrels and casks.
1874	60,202
1875	73,814
1876	66,988
1877	45,469
1878	57,258
1879	15,668
1880	62,417
1881	65,695
1882	99,208

Of late years a large proportion of these imports has consisted of the English Portland cement, which has succeeded, partly owing to low freights, in nearly crowding out the Eastern Rosendale, at one time extensively used. The following are present ruling prices for cement in San Francisco: California, $2; Rosendale, $2.75 to $3; Portland, $4 to $4.50 per barrel.

SOAPSTONE.

Steatitic and other magnesian rocks are used to a considerable extent as refractory linings for furnace hearths, grates, stoves, register borders, foot warmers, and for making stationary laundry tubs, sinks, griddles, etc. The substance known to the trade as soapstone is distinct from the mineral talc, which in the ground state is used for en tirely different purposes. The leading quarrying States are Vermont and New Hampshire. In the former State quarries are reported in the neighborhood of Chester, Saxton's river, Grafton, Cambridgeport, and Perkinsville. The localities reported in New Hampshire are near Francestown and Nashua. Similar deposits occur in Massachusetts and many other States. The total product in 1882 is estimated by Mr. James H. Serene at 6,000 tons. The spot value per ton at the quarry ranges from $8 to $20; and the average appears to be about $15 per ton.

MARBLE DUST.

About 25,000 tons of marble, most of which is domestic, are ground annually. The dust is worth $7 per ton, and is used in the generation of carbonic acid gas in soda fountains, etc. This marble is chiefly from Vermont, Maine, New Hampshire, and New York, a large part being the scrap marble produced in dressing ornamental work.

[For plaster-of-paris, stucco, etc., see "Gypsum," page 526.]

CLAYS.

FIRE-CLAY IN THE EASTERN DIVISION.

By F. A. Wilber.

Occurrences.—Fire-clays of a more or less refractory quality are found in numerous States in this district, and the various articles made from them are largely produced in the different States. The following notice of the occurrences of these clays may be found to include localities again mentioned in the notice of pottery clay, but it is sufficient to say that in such cases the product of the locality is used for making pottery as well. In fact all fire-clays can be employed for pottery purposes, but the reverse of this does not hold.

At Brandon, Rutland county, Vermont, a clay is found which is used in the manufacture of firebrick. There are also deposits at Gay's Head, Martha's Vineyard, Massachusetts.

In New Jersey are found the most extensively worked deposits of fire-clay in the United States. The clay occurs in a belt, a few miles in width, which stretches from the eastern part of Middlesex county in a southwesterly direction across the State to the Delaware river at Trenton, and narrowing here it follows the river southward to Gloucester county. The entire area of this belt is 320 square miles, but the principal points at which the clay is found in abundance are Woodbridge, Perth Amboy, and along the Raritan river, in Middlesex county, and below Trenton on the Delaware. These deposits belong to the Cretaceous formation, and are composed of a series of strata of fire-clay, potter's clay, brick-clay, sand, and lignite. During the year 1882 over 300,000 net tons of the various kinds of refractory material were dug in New Jersey. The amount produced increases yearly. Analyses of some of these clays are given on pages 468 and 469.

Pennsylvania also has large supplies of fire-clay. It is dug in Center county; at Woodland, Clearfield county; near Johnstown, Cambria county, and is found in various localities in the bituminous coal region of the State underlying the Coal Measures. (For analyses of some of the best of these clays see table, pages 468 and 469.)

An inferior red clay is found at Newcastle, Delaware, and elsewhere in Newcastle county. A good quality of fire-clay is found at Mount Savage, Maryland. (See analysis, pages 468 and 469.)

In Virginia undeveloped beds occur underlying the Coal Measures of the southwest corner of the State. They are found also in Cumberland, Buckingham, and Appomattox counties, and at some other points. These localities are not yet productive.

West Virginia has deposits in its coal regions, some of which are worked. Clay is found in Marion, Taylor, Preston, Monongalia, Kanawha, and Wayne counties.

In the coal series of North Carolina fire-clay occurs. That of the Deep river coal field has attracted attention, and it is possible that some of the Tertiary and Quaternary clays in the eastern counties can be used for fire-clay purposes.

At King's mountain, York county, South Carolina, a fine fire-clay is found, which is also used for paper glazing.

In the Coal Measures of Alabama beds occur. There is a working locality in Bibb county.

Yellow and cream colored clays are common in the Orange sand formation, in the larger part of the State of Mississippi. These clays are as yet only used for making common stoneware. A fire-clay is found in Tishomingo county.

In Texas fire-clay is found underlying the Belknap coal bed from Young county south to the Colorado river. The beds are entirely undeveloped.

Missouri has extensive deposits of these clays. At Cheltenham, Saint Louis county, are noted beds, the product of which is largely used. The clay from this locality, together with that obtained in Montgomery county, is suitable for the manufacture of glassmaker's pots and is prepared and shipped in large quantities for this purpose. These are the only localities in the United States which have yet produced clay suited to this manufacture, and there is consequently a ready market for the output. In Cheltenham there were, in 1882, 11 establishments having a capital of $575,000, employing 1,055 hands, and producing $1,450,000 worth of clay. (For analyses of the Cheltenham clay see table). Clay is also found in the eastern part of Johnson county, the western part of Pettis county, in Macon and Howard counties, and elsewhere in the State. These last deposits underlie the Coal Measures, and are not yet developed.

Fire-clay occurs under the coal beds in Tennessee in many localities. It is dug at Ætna, Marion county, and at Chattanooga, and has local use there. Beds are also worked at the Cumberland Iron Works, Stewart county, and at McMinnville, Warren county.

In Kentucky, under the Coal Measures of the east coal field in Greenup, Carter, and other counties, beds occur and are worked. Deposits are found in Edmonson, Muhlenburg, and other counties of the western coal field. Excellent clay is also found in the Tertiary group in Ballard, Hickman, and Fulton counties.

Ohio possesses valuable deposits. At Dover and Mineral Point, Tuscarawas county, are beds which are extensively worked. Flint clay from the Coal Measures is used in large quantities at Akron in the manufacture of firebrick of all kinds. In Summit, Portage, Columbiana, Holmes, and Jefferson counties thick beds are found which produce large amounts. Ohio manufactures a large quantity of the various articles that are made from refractory clay.

Underlying the Coal Measures in Indiana are extensive beds of fire-clay. Those at Brazil and vicinity, Clay county, are worked; and firebrick, terra-cotta, and pottery are made from the materials obtained here. Deposits also occur in Vermilion, Putnam, and Park counties.

In Illinois fire-clay is again found under the Coal Measures. The best clay is that which occurs with coal seam No. 1. There is a thick bed at Wolf's Run, Madison county; another at Winchester, Scott county. A bed at Lowell, La Salle county, furnishes clay for both firebrick and stoneware; and the same is true of one at Rock Island, Rock Island county, and of others at Ripley and La Grange, Brown county. Beds occur in Schuyler county; at Avon, Fulton county, and at Colchester, McDonough county. Firebrick are made from this bed.

Firebrick are also manufactured at Jackson, Michigan, from clay obtained in Jackson county.

At Grand Rapids, Wood county, Wisconsin, a deposit occurs in the kaolin belt mentioned in the notice of pottery clays, and this is worked as a fire-clay.

The Coal Measures in southwestern Iowa are underlaid by clay beds. Deposits also occur in Des Moines, Cedar, Henry, Portland, Van Buren, Jefferson, and Wapello counties.

Beds are found in the southeastern part of Nebraska in the Coal Measures, and the same is true in Kansas at Fort Scott, Bourbon county, and from Lawrence to Leavenworth. These localities are not yet developed.

Many of these occurrences of fire-clay furnish material for local use in making sewer-pipe, stoneware, and other coarse articles. The principal manufacturing points have been mentioned in passing.

Uses.—The uses made of fire-clay are best shown by a brief statement of the wares manufactured from them in New Jersey, since this State probably produces three-fourths of the entire amount of such manufactured articles. The largest use of the white clays of New Jersey is in making firebrick and retorts for gas works and for zinc works. One firm alone at Perth Amboy used in 1881 3,000 tons of clay in the manufacture of 520,000 hollow brick and 1,750,000 firebrick, gas retorts, etc. Refractory clay is also used for making sewer-pipe and chimney-tops, and the poorer qualities are shipped in enormous quantities to other States, to be used there for sewer and drain pipe. Terra-cotta is also made from the poorer grades; and New Jersey produced in 1882 80 per cent. of the entire amount of this article made in the United States. Porous brick and terra-cotta lumber are made in large quantities, and are used for fireproof partitions, floors, ceilings, roofs, etc., for safe and refrigerator linings, and for other purposes where non-conducting and fireproof materials are required. Roofing tiles and hollow brick are also made. These clays are largely used by paper manufacturers in glazing and weighting paper. A considerable quantity is used in the manufacture of alum. The use for glassmakers' pots has been already mentioned.

Composition.—The following table of analyses is inserted to show the character of some of the best fire-clays of the eastern division. The essential constituents of a fire-clay are given in columns numbered 1, 2, and 3, and their sum in column 4. The accidental constituents are given in the remaining columns up to 14, and upon the varying amounts or absence of these depend the peculiarities of different clays. Column 15 gives the sum of the constituents on a scale of 100, the table being given in per cents.

Analyses of fire-clays from New Jersey, Pennsylvania, Delaware, Maryland, Indiana, Illinois, and Missouri. (*a*)

Localities.	1. Silica (combined) (SiO_2.)	2. Alumina (Al_2O_3.)	3. Water (combined) (H_2O.)	4. Total of first three columns.	5. Titanic acid (TiO_2.)	6. Silica (quartz sand) (SiO_2.)	7. Total of columns 5 and 6.
Woodbridge, New Jersey, Loughridge & Powers.	42.23	39.53	13.59	95.35	1.40	0.50	1.90
Woodbridge, New Jersey, A. Hall & Son	42.05	35.83	12.20	90.08	1.10	5.70	6.80
Woodbridge, New Jersey, H. Cutler & Son..	43.90	38.24	14.10	96.24	1.30	1.10	2.40
Woodbridge, New Jersey, Crossman Clay and Manufacturing Company.	37.85	35.75	12.30	85.90	1.60	10.50	12.10
Woodbridge, New Jersey, R. V. & H. Valentine.	39.80	36.34	12.90	89.04	with Al_2O_3	8.10	8.10
South Amboy, New Jersey, E. F. & T. M. Roberts.	42.71	39.24	13.32	95.27	1.60	0.70	2.30
Sayreville, New Jersey, Sayre & Fisher......	41.10	38.66	13.55	93.31	1.20	3.10	4.30
Woodland, Clearfield county, Pennsylvania, Woodland fire-clay.	42.15	31.43	9.40	82.98	1.60	10.25	11.85
Johnstown, Pennsylvania, flint clay from Solomon run.	42.95	37.02	12.60	92.57	1.70	3.85	5.55
Johnstown, Pennsylvania, Mineral Point fire-clay.	44.95	38.84	12.50	96.29	1.55	0.30	1.85
Mount Savage, Maryland, Mount Savage fire-clay.	39.90	30.08	7.60	77.58	1.15	16.90	18.05
Winchester, Illinois, fire-clay	23.15	17.08	6.30	46.53	0.90	46.70	47.60
Cheltenham, Missouri, fire-clay	38.10	31.53	11.30	80.93	1.50	12.70	14.20
Montgomery county, Missouri, Evans mine fire-clay.	43.93	40.09	13.80	97.82	with Al_2O_3	0.60	......

a From the "Report on the Clay Deposits in New Jersey," New Jersey State Geological Survey.

Analyses of clays from New Jersey, etc.—Continued.

Localities.	8. Potash (K_2O.)	9. Soda (Na_2O.)	10. Lime (CaO.)	11. Magnesia (MgO.)	12. Sesquioxide of iron (Fe_2O_3.)	13. Total of columns 8 to 12.	14. Water (hygroscopic) (H_2O.)	15. Total.
Woodbridge, New Jersey, Loughridge & Powers.	0.41	0.08	0.10	... .	0.50	1.09	1.21	99.55
Woodbridge, New Jersey, A. Hall & Son	0.44	......	....	0.11	0.77	1.32	1.50	99.70
Woodbridge, New Jersey, H. Cutler & Son..	0.15	0.00	trace	0.11	0.96	1.22	0.70	100.56
Woodbridge, New Jersey, Crossman Clay and Manufacturing Company.	0.37	......	....	Trace	0.95	1.32	1.00	100.32
Woodbridge, New Jersey, R. V. & H. Valentine.	0.15	......	....	0.04	1.01	1.20	1.20	99.54
South Amboy, New Jersey, E. F. & T. M. Roberts.	0.47	0.42	0.20	....	0.46	1.55	1.58	100.70
Sayreville, New Jersey, Sayre & Fisher......	0.28	0.18	....	....	0.74	1.20	1.00	99.81
Woodland, Clearfield county, Pennsylvania, Woodland fire-clay.	2.01	......	....	0.32	1.57	3.90	1.20	99.93
Johnstown, Pennsylvania, flint clay from Solomon run.	0.20	......	....	....	0.88	1.08	0.80	100.00
Johnstown, Pennsylvania, Mineral Point fire-clay.	0.35	......	....	....	0.91	1.26	0.70	100.10
Mount Savage, Maryland, Mount Savage fire-clay.	2.30	......	....	....	1.67	3.97	0.90	100.50
Winchester, Illinois, fire-clay	1.10	......	....	0.28	3.47	4.85	1.20	100.18
Cheltenham, Missouri, fire-clay...............	0.40	......	....	Trace	1.92	2.32	2.50	99.95
Montgomery county, Missouri, Evans mine fire-clay.	0.20	......	....	....	0.88	1.08	0.80	100.00

POTTERY CLAY AND KAOLIN IN THE EASTERN DIVISION.

Occurrences.—Beds of common earthenware or stoneware clay are of frequent occurrence in the States on the Atlantic and Gulf coasts, and in the interior. Deposits of clay suitable for ironstone and fine earthenware are much less common, while porcelain clay is rare in its occurrence. The following is a brief notice of the known occurrences of these clays in the district mentioned above:

At Bennington, Vermont, a clay for coarse ware is found.

In Connecticut kaolinite, produced by the disintegration of gneiss rocks, occurs near New Milford, Litchfield county. It is not known that more than a local use is made of these deposits.

In New York kaolin is mined for the market at East Fishkill, Dutchess county. In 1881 400 net tons were produced here.

New Jersey produces a very large amount of the different qualities of pottery clay. The principal beds are at Woodbridge and Perth Amboy, Middlesex county; and the clay mined here is widely distributed. Much of it is used in the potteries at Trenton, together with that brought from other localities.

A very fine grade of potter's clay is mined at Brandywine Summit, Chester county, Pennsylvania.

At Hokessin, Newcastle county, Delaware, a superior porcelain clay or kaolin occurs. It has been produced by the disintegration of feldspathic rock.

In Maryland, near Abingdon, Harford county, and in Cecil county, large deposits are found. Other localities are known in the feldspathic rock district of this State.

Pottery clays are found in Virginia in Augusta, Prince Edward's, Cumberland, Warren, and Fauquier counties. Kaolin, produced from disintegration of feldspathic rocks, occurs in extensive deposits in Ashe county on the south fork of New river, and near Wytheville, Wythe county. It is also found in Smyth county. No development of these deposits has yet been made.

North Carolina has beds of pottery clay in Guilford, Harnett, Robeson, Johnston, Chatham, and Wake counties, in the central part of the State; and in Mitchell, Yancey, Macon, Lincoln, and Burke counties in the western part.

In South Carolina a deposit is found at King's Mountain, York county, which furnishes clay for paper glazing. Pottery clay also occurs at Aiken, in Barnwell county; Hamburg and Graniteville, Aiken county; Edgefield county; Chesterfield, Chester county; Abbeville Court House, Abbeville county; and at Congaree creek, Lexington county. Considerable quantities of clay are mined at some of these localities.

Georgia has beds in Cherokee, Pickens, Heard, McDuffy, Columbia, and Richmond counties, which are not yet developed. A white porcelain clay occurs in Randolph county, and near Sulphur Springs Station, De Kalb county. This last locality is worked. Pottery clays are found also in Coosa and Macon counties, and extensive beds occur near Jacksonville, Calhoun county.

The deposits in Mississippi lie in the northeastern part of the State and are numerous. Some of them are in local use for common ware production.

In Louisiana, potter's clay is found in Catahoula, Fort Jessup, and Natchitoches parishes, but no use is made of it.

A large deposit of kaolin, produced by the decomposition of granite, is found at Fourche Cove, Pulaski county, Arkansas; and beds of pottery clay occur in Saline and Greene counties in this State.

At Pilot Knob, Iron county, Missouri, a thick deposit is found, and beds are reported at other points in the southeastern part of the State. A superior clay, largely used as a fire-clay, is obtained in Montgomery county, and at Cheltenham, Saint Louis county.

Common ware clays are found in abundance in Hickman, Perry, and other counties in the Tennessee Valley region of Tennessee, and also in the counties of Kentucky lying west of the Tennessee river.

Ohio has much valuable pottery clay, and ranks next to New Jersey in its pottery manufactures. East Liverpool and Wellsville in the extreme southeastern part of the State, on the Ohio river, are the points at which the pottery industries are centered. White earthenware is made here from a mixture of the clays of this region and those from other localities. In Muskingum county clay is found.

At Huron, Lawrence county, Indiana, is a noted deposit of indianite or porcelain clay. This clay is used throughout the United States for fine whiteware. It occurs also in Owen and Lawrence counties. The kaolin from these localities is used at Indianapolis in the manufacture of encaustic tiles. Tiles of rare beauty and excellence are produced here, equally vitrified and as good as those produced in the best factories of England and France.

In Illinois, pottery clay is found at Anna, Union county; Lowell, La Salle county; Ripley and La Grange, Brown county, and at Rock Island, Rock Island county. Clay from these beds is used largely in local potteries.

In Wisconsin, kaolin occurs in a belt of Laurentian rocks 50 miles long and 15 miles wide, which stretches from Black river, Jackson county, to the Wisconsin river, in Wood county.

An extensive deposit of kaolin, formed by the decomposition of granitic rocks, is found at Rockwood Falls, Minnesota.

Common earthenware clay occurs at Louisville, Cass county, Nebraska, and in Dakota and Webster counties, in the same State.

There are undoubtedly fine pottery clays and kaolin, in the region noticed here, which are not yet developed or even known; and it may be expected that further exploration in the States already producing them will disclose further supplies.

Manufactures.—The ware produced in the United States is largely of the commoner and cheaper kinds. The manufacture of yellow and Rockingham ware is carried on in numerous localities, and the amount of foreign ware of this grade imported is small. At Trenton, New Jersey, and at East Liverpool and Wellsville, Ohio, large amounts of common white ware, ironstone china, and "C. C." ware, both plain and decorated, are produced. The grade of the goods of this class is constantly improving.

The following table shows the importance of the pottery industry in the United States. The figures are given by the Hon. J. H. Brewer, of Trenton, New Jersey, president of the United States Potters' Association. The statistics are for the year 1880, and, according to the report of the New Jersey State Geologist for 1881 the production for that year was essentially the same.

Statistics of potteries making whiteware at Trenton, Elizabeth, and Jersey City, New Jersey.

Number of kilns	110
Average capacity (each)	$30,000
Amount produced if fully employed	$3,300,000
Amount actually produced, about	$3,000,000
Amount produced in the United States	$5,000,000
Amount imported, about	$4,000,000
Production of New Jersey (clays, flint, and spar) .... tons	50,000

Coal used ......tons..	50,000
Wages paid, yearly	$1,400,000
Hands employed	3,000

Analyses.—The following table of analyses is intended to show the composition of some of the best pottery clays in the country. No analyses of the commoner grades are given, as they would not vary largely from those of any fire-clay:

Analyses of porcelain and earthenware clays. (a)

Localities.	1. Silica, (combined) (SiO_2).	2. Alumina ($_2O_3$).	3. Water (combined) (H_2O).	4. Total of first three columns.	5. Titanic acid (TiO_2).	6. Silica, quartz sand (H_2O)	7. Total of columns 5 and 6.
(b) South Amboy, Middlesex county, New Jersey—E. F. & J. M. Roberts (selected).	44.20	39.14	14.05	97.39	1.05	0.20	1.25
Hokessin, Delaware—Trucks & Porter (washed clay).	40.72	34.10	12.35	87.15	0.00	6.50	6.50
(c) Huron, Lawrence county, Indiana—china clay.	40.10	36.35	22.60	99.05	0.00	0.40	0.40
Pope county, Illinois—potter's clay	34.70	31.34	12.06	78.04	......	12.20	12.20
Woodbridge, Middlesex county, New Jersey—Hampton Cutler & Sons.	44.14	38.81	12.97	95.92	1.30	0.80	2.10

Localities.	8. Potash (K_2O).	9. Soda (Na_2O).	10. Lime (CaO).	11. Magnesia (MgO).	12. Sesquioxide of iron (Fe_2O_3).	13. Total of columns 8 to 12.	14. Water, hygroscopic (H_2O).	15. Total.
(b) South Amboy, Middlesex county, New Jersey—E. F. & J. M. Roberts (selected).	0.25	......	......	......	0.45	0.70	0.90	100.24
Hokessin, Delaware—Trucks & Porter (washed clay).	1.64	0.27	......	0.39	2.49	4.79	1.35	99.81
(c) Huron, Lawrence county, Indiana—china clay.	0.14	......	......	0.13	0.15	0.42	......	99.87
Pope county, Illinois—potter's clay..	0.79	0.16	......	0.10	0.16	1.21	8.00	99.45
Woodbridge, Middlesex county, New Jersey—Hampton Cutler & Sons.	0.17	0.00	Trace.	0.11	1.14	1.42	1.23	100.69

a "Report on the Clay Deposits in New Jersey," New Jersey State Geological Survey.
b Also used for paper glazing.
c Porcelain clay.

The figures in the columns marked 1, 2, 3, and their sum in column 4 are the ones which show the essential or necessary elements of a fire-clay. The columns marked 5, 6, 8, 9, 10, 11, 12, and 14 give the accidental constituents, which may or may not be present. The figures given are per cents. in a total one hundred parts.

CLAYS OF THE ROCKY MOUNTAIN DIVISION.

Fire-clay.—Fire-clay is an almost invariable accompaniment of the Coal Measures throughout Montana, Wyoming, Colorado, and New Mexico. It is found in many places in extensive beds of great purity and suitable for a great number of purposes, and the supply is practically illimitable, being regulated only by the already large and growing demand.

Of the numerous beds throughout the lignite fields of Montana but one is at present worked. This is situated near Helena, and furnishes the clay from which superior firebrick and crucibles are made to supply the local demand for use in the smelting and roasting furnaces of Helena and Butte; but no statistics of the production in past years have been obtainable.

Along the line of the Union Pacific railroad, in Wyoming, large deposits of good fire-clay exist, but they have not as yet been developed.

In Colorado the most available beds are found in the vicinity of the coal veins near Golden, Ralston creek, Morrison, and Boulder. It is also found in great abundance in the South Park, Middle Park, and various other sections of the State. The following is given as an analysis of the fire-clay from Morrison:

Silica	71.8
Alumina	15.0
Iron	trace.
Lime	3.8
Water	8.3
	98.9

The manufacture of firebrick, etc., has extended into a large and constantly increasing branch of production. Three establishments of very large proportions are to-day actively at work in Golden, while two extensive works in Denver are provided for by the fire-clay deposits of Golden. Among the products of these establishments are three grades of firebrick, fine silica lime bricks, pattern bricks for furnaces and furnace arches, muffles, crucibles, scorifiers, etc. All the firebrick used in the various smelting works of Colorado and New Mexico is made either in Golden or in Denver, and the quality of the muffles, scorifiers, and crucibles made there is acknowledged to be fully equal, if not superior, to the imported Battersea muffles, etc., and they have gradually usurped the place of the latter in the assay offices of this region.

The fire-clay in the vicinity of Golden is singularly pure, its composition being shown by the following analysis of clay from the bank owned by G. A. Duncan & Co.:

Silica	52.41
Alumina	32.21
Oxide of iron	.66
Lime	.20
Magnesia	.06
Potash	.61
Water	14.05
	100.20

The excellence of this clay is shown by a comparison of the three following analyses of well known fire-clays. No. 1 is the Cheltenham, from near Saint Louis. No. 2 and No. 3 are the celebrated Stourbridge clays of England:

Analyses of Cheltenham and Stourbridge clays.

	No. 1.	No. 2.	No. 3.
Silica	61.22	67.34	64.05
Alumina	25.64	23.03	23.15
Oxide of iron	1.70	2.03	1.85
Alkalies	1.31	1.38	0.10
Sulphur	0.45		
Water	9.68	8.24	10.00
	100.00	102.20	99.15

Fire-clay has been mined in Jefferson County, Colorado, since 1865, and the manufacture of firebrick and furnace material has kept pace with the growth of the smelting industry in the West. No statistics of the production of firebrick, muffles, etc., are available, and the consumption of fire-clay by the works at Denver and Golden could not be secured for the years previous to 1880, except in one case. The following table gives the amount of clay used by years, in tons of 2,000 pounds. Previous to 1880, the Denver Fire-Clay Company, of Denver, used 1,500 tons of clay in manufactures:

Fire-clays manufactured in Colorado.

Works.	Location.	1880.	1881.	1882.	1883, to June 30.
		N't tons.	*N't tons.*	*N't tons.*	*Net tons.*
Cambria Brick and Tile Company	Golden		2,000	3,000	2,000
G. A. Duncan & Co	do	4,000	6,000	9,000	5,500
Golden Brick and Coal Company	do	5,000	4,500	960	500
Denver Fire-Clay Company	Denver	1,200	1,200	1,500	800
Denver Fire-Brick Company	do			4,000	750
Total		10,200	13,700	18,460	9,550

The number of fire-bricks made in 1882 in Golden, is estimated at 2,500,000, and the total value of all the products of the industry at the same place at $167,000.

Cornish clay miners are paid $2.50 per day of 10 hours, and in the works the wages paid vary from $1 for boys to $2.25 for men, per day of 10 hours.

Pottery clay.—Pottery clay is found quite abundantly in many parts of the Rocky Mountain region, occasionally, as at some points along the line of the Union Pacific railroad in Wyoming, and at Golden and Morrison in Jefferson county, Colorado, in a state of great purity and excellence. Two establishments in Colorado, the Cambria Brick and Tile Works at Golden, and the Terra Cotta Works at Denver, owned by Mr. Thomas Moulton, are engaged in the manufacture of the best quality of drain tiles, and pavement tiles, making also large quantities of sewer piping of unsurpassed durability. Both works also manufacture flower-pots, hanging-baskets, jars, jugs, and many other forms of earthenware.

These wares are sold at prices said to be as low as those of the eastern works, and are of excellent quality. The entire local market and the demand in the adjoining towns is supplied by the works at Golden and Denver.

The Denver Terra Cotta Works used during 1882 one carload of pottery clay per week, and 550 tons during the year.

CLAYS OF THE PACIFIC COAST.

While most of the discoveries of fire and fine potter's clays so frequently announced have proved disappointments, the deposits found consisting of infusorial or other nearly worthless earths, material suitable for making firebrick and fine earthenware really exists in many places on the Pacific coast, the following being the California localities most distinguished for these natural products: Steatite, saponite, or soapstone, a good fire-clay, reported as occurring near Mokelumne Hill, Calaveras county; at the town of Antioch, and in the clay seams of the Black Diamond coal mines, Contra Costa county; in the Cerro Grande mine, Inyo county; and at various places in El Dorado, Mendocino, Santa Barbara, and Los Angeles counties. Clay from some, if not all, of these localities has been made into firebrick, crucibles, etc., and is found to answer well for these purposes.

While some of the trials made of the California fire-clays have, through a careless selection of material, turned out badly, others have proved entirely successful, and there is little doubt but the greater portion of the firebrick hereafter used in that State will be made at home. The price of the imported article, Scotch and English, ranges in San Francisco from $35 to $43 per thousand, that of domestic manufacture selling for about one-fourth less.

A clay found in Bingham cañon, and at other various points about Salt Lake City, Utah, has been used extensively and with satisfactory results at the large smelters operating in the vicinity of that city. A species of sandstone quarried in Red Butte cañon, three miles east of Great Salt Lake, has also been employed for building furnaces at these establishments, and found to stand about as well as the best English firebrick.

Deposits of kaolin, some of them very extensive, have been found in many parts of the Far West. Though not of the finest quality, some very handsome porcelain ware has been made from this material. Clays suitable for the manufacture of stoneware and the more common kinds of earthenware so abound that potteries are numerous in California, Oregon, and Utah. Sands of the several kinds required in manufacturing glass are found everywhere. There is in Monterey county, California, plenty of the white sand used in making the finer varieties of glass, that for coarser wares being obtained from the sand hills and dunes about San Francisco.

ABRASIVE MATERIALS.

CORUNDUM AND EMERY.

BY HENRY GANNETT.

Definition.—These substances, so nearly allied mineralogically, are sharply distinguished in the trade. Mineralogically, the former is a nearly pure alumina, while the latter contains a large proportion, from 20 to 33 per cent., of iron oxide. The trade distinctions are somewhat as follows: Emery is always black, while corundum is of various colors, though more frequently gray, and is never black. It is much harder than emery, and sharper, cuts deeper and more rapidly, but is on the other hand more brittle and consequently less durable.

Imports of emery.—Almost all our supply of true emery is imported. Many supposed discoveries of emery of good quality have been made, but all have failed to stand the commercial test. Magnetite, ilmenite, and massive garnet are often mistaken for emery, and indeed attempts have been made to replace true emery by these substances. For some time emery was produced at the well known mine at Chester, Massachusetts, but the material was found to be too soft and the mine is now abandoned. It comes from Turkey, near Smyrna, and the island of Naxos. Other foreign localities are reported, but their product does not appear to be of importance, and none is imported from them to the United States. The importations in the fiscal year 1882 are reported at 45,560 cwts., valued at $58,428, of the crude emery ore, which is ground here, and $28,975 worth of ground emery, prepared in England. The average price of Turkish emery, ground in this country, is reported as follows: grain, 3⅛ to 6 cents per pound. That of the best English ground is: grain, 10 cents per pound; flour, 8 cents per pound.

American corundum localities.—Corundum has been discovered at a large number of points in the United States, particularly in the Appalachian region, and the material from some of these localities has gone extensively into the trade, where it is supplanting emery to a certain extent, although its higher price, produced by the greater expense involved in crushing and grinding it, tends to reduce the demand for it.

The following localities are reported:

Chester, Hampden county, Massachusetts. This locality was worked originally for emery, as above stated.

Westchester county, New York. It may be that this is an emery. It is reported as being too soft for most purposes.

Chester and Delaware counties, and near Allentown, Pennsylvania. A large part of the production at present comes from Chester county, Pennsylvania.

Delaware, but in small amount.

Cullakenee mine, western North Carolina. This mine has been worked, but its product is not known.

Corundum Hill, Macon county, North Carolina. This locality is reported as having produced 200 tons. Various precious stones are found here, as emeralds, rubies, sapphires, topazes, and amethysts. Corundum also occurs at the Hogback mine, Jackson county; Paisley mine, Heywood county, and in Madison county, in the same State.

In Fannin county, Georgia, where recent discoveries have been made. It is also reported as occurring at other points in Georgia, in South Carolina, Alabama, and Arkansas.

The principal sources of supply appear to be Chester and Delaware counties, Pennsylvania, and North Carolina.

Figures of production are difficult to obtain. Estimates for the year 1882 range from 400 to 1,000 tons, although it appears that 500 tons is probably near the truth. The crude rock sells for $10 to $15 per ton, while the ground corundum brings from 12 cents to 15 cents per pound. The demand appears to be as yet comparatively light.

BUHRSTONES.

Most of the buhrstones used in this country are imported. The sources of supply are France, Belgium, and Germany, whence the material is brought, partially dressed, by steamer, at low rates of freight. The French and Belgian stones are a subaqueous deposit of silica mixed with shell. The stone is both hard and porous. The German stone is a basaltic lava.

The principal localities from which buhrstones are obtained in the United States are:

Ulster county, New York, where a rock known as the millstone grit is quarried, which in the form of dressed stones is preferred for grinding minerals, etc.

Peninsula, Ohio, where the white variety of the formation known as the Berea grit (described by Professor Read in the following section) is quarried for the purposes of grinding oatmeal and pearling barley, for which it is said to be especially well adapted.

In the Southern States, for grinding corn, a great variety of stones is employed, as almost any sharp siliceous rock will answer the purpose.

In the larger mills metallic rollers have to a large extent supplanted buhrstones. It is estimated that of the larger flouring mills from one-half to two-thirds are now using rollers.

BEREA GRIT.

By M. C. Read.

The Berea sandstone, Berea grit, Amherst stone, or Ohio stone, as it is variously called, is a characteristic member of the sub-Carboniferous rocks of Ohio, found about 300 feet below the Coal-Measure rocks, with its outcrop extending from the Ohio river northward through the central part of the State into Huron county, and passing thence eastwardly, in an undulating line, to near the northeast corner of Trumbull county.

It is ordinarily a rather fine-grained sandstone, with a sharp grit, but differing greatly in its character in different localities. Amherst has furnished from it the best building stone, Berea the best grindstones; but other localities in the region described are capable of furnishing equally good material for both of these uses.

In places the rock is massive, in others it is in regular layers, of a thickness varying from several feet to a few inches; much of the latter is evenly bedded, making an excellent flagging stone. In some of the quarries, especially in Huron county, these thin strata furnish the finest examples of ripple-marking to be found in the State.

Its exposure in Summit county is confined to the valley of the Cuyahoga river and the bluffs bordering it. It appears at the bottom of the valley near the south line of Borton township, and from thence rises in the bluffs to the north line of the county. It is in this county a hard, evenly-bedded, compact rock varying in color from nearly white to a dark brown, but in places so irregularly colored as to detract somewhat from its value as a building stone.

The quarry most extensively worked is a little south of the village of Peninsula, in Borton township. The upper part has here been removed by glacial action, leaving about 40 feet undisturbed, which can be quarried with a slight stripping of earth, while the product is carried by a gravity road to the canal and railroad below.

Some years ago a diligent search was made in the State for a stone especially fitted for the construction of a safe vault, and after thorough tests the white rock from this quarry was selected as the best that could be found. The preference was given to it on account of its strength and hardness and because of the facility with which blocks of any required size could be obtained. It is largely used for buildings, for abutments of bridges, and other similar purposes. But there is a special use to which it has been applied which is worthy of mention.

Mr. Fred. Shumacher, of Akron, is the founder of the oatmeal industry in this country, and has also been extensively engaged in the work of pearling barley. He found considerable difficulty in obtaining millstones suitable for his work, and after protracted tests of all available material, selected the white variety of this Peninsula stone as the best that he could find. Its great hardness and very sharp grit especially fitted it for this use. A layer, the bottom of which was 3 or 4 feet above the underlying shale, proved to be the best, that which is of strictly first-class quality having been yet found only in this quarry. He has used for this purpose about 250 blocks ranging in diameter from 4 to 5 feet and in thickness from 14 to 18 inches, and has sold to others about 30 such blocks. These blocks he values at from one to two dollars per cubic foot. In his mills at Akron he is now using 28 runs of these stones, and producing 80,000 barrels of oatmeal and 50,000 barrels of pearl barley per annum. The stones used for pearling barley are placed upright in iron shells revolving slowly in a direction opposite to that of the stone. Mr. Shumacher is now putting the machinery into a new mill, which will increase the annual production of oatmeal to 240,000 barrels, of the value of $1,500,000.

The success of this industry is largely the result of the peculiar character of a small part of the stone from this quarry. The work was commenced in 1856, and has steadily increased until the present time. Its dependence upon the character of this rock, in the estimation of Mr. Shumacher, is indicated by the fact that he has purchased the entire quarry and is now putting it in shape for a large production of building stone, expecting, as this is removed, to uncover and make available a full supply of that which is especially fitted for milling purposes.

GRINDSTONES.

The principal source of material for grindstones is the sandstone of Ohio, very largely that formation known as the Amherst stone or Berea grit (described in the foregoing section), and also from the neighborhood of Lake Huron, Independence, and Minetta. The principal center of manufacture is Cleveland, Ohio. The production during the year 1882 is estimated at about 50,000 tons, valued at $700,000.

Our exports, which are of considerable amount, are mainly to the West Indies, Central America, South America, and Mexico.

Grindstones are imported to a small extent, mainly from England and Nova Scotia.

INFUSORIAL EARTH.

One variety of infusorial earth, containing over 80 per cent. silica in a finely comminuted state, is found in Nevada, and has been placed on the market as a polishing powder under the name of electro-silicon. Its composition, as determined by Mr. W. Habirshaw, is:

Silica	81.08
Water at red heat	18.44
Loss	0.48
	100.00

This substance is remarkably fine, and free from coarse grit. It has no use except as a polishing powder, and the company working it report that it could not be sold for any other purposes for the cost of freight. For the special purpose for which it is utilized, however, it serves excellently. The method of manufacturing a merchantable article is simply to pulverize the crude mineral, the particles of which are loosely adherent. The amount utilized for making electro-silicon in 1882 was derived chiefly from a stock which had been mined in previous years.

Infusorial earth of a different character and texture from that used as electro-silicon is found in Nevada; and there are large deposits in Los Angeles county, California, which have been utilized to a small extent in furnishing a polishing powder. This substance is often mistaken by prospectors for kaolin.

At one time infusorial earth imported from Gemany was used to a considerable extent in California in the manufacture of giant powder. The mineral found in California and Nevada did not possess sufficient absorbent powers, although it was tested for this purpose. Latterly, however, infusorial earth of all kinds has been supplanted in the manufacture of giant powder at the California works by wood pulp brought from the Eastern States.

Besides its use as a polishing powder, infusorial earth is sometimes used to give "body" to soap.

PUMICE-STONE.

Nearly all the pumice used in this country is imported in the lump from Italy, where it is found in the neighborhood of Mount Vesuvius, and is ground here—the only exception being small lots of California pumice-stone which have reached the market from time to time. There are abundant deposits of pumice-stone at Lake Honda, San Francisco county, California; also at Little Owens lake and other localities in Inyo county in the same State. It is of good quality. Whittier, Fuller & Co., of San Francisco, own the Lake Honda deposits, and manufacture from 60 to 70 tons per year, supplying the market on the coast for the most part. A portion of the pumice used on the Pacific coast is imported stone, prepared in New York. Formerly all that was used there was imported, but now two-thirds of what is consumed is made in San Francisco, the above-named firm being the only manufacturers. The Italian sells at $25 per ton in New York City. During the fiscal year 1882 the imports amounted to $29,019 and the exports to $2,423. Pumice-stone is chiefly used in polishing marble.

CARBONS.

Borts, black diamonds, carbons, or carbonados, as the black variety of the diamond is variously called, are used more and more extensively in the arts every year. This substance is employed largely in diamond drills used in mining and for machinery designed to saw, cut, and dress various refractory substances. It consists of pure carbon excepting from 0.27 to 2.07 per cent. The specific gravity ranges from 3.012 to 3.416. In size, shape, and temper, very great differences exist. Pieces from 400 to 700 karats have been found. The supplies used in this country come from the province of Bahia in Brazil. Carbons have also been reported to occur in South Africa, India, and Russia, but these occurrences have not been authenticated.

Very frequently discoveries of carbons are reported to have been made in the United States, but the supposed black diamond is commonly found to be titanic iron, easily crushed to dust by means of a light hammer or by strong pliers. Inquiries addressed to dealers and experts failed to develop any authentic occurrences.

The price of carbons has advanced during the past three years from \$3 to the present rate of \$15 to \$20 per karat, a price so high as to almost stop the use of this important mineral except in very special cases.

PRECIOUS STONES.

Domestic production.—Although so many varieties of gem stones are known to occur in the United States, many of which afford fine specimens, while a few valuable stones are exclusively indigenous, the annual output is still very small in comparison with the prospective extent of the field. It is impossible to obtain exact statistics of the product, but an extensive correspondence with experts and dealers justifies an estimate of between $50,000 and $60,000 as the sales in 1882 of cut gem stones of domestic production, exclusive of the gold quartz souvenirs, which should be credited to precious metal mining. The value of the stones before cutting was much less—probably little above $10,000, as about four-fifths of the market value of the stones represents the enhancement due to cutting. This applies more strictly to the common gem stones; and in the case of agates and moss-agates the value of the uncut stones is often not one per cent. of the price of the gems after cutting. The amount stated as the value of uncut stones is of those sold to be cut; besides which, as shown in the accompanying paper by Mr. Kunz, there are sales of small amounts, to tourists and collectors, of stones which are valued merely as specimens, and which do not reach the gem market.

Few persons are familiar with the appearance of gem stones in their native state; so that while quartz pebbles are often mistaken for rough diamonds, garnets for rubies, ilmenite for black diamonds, etc., on the other hand it is quite probable that many valuable occurrences have escaped notice. The competition of the cheap foreign cutting is also a disadvantageous factor.

Imports and re-exports.—The following tables show the values of foreign stones imported and re-exported during a series of years. They probably include small quantities of American stones, as these are sometimes cut in Europe and thus lose their identity.

Precious stones imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

	Values.
1872	$3,053,595
1873	2,870,690
1874	2,274,790
1875	3,399,593
1876	2,480,214
1877	2,114,704
1878	2,975,512
1879	3,842,007

	Values.
1880	$6,698,488
1881	8,332,511
1882	8,444,525
Calendar year 1882	8,154,397

Precious stones of foreign production exported from the United States during the fiscal years specified.

	Values.
1882	$34,438
1873	9,393
1874	102,932
1875	185,231
1876	79,631
1877	51,730
1878	15,569
1879	5,785
1880	7,605
1881	64,256
1882	85,001
Calendar year 1882	93,537

An annual importation of $8,000,000 worth of precious stones (to say nothing of the considerable quantities smuggled, which escape the record), shows that this country is an exceptionally heavy purchaser—as would be supposed even in the absence of statistics. The imports vary greatly in different periods and are largely determined, as may be seen by a comparison of the years cited, by changes in the general prosperity or by speculative profits. The new tariff law fixes the duty on precious stones of all kinds at 10 per centum ad valorem.

AMERICAN GEMS AND PRECIOUS STONES. (*a*)

BY GEO. F. KUNZ.

In the United States, systematic mining for gems and precious stones is being carried on at only two places, viz., Paris, Maine, and Stony Point, North Carolina. In other cases where gems are found they are either met with accidentally, or occur in connection with other materials that are being mined, or in small veins which are only occasionally met with. They are often gathered with little system on the surface, as is the case with the sapphire, garnet, and olivine found in Montana and New Mexico; or from the beds of streams and decomposing rock, as

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a This paper is the result of an application by Mr. Williams to Messrs. Tiffany & Co., of New York City, for the purpose of obtaining certain facts relative to the gems and precious stones of the United States. I may here state that whatever information is presented is due to the usual courtesy and generosity of that firm, whenever they can assist in advancing science or art, in placing at my disposal not only all the facts and material at their command, but also the time required by me in collecting whatever other existing data there might be relative to this subject. In view of the little that has been published and the paucity of reliable facts, it is hoped that the deficiencies in this article may be overlooked.—G. F. K.

the moss-agate from Colorado; or on beaches, as the agate, chlorastrolite and thomsonsite from Lake Superior.

Nearly all the gems found in these ways are sent to the large cities in small parcels, or are sold at the localities to tourists, or are sent to other localities to be sold as having been found in the vicinity. Many of the gems are known only locally, some to mineralogists only, and others that are mentioned here are known only to a certain few who constitute the gem collectors of the United States, and whose one object is to find something that possesses the qualities of a gem or precious stone, for the purpose of enriching their cabinets; still a list of this kind will be of interest and value to the mineralogist and to many others who may have never known of their existence in this country, to whom this knowledge may have a commercial value, should some of these minerals be met with in sufficient quantities and of good quality; it may also direct attention to what has a value and has not heretofore been utilized. Wherever a gem is mentioned from the sale of which a small amount has been realized, it is mentioned merely to note its occurrence in this country, whereas in other countries the gem is often found of better quality and in larger quantities. A list is added of the principal gems that have not been found in this country, and also a list of those that have not been found elsewhere.

We know that the mound builders have worked the turquois mines of New Mexico, that they have made arrow and spear points of rock crystal, smoky quartz, and obsidian, and that they have buried crystals of quartz with their dead; that the fluorite of Hardin county, Illinois, was by them worked into ornaments, and that some of the most beautiful agatized and opalized woods, agates, jaspers, and obsidian were by them worked into arrow-points, and now after a long time are mounted as ornaments by the white man, the precious stones thus serving a double purpose.

Diamonds.—Diamonds have been occasionally found at a number of localities in the United States, but as yet at no place has more than an occasional crystal occurred, never enough to warrant any extended mining for them. The diamond found at Manchester, opposite Richmond, Virginia, weighing after it was cut over 10 karats, is worthy of mention. An occasional stone has also been found at the Portis mine, North Carolina, Hall county, Georgia, (*a*) and with platinum in Oregon. They are also reported from Idaho, San Juan county, Colorado, and from Cherokee Flat and several other localities in Butte county, California. A beautiful crystal that cut a remarkably fine three-eighths karat stone was found near San Francisco. Two crystals weighing over 2 karats each are on exhibition at a jeweler's in Indianapolis, and are said to have been found in Indiana. Within the past year a diamond is reported to have been found in Missouri by a hunter who was stopping to take a drink of water at a small brook. This diamond weighs 2½ karats, and by some

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a *American Journal of Science*, II., ii., 253, and xv., 373.

experienced judges is pronounced of Brazilian origin, so that the occurrence is somewhat doubtful.

Many experienced geologists hold to the opinion that so many of the associations of the diamond are present in North Carolina that they have hopes of their being found there. The garnet districts of Arizona and New Mexico may also be looked upon as favorable for the occurrence of this gem.

No estimate can be put on the annual amount found. Many reported finds of diamonds of large value in the newspapers are either myths or are based on the finding of rock crystal or even glass, and a diamond value is attached, as in the case of the Missouri diamond mentioned above. It would be possible for diamonds to occur and be for a long time overlooked in a district inhabited or frequented by no one who really knows the diamond in its rough state, whereas rock crystal is often mistaken for diamond.

[Mr. John H. Tyler, sr., of Richmond, Virginia, furnishes the following account of the large diamond found at Manchester:

"This diamond was found in Manchester, Chesterfield county, just opposite Richmond, by a laborer engaged in grading one of the streets. It was brought to me to ascertain its character and value. I pronounced it at once a very valuable diamond, and recommended the finder to keep it carefully and to see me again about it. I did not know his name, and have not seen him since. The next I heard of this stone it was on exhibition at Ball, Black & Co.'s store in New York, and that it had been sold by the finder to some one in New York for $1,800, though I could have got for him $5,000 for it. I understand that it was sent to Germany to be cut. It was an octohedron, and had only one small black spot near one of the points, thus enabling it to be cut to great advantage. I was the first to examine and pronounce upon it."]

Sapphires and rubies.—Sapphires and rubies have been found at Vernon, New Jersey, but always more or less opaque, and although a number have been cut from this locality, the probability is that there has not been a single gem.

At the Jenks mine, Franklin, Macon county, North Carolina, where corundum mining was being carried on some years ago and has recently been resumed, the mineral being mined for use as a grinding and polishing substance, fully fifty gems were found, some of them weighing two karats. Only about one-half of these were of good color, most of which were really gems in every sense of the word.(*a*) The colors were rich blue, violet blue, ruby red, light red, pink, and yellow; and others were colorless. No one of these gems had a higher value than possibly $100. The smaller ones were the richest in color.

The principal locality for sapphires in the United States is in the garnet districts near Helena, Montana; Santa Fé, New Mexico; southern

a Collection of Dr. Jos. Leidy.

Colorado, and Arizona. Here they occur in the sand, associated with peridot, pyrope and almandine garnet. From this district they are sent to the cities in odd lots, as they happen to be met with, and no regular searching for them is carried on. They are often found with the associated gems on ant-hills, which abound in this district. Two gems (*a*) from here may be mentioned, although weighing only one-eighth of a karat each, one of which was a true ruby red, and the other a sapphire blue, colors rarely met with. The gems are usually of a light green, greenish blue, light blue, bluish red, light red, and red; also, of all the intermediate shades. They are usually dichroic, and often blue in one direction and red in another, or when viewed through the length of the crystal, and frequently all the colors mentioned will assume a red or reddish tinge by artificial light. A very interesting piece of jewelry (*b*) was made of these stones in the form of a crescent; at one end the stones were red, shaded to a bluish red in the center and blue at the other end; by artificial light the color of all turned red. Perfect gems of from four to six karats each are frequently met with. Occasionally crystals are found which would afford ruby and sapphire asterias of a poor quality.

The value of the gems that are cut of material found in this district amounts to fully $2,000 per annum. There are, however, a great many found that are never cut, owing to the higher cost of cutting, and the greater skill required in cutting this gem.

Spinel.—Spinel has been only occasionally met with in gem form in the United States. From the locality near Hamburg, Sussex county, New Jersey, may be mentioned specimens of a smoky-blue, a velvety-green, and a dark-tinted claret color; they are all very good gems and weigh about two karats each. (*c*) Some half dozen very fine ones from San Luis Obispo, California, of very good quality and weighing about two karats each, are also worthy of note. (*d*)

Topaz.—Topazes have been found in Arizona, New Mexico, and occasionally in southern Colorado. Those from the last-named locality are of a beautiful light-blue color, and one (*e*) of them weighed over 30 karats. They have also recently been found at Pike's Peak, (*f*) Colorado, and more recently at Stoneham, (*g*) Maine. At both the last-named localities they occur in large crystals, but if cut into gems would afford only small stones of little value. The color of the Pike's Peak topaz is light blue, and it is quite clear. The price of such stones is regulated by the color, perfection, and size. The supply yields less than

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a Collection of G. F. Kunz.

b Collection of Tiffany & Co.

c Collection of Rev. Alfred Free.

d Collection of James W. Beath.

e Collection of Tiffany & Co.

f *American Journal of Science*, October, 1882.

g *American Journal of Science*, III., xxv., No. 146, p. 161; and New York Academy of Sciences, November 7, 1882.

$100 a year at present; but it is probable that this amount will be increased in the near future by the Pike's Peak production.

Beryl, emerald, aquamarine.—Emerald has been found at Stony Point,(*a*) Alexander county, North Carolina, in crystals, some from eight to ten inches in length associated with hiddenite, rutile, and garnet. The crystals as a rule have a white core, and although as mineral specimens they are grand, yet few gems have been found up to the present time, and these of second grade. Future developments may, however, bring some fine gems to light. Beryl, spodumene, and the associated minerals have been found on the Lyons property, adjoining that of the Emerald and Hiddenite Mining Company.

Aquamarine has been found at a number of localities in America, the principal among them being Royalston, Massachusetts; Actworth, New Hampshire; Grafton, Vermont; Burke county, and Stony Point, North Carolina; Paris, Maine; Fitchburg, Massachusetts; and Avondale, Pennsylvania. The richest known gems from any known locality have been found at Royalston, (*b*) Massachusetts, and although small are almost as blue as the sapphire. Large clear gems of a light-blue and sea-green tint have been found at Actworth, Grafton, and Stony Point, at the latter locality shading into the beryl-emerald. At Stoneham, Maine, two fine crystals have been found in a pasture; one of which will furnish a fine blue gem over 20 karats in weight. The crystal of which only one-half was found is 5 inches long and 1 inch across; it is equal in color to any from Siberia, but has been badly broken by frost or by the hand of some one who was ignorant of its value.

The entire amount of beryl gems found in the United States in the last ten years would not bring over $2,000, and they are scarcely known to others than collectors.

Phenakite.—Phenakite has recently been found at Pike's Peak, Colorado, (*c*) in crystals of sufficient size and quality to furnish fair gems. Some fair sized crystals of remarkable clearness were found here recently. They are equal in point of quality to any found elsewhere, and further finds may produce crystals equal in size to those from Siberia. Though rare, this gem is colorless, and hence its value is almost purely mineralogical.

Zircon.—Zircon has not yet been found in this country in pieces sufficiently large or good to warrant cutting. Some very small crystals of good color have been found in Burke county, North Carolina, and the ends of some of the Saint Lawrence county, New York, zircons might cut into very small imperfect gems; but nothing further of more than mineralogical value has been found.

Garnets.—The garnets found in New Mexico and Southern Colorado,

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a Cf. paper by Mr. W. E. Hidden, p. 500, of this report, and *American Journal of Science*, xxii., 489, 1881.

b Collection of G. F. Kunz.

c *American Journal of Science*, October, 1882.

and there called "rubies," are as fine as those from any other known locality, the blood-red being the most desirable. Very fine almandine, hyacinth yellow, and other colors, are also found associated with olivine and sapphire. Chester county, Pennsylvania, has afforded some fair gems, and some quite fine ones have been found at Stony Point, North Carolina, and at other localities, but the only ones used as gems are from New Mexico, Arizona, and Colorado, which yield annually about $5,000 worth of cut stones. As an example of their quality, a remarkably fine one was sold to a gem connoisseur for $50, but equally good stones have often sold for much less.

Essonite (cinnamon garnet).—Essonite has been found in very fine crystals at Phippsburg and Warren, New Hampshire; Raymond, Maine; and at many other points in America. Yet only occasionally crystals are found that will cut gems even of value to collectors.

Grossularite has recently been found in perfect, opaque crystals in Gila cañon, Arizona.

Tourmaline.—The principal source of tourmaline in the United States is the famous locality, Mount Mica, at Paris, Maine, which place has from time to time produced some of the handsomest achroites, rubellites, indicolites, and green tourmalines known. The tints of the green, blue, pink, and yellow tourmalines found here are usually of the light and most desirable shades. (*a*) Work is now being carried on. The yield for 1882 was something over $2,000, and the entire quantity of gems that have from time to time been taken from this locality at the higher rate asked for them as American gems would possibly amount to from $50,000 to $65,000.

Colored tourmalines have been found at Hebron, Norway, and Auburn, Maine. Extended work may bring as fine gems to light here as at Paris, Maine, as the indications are equally good at all these places.

Colorless and brown tourmalines, which cut into fair gems, (*b*) have been found at De Kalb, New York. The fine black from Pierpont and the fine brown from Gouverneur, in the same State, have no value as gems.

Iolite.—Iolite has been found at Haddam, Connecticut, in pieces of a dark-blue color and sufficiently clear to cut small gems, but these were of local and mineralogical value only, owing to their small size.

Spodumene.—Spodumene has been found transparent at two localities in the United States, the variety hiddenite or "lithia emerald" at Stony Point, Alexander county, North Carolina, and a variety of amethystine color at Branchville, Connecticut.

Hiddenite, (*c*) or "lithia emerald," is found associated with emerald, beryl, rutile, and garnet; the more valuable is the rich grass-green, and is rarely met with. Quite perfect gems of good color, weighing 2½ karats, have been cut. The light-green, yellow, yellow-green, and colorless

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a Collections of Dr. A. C. Hamlin, Dr. Joseph Leidy, and Prof. C. U. Sheppard.
b Collection of Dr. Joseph Leidy.
c Cf. paper by Mr. W. E. Hidden, p 502 of this report.

have a lower value. The green is a new and strictly American gem, and the demand exceeds the supply. This and the tourmaline are the only gems that are being actively mined at present. The total sale of gems found and sold from the beginning of operations in August, 1880, to the close of 1882, amounted to about $7,500, the yield in 1882, during which only preparatory work was being done, being about $2,000 worth of gems.

The Branchville spodumene (*a*) would afford only very small gems of a light amethystine color. The alterations in color which have taken place have entirely changed it to what might almost be called a defunct gem, which would otherwise have afforded material for gems over one inch in thickness and several inches in length. The color before the alteration was probably much richer. The Branchville variety has only a mineralogical value.

Danburite.—Danburite (*b*) has been found in considerable abundance at Russell, New York. Only an occasional crystal is clear enough to cut even a small gem. The color is usually wine-yellow, honey-yellow, or yellowish brown. It has not yet been used as a gem.

Rock crystal (*quartz*).—Rock crystal is found at a great many localities in America. In Herkimer county, at Lake George, and throughout the adjacent regions in New York State the calciferous sandstone contains single crystals, and at times cavities are found filled with doubly terminated crystals often of remarkable perfection and brilliancy; these are collected in numbers, cut, and often uncut are mounted in jewelry and sold to tourists under the name of "Lake George diamonds." Those sold in large cities under the same name are, however, often simply paste or glass, which possess more brilliancy but have not the same durability. Of the Herkimer crystals possibly $3,000 worth are sold per annum. In Arkansas, at Crystal Mountain and in the region for about forty miles around Hot Springs, large veins of quartz are frequently met with. The quartz is taken to Hot Springs and Little Rock by the wagon load by the farmers, who often do blasting to secure the crystals, looking for them at such times as their crops need no attention. In the course of a year possibly 100 loads are sold, principally as mementos, to the visitors at these resorts. Crystals are also sent to other localities for sale. Usually only one-half of the crystal is clear, and a clear space over two inches square is quite uncommon. The sale of the uncut ones from this region amounts to fully $10,000 per annum.

At Hot Springs clear, rolled pebbles are often sold, that have been found on the banks of the Ouachita; these are more highly prized than the crystal, as the common fallacy prevails that they cut clearer gems. The scarcity of these and the demand for them has so worked upon the cupidity of some that they have learned to produce rolled pebbles by putting numbers of the crystals in a box which is kept revolving for

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a American Journal of Science, i., 318, 1879.
b American Journal of Science, III., xx., III., 1880.

a few days by a water power. Any expert, however, can discern the difference, since the artificial ones are a little whiter on the surface.

Many localities in Colorado furnish fine specimens, and all along the New Jersey coast at Long Branch, Atlantic City, Cape May, and other places, transparent pebbles are found in the sand, and are sought after and found by the visitors, who often have them cut as souvenirs.

Large masses of clear rock crystal have been found in North Carolina, and would be of use in the arts.

At all of these places large quantities of the quartz cut in gems, seals, and all manner of ornaments are sold as having been found in the vicinity. Sometimes even the stones that have been found by the visitors and brought by them to be cut are exchanged for those already cut and brought here from Bohemia, Oldenburg, and the Jura, where cutting is done on a large scale and by cheap labor; the cut stones costing delivered in America not more than one-tenth of the price of cutting done here, as the rock crystal in the articles really costs very little.

The annual sale of cut stones and money expended in cutting, at the different localities, may amount to $20,000 or more per annum, and the sale of specimens to as much more.

The clear crystal for optical purposes used in this country is almost entirely Brazilian, not that the American is not fine enough, but the good material found here rarely reaches the proper channels, and the Brazilian is cheap and is used from custom.

Smoky quartz or cairngorm.—Smoky quartz, smoky topaz, or cairngorm, is found in large quantities at and near Pike's Peak, Colorado. It is also found to some extent at Anteros Summit, Colorado; Magnet Cove, Arkansas; Burke and Alexander counties, North Carolina, and at other points. The Pike's Peak material is sent abroad in large quantities for cutting, and the larger part is returned to be sold in tourists' jewelry, principally at Denver and Colorado Springs, Colorado; Hot Springs, Arkansas, and other western cities and resorts. The sum realized from the cut material amounts to fully $7,500 annually, and the crystals sold to fully $2,500 more.

Rose quartz.—Rose quartz occurs in large masses at Albany and Paris, Maine; Southbury, Connecticut, and at many other places in America, but as yet it has not been used at all in the arts or as a gem.

[*Gold quartz.*—Rich pieces of gold quartz are worked into jewelry and souvenirs on a considerable scale in San Francisco, and to a less extent in many of the larger towns in the mining regions. Some of the gold mines in California, Oregon, Idaho, and Montana have furnished very fine specimens, which are especially handsome when the quartz is clear and the gold penetrates it in compact stringers. Gold miners, however, often have a prejudice against what are known as "specimen mines;" that is, mines furnishing ore of this class. A few years ago it was estimated that $50,000 worth of this gold quartz was thus manufactured annually, but both the demand and the supply have latterly declined.—A. W., jr.]

Amethyst.—Amethyst has been found on Deer Hill, at Stowe, in a vein fully one-quarter of a mile long, and at other places in Oxford county, Maine; Chester county, Pennsylvania; in Colorado and Virginia and other regions, although not affording as large fine gems as the Brazilian or the Siberian. It is not used except for mineralogical gem collections. There are a great many amethyst crystal groups sold to tourists and collectors, and the sales from this source may amount to from $1,500 to $2,000 per annum.

Sagenite.—Sagenite, "rutile in quartz," "*flèche d'amour*," or "Venus's hair stone," is found at many localities in the United States. The principal supply comes from Iredell, Alexander, and other counties in North Carolina. The rich red, golden yellow, brown, and intervening shades are often cut into oval seals and charms for use as jewelry. The stone gives a very pleasing effect by sun or gaslight. The quantity used annually will amount to over $250 as gems, and as much more for mineral specimens.

Thetis hair stone.—Thetis hair stone, near Sneach Pond at Cumberland, Rhode Island, is occasionally met with in fair pieces, and is used to a limited extent in jewelry, probably less than $100 per annum.

Hornblende in quartz is found at Diamond Hill, Rhode Island, and is used to some extent in jewelry, principally in the cheaper grades. The amount used annually is probably worth about $500.

Agate and chalcedony.—Agate and chalcedony are found in a great many localities in America. Among them may be named Agate bay, Lake Superior, where large numbers of small banded agates, usually of a red color, are found. These are quite extensively cut and are sold to tourists who visit Lake Superior. Some fine large agates are found in different parts of Colorado and through the Rocky mountains, many of them very beautiful; though only a small proportion are cut or polished, owing to the cheapness of the agates from Brazil and Uraguay, which are cut and sold at so much lower rates in Germany. Nearly all the polished agate specimens sold in America are from the German market. Possibly $2,000 worth of American agates are sold annually.

Moss agate.—Of all the American stones used in jewelry there is no other which is sold so cheaply, and of which so much is sold, as the moss agate. Those found in the brooks and streams called "river agates" are the most desirable. Nearly all are sent abroad for cutting and then most of them are returned for home use. When this stone was fashionable fine ones were worth from $10 upwards, and as many as $20,000 worth were sold a year, but at present they are used only in cheap and tourists' jewelry. The principal sources of supply are Utah, Colorado, Montana, and Wyoming Territory. At present the moss agates collected amount to about $12,000 to $15,000 worth per annum, and the demand is declining.

Silicified wood.—Wood agate, wood opal, and silicified woods of all kinds are found in great abundance in Colorado, California, and others of the western States and Territories. For colors, variety, and the polish they admit, they are unequaled elsewhere; a great many articles of cheap jewelry and a variety of fancy articles are made from this material and are sold principally to tourists. Some pieces having a marked and desirable peculiarity or beauty are often sold at fancy prices. The quantity annually cut and sold amounts to nearly $10,000, and besides a large quantity is sold as cabinet specimens.

Jasper.—Jasper is found at many localities and in a great variety of colors in the United States. A fine green jasper is reported to have been found at Norman's Kill, (*a*) New York, fine red, yellow, and brown at Murphy's, Calaveras county, California, in great variety, and also in parts of Colorado. Near Colyer, Graham county, Kansas, is a bed of banded jasper; the colors are mainly red and yellow, with bands of white, and these bands are so remarkably even that the stone would furnish an excellent material for cameo work. Should this style of jewelry come into vogue again this may prove of considerable value; as it is, the beautiful red and yellow are so strikingly relieved by the white that it makes a fine ornamental stone. Jasper is very little used in the arts, for so common a stone, and the entire annual sales would not be more than $1,000.

Novaculite.—Novaculite is found at Hot Springs, Arkansas, and has been used to a very limited extent for cutting figures, such as owls and birds, for jewelry. It is pure white, and makes a very pretty ornamental stone. The amount sold is now less than $100 worth per annum.

Epidote.—Epidote, although found in many localities in the United States and in very large crystals ranging from brown to green in color, is only translucent or semi-opaque when in very minute crystals, and no American gems of this mineral have come to our notice.

Idocrase:—Idocrase, although found in fine crystals of a dark-brown color at Warren, New Hampshire, Sanford and Raymond, Maine, and other localities, rarely occurs with sufficient transparency to cut even small desirable gems.

Chrysolite, olivine, peridot.—Peridot is found of very good quality in small, olive-green, pitted grains or pebbles, associated with garnet and sapphire, in the sands of Arizona, New Mexico, Colorado, and Montana. This material affords smaller gems than those from the Levant, and as the demand seems to be for the large peridots and also the richer olive-green color peculiar to these, and not to the American, for these reasons only a small number of the American are cut into gems, and $500 will fully cover the amount sold annually.

a A fine specimen of heliotrope or bloodstone is reported to have been found here, but the same finder reported a similar and entirely unreliable occurrence in Texas, and the stones from both are evidently of foreign origin.

Rutile.—Rutile has been found of sufficient compactness and luster in Alexander county, North Carolina, and at Graves mountain, Georgia, to be used as a gem.(*a*) The rutile from the former locality, when cut, more closely resembles the black diamond in color and luster than any other known gem. If enough could be found fit for cutting, it would become popular as a rich mourning gem. The rutile from Graves mountain, when cut, more nearly approaches the garnet in color, and is therefore not as desirable.

Hematite.—Hematite, although found at many localities in the United States, is rarely compact enough for cutting, and is not used for that purpose, owing to the cheapness of the foreign mineral and cheap-cut gems sent to this country. Some exceptionally small, richly-colored pieces have been found near Gainesville, Georgia. The cut specimens sold at the Lake Superior resorts are almost entirely of foreign stone and cutting.

Isopyre.—Isopyre(*b*) is found in small veins from one to three inches in width at the iron mines near Dover, New Jersey. In color it very nearly resembles the darker green jasper, or, in other words, bloodstone without the red spots. It is used only as a gem in the cabinets of collectors.

Prehnite.—Prehnite (*c*) has been found at a number of localities in the United States, and gems have been cut from material found at Bergen Hill and Paterson, New Jersey.

Zonochlorite.—Zonochlorite has been found only at Neepigon bay, Lake Superior, and is scarcely known as a gem, except to collectors, some of the specimens showing the rich dark-green tints, arranged in concentric layers, and are very beautiful.

Turquois.—This stone has been found at three localities in the United States—Los Cerillos, New Mexico, Turquois mountain, Cochise county, Arizona, and at a point in Southern Nevada. At the latter place it occurs in veins of small grains in a hard shaly sandstone. The color of this turquois is a rich blue, almost equal to the finest Persian, and the grains are so small that the sandstone is cut with the turquois in it, making a rich mottled stone for jewelry. The principal sale for this stone is in San Francisco. At Los Cerillos some pieces have a decided blue color when found or broken, but show a marked tendency to turn green, and usually become quite green in a very short time.

At Turquois mountain the normal color appears to be green, although at times a faint shade of blue is perceptible.

[Prof. W. P. Blake writes to the *American Journal of Science*, March, 1883, concerning this new locality of green turquois, as follows:

"In this *Journal*, March, 1858, I directed attention to the occurrence in New Mexico of a green turquois highly prized as a gem by the aborigines and known as '*Chal-che-we-te*.' The completion of the railway

a American Journal of Science, III., xxi., 1881, i.. 227.

b Collection of F. A. Canfield.

c Collection of G. F. Kunz.

along the valley of the Rio Grande has made the Cerillos mountain, in which the gem occurs, much more accessible than it was, and the ancient mine has been reopened and worked to some extent by Eastern capitalists, as made known by Professor Silliman. The stone is in consequence more abundant than before, and at Wallace Station on the railway very good specimens can frequently be obtained of the Pueblo Indians.

"I have recently visited another locality where chalchuite occurs and was mined by the ancients. This is in Cochise county, Arizona, about 20 miles from Tombstone, in an outlying ridge or spur of the Dragoon mountains, and not far from the stronghold of the Apache chief, Cochise, so long the terror of that region. This elevation is now known as the 'Turquois mountain,' and as there are several deposits of argentiferous ores near it, a mining district has been formed called the 'Turquois district.'

"At the turquois locality there are two or more ancient excavations upon the south face of the mountain, and large piles of waste or *débris* thrown out are overgrown with century plants, yuccas and cactaceæ. It has not been worked for a long time, and probably never by the Apaches. The excavations are not as extensive as at Los Cerillos, and it is more difficult to find specimens of the mineral. It is evidently much less abundant than at the New Mexican locality. Enough of the gem was obtained, however, by searching in the waste heaps, to show that it is identical in its appearance with the New Mexican chalchuite. The rock is also similar, and the chalchuite occurs in seams and veinlets rarely more than an eighth or a quarter of an inch in thickness.

"The color is light apple-green and pea-green, precisely that of the New Mexican stone, as generally seen. There is in some fragments a faint shade of blue as at Los Cerillos, but the true normal color appears to be green rather than blue.

"The specific gravity I find to be, of two different fragments, 2.710 and 2.828. The first was slightly porous and earthy, and the second dense, hard, and homogeneous. These results are higher than I obtained with the specimens from the surface at the New Mexican locality, viz., 2.426 to 2.651. Two determinations recently made gave 2.500 as the specific gravity of two partly-cut stones from the old Cerillos locality."

Mr. F. F. Chisolm furnishes the following additional particulars concerning the New Mexican turquois:

"Turquois is found in the Rocky Mountain division only on Mount Chalchihuitl, in Santa Fé county, between the Santa Fé and Galisteo rivers, about 20 miles southeast of Santa Fé. The mountain is composed of eruptive rocks, probably of Tertiary age, and is distinguished from the other peaks of the Cerillos range by its white color. The origin of the Los Cerillos turquois, in view of late observations, is not doubtful. Chemically, it is a hydrous aluminum phosphate containing 3.81 per cent. copper. Neglecting this constituent, the formula for turquois requires, phosphoric acid, 32.6; alumina, 46.9; water, 20.5.

"Evidently the decomposition of the feldspar of the 'trachyte' furnished the alumina, while the apatite or phosphate of lime, which the microscope detects in thin sections of the Cerillos rock, supplied the phosphoric acid. It seems probable that the bluish-green color of the mineral is due to the associated copper, which is derived from the copper ores occurring in the Cerillos mountains.

"The turquois occurs in thin veinlets or concretions throughout the mass of yellowish white rock. The concretions or 'nuggets' are covered with a crust of nearly white aluminous rock, and on being broken generally afford the commoner and less valued varieties of the stone, such as are cut roughly and sold on the Atchison, Topeka, and Santa Fé trains by the Indians at the towns of Wallace and Algodones. Fine stones of sky-blue color and of considerable value are extremely rare, and many tons of rock may be broken before finding a stone which could be classed as a gem.

"The observer is deeply impressed on inspecting this locality with the enormous amount of labor which in ancient times has been expended here. The waste of débris excavated in the former workings covers an area of at least 20 acres. On the slopes and sides of the great piles of rubbish are growing large cedars and pines, the age of which must be very great. That considerable quantities of the stone have been obtained can hardly be questioned. The early Mexican settlers attached great value to the turquois, as do the Indians of the present day. It is a matter of history that these mines were well developed in 1680, in which year a large section of the mountain suddenly fell in as a result of undermining the mountain by the Indian miners, killing a considerable number of them."]

All the American turquois is sold to either tourists or collectors, or in the jewelry trade only as oddities. The material cut and sold as gems annually amounts to about $1,500. That cut into specimens and sold amounts to fully as much more.

Labradorite (*Labrador spar*).—Labrador spar is found in large quantities in Lewis and Essex counties, New York, and in bowlders all the way down to Long Island and New Jersey in the drift from the New York counties named above. It is scarcely used at all in the arts, owing to the cheapness and superiority of the same mineral from Labrador.

Amazon stone.—Pike's Peak, Colorado, and several localities in North Carolina, furnish this mineral, which is often cut and is generally used in cheap and tourists' jewelry. The quantity of material thus cut and sold amounts to over $1,000, while that sold as mineral specimens brings probably two or three times that amount.

Sunstone.—Sunstone of very good quality, almost equal to the Norwegian, is found at Media, Delaware county, Pennsylvania, and at Orange Court-house, Amelia county, Virginia. It is as yet used to a very limited extent, and the annual sales may amount to about $250.

Moonstone.—Moonstone of very good quality, resembling the St. Gothard variety, and not the Ceylonese, is found at Media, Pennsylvania, and at Orange Court-house, Virginia. The quantity sold amounts possibly to over $250 annually.

Elæolite.—Elæolite has been found in some abundance, and of a very compact, rich, flesh, cinnamon, and yellow-brown color that would warrant its use for certain purposes in jewelry, at Magnet Cove, Arkansas.

Obsidian.—American obsidian is scarcely used at all in jewelry, although found in masses in California and others of the Pacific States. The Pitt River country is a well-known locality, and furnishes handsome specimens of "mahogany obsidian." The streaked marekanite, so called, has been used, but to a very limited extent, probably amounting to not more than $100 annually.

Chlorastrolite.—Chlorastrolite is found only at Isle Royal, Lake Superior, where it occurs in the form of rolled pebbles which have fallen or worn out of the trap rock. They are entirely opaque, of a green color, mottled with stellations, and admit of a high polish. It is one of the few strictly American gems. Large numbers are sold annually to tourists who visit the Lake region. Chlorastrolites measuring one inch in length and of good color have sold for $50. The annual sales amount to fully $2,500.

Thomsonite.—Thomsonite is found at Grand Marais, Lake Superior; in color flesh-red, with zones of green, red, and white, resembling the eye-agate, the peculiarly soft tones of color making it a very pretty stone. It is cut to some extent, and possibly from $500 to $750 worth is sold every year, principally to tourists.

Diopside.—This mineral has been found at De Kalb, (*a*) New York, in short, stout, oily green crystals, in color resembling the crystals from Ala, in Piedmont. Specimens have been found sufficiently large and clear to cut into gems weighing from 6 to 8 carats each, and recently crystals have been obtained which in size and perfection rival the foreign, and some will furnish gems of 12 to 15 karats each. This is the only known locality for this gem in the United States.

Opal.—Opal has not yet been found in the United States of sufficient merit to entitle it to the name of a gem.

Willemite.—This stone (*b*) has been found sufficiently transparent at Franklin, New Jersey, to make a very fair gem. The color is of a rich yellow, in shade between the topaz and chrysoberyl from Brazil, with the vitreous luster of the Tavetsch titanite. One crystal furnished seven gems, one of them weighing over 8 carats. As this gem occurs in colors of rich brown and one of the richest greens, we may in time expect to see gems in both these varieties.

Rhodonite.—Rhodonite is found in a number of localities in the United States. At Cummington, Massachusetts, it occurs in fine large pieces of a rich red color, occasionally beautifully streaked with the black ox-

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a New York Academy of Sciences, March, 1882.
b Collection of F. A. Canfield.

ide of manganese, equal in every respect to the finest from Russia. It also occurs in pink and flesh colored masses mixed with rhodocrocite, at the Alice mine, Butte City, Montana. It has been very little used in the arts.

Bowenite.—This variety of serpentine is found in some quantity at Smithfield, Rhode Island. Its rich color, peculiar toughness, and hardness, recommend its use where jade has heretofore been employed.

Williamsite.—This variety of serpentine from Texas, a town of Lancaster county, Pennsylvania, has been used to a limited extent as a substitute for jade, it being more easily cut and usually of a more pleasing color. The amount realized from this stone is not more than $100 per annum.

Fluorite.—Fluorite has been found at many localities in the United States, some of the richest colors in Hardin county, Illinois, at Rose Clare, Shawneetown, and Elizabethtown. In the mounds in this region it is occasionally found shaped into ornaments by the hand of prehistoric man. (*a*) This is the only use it has had as yet as an ornament in the United States. The amount mined here for the arts figures over $15,000 per annum.

Fossil coral.—The fossil corals found in Iowa, near Dubuque, have been used to some extent in jewelry, shaped into stones for cuff, shirt, and vest buttons, the light cream color making a very quiet, rich stone for this purpose. The amount used is less than $250 per annum.

Malachite.—Malachite, although occurring in many localities in the United States, and in considerable abundance at times as one of the ores, or associated with the other ores of copper, is however very rarely found in a form fit for cutting, and no cut specimens have come under our notice.

Jet.—This substance has been found in abundance and of very good quality in El Paso county, Colorado, and in some parts of Texas. As yet it has not been utilized in the arts, although it is likely to be at no distant day. A large number of pieces have been polished for cabinet specimens, and the sale of these in the last seven years has probably amounted to several thousand dollars.

Andalusite is found at a number of localities, and recently in crystals one inch in diameter and six inches long at Gorham, near Sebago lake, Maine; yet no transparent gem stones have been furnished from any American locality.

Chiastolite (*macle*).—Many hundred beautiful crystals of this mineral, with its curious cross-like markings, have been found; yet no use has been made of it for gem purposes, although a number are sold abroad for this purpose. There are occurrences at Lancaster, Massachusetts, and in California.

Natrolite occurs at many localities in beautiful crystals, but too small to cut for gems.

a Collection of G. F. Kunz.

Catlinite (*pipestone*).—This mineral is found in large beds in the upper Missouri region, and in Pipestone county, Minnesota. As yet it has only been used by the Indians. It would furnish a cheap ornamental stone.

Axinite has not been found in fine or large enough crystals to furnish gems.

Titanite (*sphene*).—This mineral is met with in abundance in fine black and brown crystals, yet no gems have been found in the United States, although it occurs in such rich, vitreous, yellow gems in Switzerland.

Cassiterite has not been observed except in fractured crystals, and none have been found clear enough to cut even a small gem. The wood-tin of Durango, Mexico, is used to a very limited extent on the Pacific coast, the stone being simply polished flat.

Amber has been found at Gay Head, Martha's Vineyard, and Nantucket, Massachusetts; at Harrisonville, (*a*) Gloucester county, near Trenton, near Camden, and all through the marl region of New Jersey; and at a number of other localities in the United States; but only rarely of a quality or in sufficient quantity to warrant its use in the arts.

Jadeite.—An impure variety is found near Easton, Pennsylvania; and it has recently been brought from Alaska in the form of ornaments, and has also been found in place there. This mineral has not been used in the arts as yet from any American locality.

Ilvaite.—This mineral has not been found in compact or large enough pieces to afford gem stones.

Lapislazuli has not been found at any American locality.

Pyrite is found in beautiful crystals, and in compact masses of a fine yellow color at many American localities, notably in Gilpin county, Colorado. It has little or no value as an ornament, although it has been used to some extent abroad in former times.

Sodalite is found associated with cancrinite, elæolite, and in fine blue patches and masses, some several inches across and one inch thick. Fine pieces are of rare occurrence, and the stone is only a mineralogical gem.

List of gem stones known to occur in the United States.

Achroïte (tourmaline).	Catlinite.
Agate (quartz).	Chalcedony (quartz).
Agatized wood (quartz).	Chiastolite.
Almandine (garnet).	Chlorastrolite.
Amazon stone (microcline).	Chondrodite.
Amber.	Chrysolite.
Amethyst (quartz).	Danburite.
Aquamarine (beryl).	Diamond.
Asteria.	Diopside (pyroxene).
Beryl.	Elæolite (nephelite).
Bloodstone.	Emerald (beryl).
Bowenite (serpentine).	Epidote.
Cairngorm (quartz).	Essonite (garnet).

a American Journal of Science, March, 1883.

Flèche d'amour (quartz).
Fluorite.
Fossil coral.
Garnet.
Grossularite garnet.
Heliotrope.
Hematite.
Hiddenite (spodumene).
Hornblende in quartz.
Idocrase.
Indicolite (tourmaline).
Iolite.
Isopyre.
Jade.
Jasper (quartz).
Jet (mineral coal).
Labradorite.
Labrador spar (labradorite).
Lake George diamonds (quartz).
Lithia emeralds (spodumene).
Macle.
Malachite.
Moonstone (feldspar group).
Moss agate (quartz).
Novaculite (quartz).
Obsidian.
Olivine (chrysolite).
Opalized wood (opal).
Peridot (chrysolite).
Phenakite.
Prehnite.
Pyrope (garnet).
Quartz.
Rhodonite.
Rock crystal (quartz).
Rose quartz (quartz).
Ruby (corundum).
Rubellite (tourmaline).
Rutile.
Rutile in quartz (quartz).
Sagenite (quartz).
Sapphire (corundum).
Silicified wood (quartz).
Smoky quartz (quartz).
Smoky topaz (quartz).
Spinel.
Spodumene.
Sunstone (feldspar).
Thetis hair stone (quartz.)
Thomsonite.
Tourmaline.
Topaz.
Turquois.
Venus hair stone (quartz).
Willemite.
Williamsite (serpentine).
Wood agate (quartz).
Wood jasper (quartz).
Wood opal (opal).
Zircon.
Zonochlorite (prehnite).

List of species and varieties found in the United States, but not met with in gem form.

Axinite.
Andalusite.
Cassiterite.
Chrysoberyl.
Cyanite.
Ilvaite.
Opal.
Prase (quartz).
Sphene.
Titanite.

List of species and varieties not yet identified in any form in the United States.

Alexandrite.
Cat's-eye chrysoberyl.
Cat's-eye quartz.
Chrysoberyl cat's-eye.
Chrysoprase.
Demantoid.
Euclase.
Lapislazulite.
Ouvarovite.
Quartz cat's-eye.

List of gem stones occurring only in the United States.

Bowenite.
Chlorastrolite.
Chondrodite.
Hiddenite.
Lithia emerald.
Novaculite.
Rutile.
Thetis hair stone.
Thomsonite.
Willemite.
Williamsite.
Zonochlorite

THE DISCOVERY OF EMERALDS IN NORTH CAROLINA.

By W. E. Hidden.

Sixteen years ago the site of the North Carolina emerald mine was covered with a dense primitive forest. Less than ten years ago the locality was, mineralogically, a blank; nothing was known to exist there having any special interest or value. It is certain, though, that this region has produced, of late years, some of the most remarkable and beautiful specimens of emerald, spodumene, beryl, quartz, rutile, and monazite thus far discovered in the United States.

In a few localities in Alexander county crystals would be found of the common opaque beryl, but now and then a semi-transparent prism, having a decided grass-green tint, much resembling the famous crystals from Siberia, would be found and offered for sale in the county towns. These came to have the name among the farmers of "green rocks" and "green bolts."

In a period of about six years there were found loose in the surface soil, on three plantations in this county, a few beryls having a tint verging distinctly on the true emerald color, none of which crystals, however, were deep colored enough or sufficiently transparent for use as gems. It was the sight of two of these so-called "green bolts" that prompted me to visit the locality where they were found, and to make a search there for the true emerald. I cannot understand why prospecting was not commenced long ago, where such favorable signs were so common; that such indications could receive only passing notice seems inexplicable. No higher inducement than the following had ever been held out to the farmers to look for these "green bolts": "A visiting collector had offered the munificent sum of one dollar for a dark green transparent crystal as long as his finger."

Such is the history of the emeralds found in this county before I commenced systematic mining for them. The location of the mine now being worked was obtained in the following manner: A corps of workmen were employed to dig a series of deep ditches in directions that would cut the strata at different angles. The site chosen for work was on the spot where at least six of these "green bolts" had been found. This location was shown to me by the farmer who had picked up the crystals while plowing. Not knowing then their manner of occurrence *in situ*, and having no precedent to work by, I expected by this plan to strike a vein bearing them.

Five weeks were spent (July–August, 1880) before any success was met with, and then at a depth of eight feet was discovered a "blind vein" (so called because it had no outcrop) bearing very small emeralds. In this vein, and outnumbering the emeralds fifty to one, was discovered the new emerald-green gem, which was such a surprise to the scientific world, and which was destined to answer the same purpose and have equal value with the gem I had been seeking for. I refer to the emerald-colored spodumene now known as "hiddenite."

The search for emeralds in North Carolina is so interwoven with my discovery of emerald-green spodumene that I cannot tell the story of one without the other; the two minerals occur intimately associated, and while mining for the one the other is constantly found.

This blind vein yielded very handsomely of the new mineral, but very sparingly of emeralds. A tunnel for the purpose of drainage was cut to this vein, a distance of 261 feet, mostly through rock. A shaft was sunk upon it to the depth of 56 feet, at which point it showed its pocket nature by "pinching out." Up to this time over 80 of these veins have been found within an area of 40 feet square, carrying emeralds and hiddenites. All these veins maintained nearly the same character of dip, thickness, length, and associations. Other pockets were found that yielded only quartz, rutile, mica, and monazite crystals of great beauty; others yet whose walls were covered exclusively with finely crystallized dolomite, calcite, apatite, rutile, pyrite, quartz, or mica. In one instance a pocket contained only mica crystals and one pellucid, colorless beryl that had both ends brilliantly terminated. I mention the above associated minerals to show the diversity in these pockets, although they are so near together. In the rock mining the presence of small streaks of massive quartz or of mica bedded in a contra-direction to the strike of the country rock, leads to an open pocket containing gems not many feet distant.

The largest emerald yet found in this mine was 8½ inches long and weighed nearly nine ounces. It was the largest of nine fine crystals contained in a single pocket; (*a*) their color was excellent, and they were all transparent, though somewhat flawed. The greatest number of emerald crystals found in one pocket at this mine was 74. This find occurred in the spring of 1882. Some of these were between 2 and 5 inches long; the majority were very small.

This mine is situated about 35 miles southeast in an air line from the Blue Ridge mountains. The contour of the country is low-hilly; its altitude about 1,200 feet. The prevailing rock is gneiss, the strata running north-northwest and south-southeast with a nearly vertical dip. The gems and crystals occur in open pockets of very limited extent, which are cross-fractures or shrinkage-fissures. They are usually nearly perpendicular in position. The most striking feature of the geology of this region is the great depth of earth "that everywhere mantles and conceals the rocks. This is readily discovered to be, for the most part, merely the result of the decomposition *in situ* of the exposed edges of underlying strata" (Kerr). At this mine the unaltered rock is found at a depth of 26 feet, and is of unusual hardness, especially where it walls the gem pockets.

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a For complete description of this remarkable pocket, see Transactions of the New York Academy of Sciences, March, 1882.

My prospecting has proved these gems to exist in a narrow belt running east and west, and scattered over a distance of three miles; in this belt signs of cross-fissures are very abundant, and it is a very common occurrence to find crystals of beryl, quartz, rutile, etc., perfectly preserved, scattered over the surface soil.

In regard to the commercial value of the North Carolina emerald it should be stated that the majority of the crystals have had little value for gem purposes; as cabinet specimens they were unprecedented, and as such had ready sale at prices ranging from $25 to $1,000 each. The best cut stones did not exceed in value much above $32 per carat. From the largest crystals gems could have been cut, but as scientific specimens the crystals in their entirety had greater value. The smallest crystals have thus far had the best color, and have furnished the purest gems. It may be interesting to note that the entire expenses of the work at this locality, done under the writer's supervision, have been more than repaid by the sales of gems and crystals discovered there.

HIDDENITE—THE NEW EMERALD-GREEN GEM.

By W. E. Hidden.

This new variety of spodumene was unexpectedly discovered in the manner described in the foregoing section. It was named by Prof. J. Lawrence Smith, of Louisville, Kentucky, who was the first to determine its true chemical nature. (*a*)

Crystals of spodumene, quite transparent, of a pale yellowish-green color, had been found in the surface soil some five years ago, before the discovery of this gem variety was made, but they were so rare and unattractive as to receive only passing attention; so much did they resemble the pyroxene found at Traversella, Switzerland, that they passed under the name of diopside. Their mode of occurrence is precisely that of the emeralds at the same locality. Hiddenites and emeralds are found intimately associated, but one or the other always predominates in number; there will be many crystals of hiddenite and only a few emeralds, or *vice versâ*.

The color of hiddenite is emerald green, of various shades, deepest and richest when viewed through the longest axis, and verging more on the yellow shades of the emerald, when examined through the prism. The gems usually are of a delightful green, which is distinct from that of the emerald, having more liquid brilliancy and fire. They rarely contain flaws. The rough mineral occurs as slender prisms, with the color generally more intense at one of the extremities. The largest crystal yet found is 2¼ inches long. The largest cut gem weighed about 2½ carats. The prismatic cleavage is remarkably perfect, yielding surfaces of the highest luster; this feature is a source of trouble to the

a *American Journal of Science*, Vol. XXI., p. 128.

lapidaries, as the gem is liable to split while undergoing the cutting process. The stone is found to be harder across the ends than across the sides.

Composition of hiddenite.

	Smith.	Genth.
Silica	64.35	63.95
Alumina	28.10	26.58
Iron oxide	.25	1.11
Chromium oxide	....	.18
Lithia	7.05	6.82
Soda	.50	1.54
Potash	....	.07
Water (loss by heat)	.15	....
	100.40	100.25

Its behavior before the blowpipe is peculiar. When heated to redness, but not fused, it loses its color, but regains it on cooling—a reaction analogous to that afforded by the emerald. Its specific gravity is 3.19. Its hardness across the crystals is above that of the emerald. In value it ranges from $32 to $200 per carat, according to the depth and purity of its color. The demand, at home and abroad, has from the first been far in excess of the production of the mine.

A force of 20 men (at times 30) are kept constantly at work in the gem quarry, and a company is engaged at present in solving the problem of mining gems, *in situ*, at a profit. The nominal capital is $200,000, with a paid up capital of $20,000. The title of the company is "The Emerald and Hiddenite Mining Company." Its success thus far has been very flattering.

FERTILIZERS.

THE PHOSPHATE DEPOSITS OF SOUTH CAROLINA.

By Otto A. Moses.

Geographical.—The phosphate rock bed which now supplies the civilized world with the chief part of all the phosphate of lime used in the manufacture of commercial fertilizers is situated on the coast of South Carolina. Its greatest length is about seventy miles, extending from the mouth of Broad river in the southwest, near Port Royal, to the headwaters of Wando river in the northeast, its major axis being parallel to the coast. Its greatest width, from the upper tributaries of Ashepoo river to Stono river near the city of Charleston, is about thirty miles. It crops out at the surface in many places, notably along the lands adjacent to Ashley river, where it was first discovered. Commencing at Broad river, where the phosphate beds end (being replaced by analogous siliceous ones), it is found very uniformly distributed over large areas at the bottom of many of the rivers leading to the ocean. Near the town of Beaufort it spreads beneath the wide streams which surround the famous sea islands. It appears in its most convenient and accessible deposits circling around Charleston at about eight miles distance. Commencing at its most southern limit and going northwardly in order, we find the following rivers to be largely paved with it: Johnson's river, Port Royal river, Battery creek, Morgan river, Parrott creek, Coosaw river, Saint Helena's sound, Bull river, North and South Wimbee creeks, Ashepoo river, Horseshoe creek, Edisto river, Church creek, Rantowle's creek, Stono river, Ashley river, Cooper river and its eastern branch, Goose creek, Back river, and Wando river.

Nearly all these river deposits have been worked, yielding rock of excellent quality. Some, like Coosaw river, Parrott creek, North Wimbee creek, and Stono river, have furnished much the greater part of what has been mined.

Those portions of the bed (averaging about one foot in thickness) which come near enough to the surface to be profitably mined at present prices ($6 a ton) are about equally distributed in the counties of Beaufort, Colleton, and Charleston. They are spoken of as the Coosaw, Edisto, and Ashley deposits, respectively, from the names of the rivers upon whose beds or banks the rock is found. These deposits are undoubtedly continuous, but the spaces between them are connected by a stratum lying at unprofitable depths.

Geological.—The entire bed lies covered or mixed with Quaternary sands and clays. The nodular phosphatic layer rests upon what has been called by Ruffin the great Carolinian marl bed, which has been observed to underlie the coast counties from Georgia to North Carolina.(*a*) This enormously thick calcareous bed has been divided in ascending order into the Santee marl, the Cooper river marl, and the Ashley river marl. All these rest upon the Cretaceous marls (well exposed on the banks of the Pee Dee river) which underlie them to a depth of many hundred feet, and extend under several adjoining States. It has been said, and it is very probably true, that no richer marl beds are to be found in the world, and there are none more available or better situated for the present demands of agriculture.

The original phosphate deposit of South Carolina is of Eocene age ("sub-Eocene" or "supra-Cretaceous," according to Holmes).(*b*)

The characteristic fossils are exclusively represented by casts of shells. These casts show in reverse position the outer and inner surfaces of the shells which have been dissolved away after the solidification of the phosphatic ocean ooze which formed the bed. This bed and its congeners were subsequently raised above the coast line. Innumerable fissures, one to two feet in depth, were produced on surface-drying, whose sides were indurated by exposure—an effect which characterizes all mineral phosphatic substances.

This upheaved deposit covered the surface of the country in a Pliocene and post-Pliocene age. During these periods the hardened upper parts were detached in many places from the lower softer parts by flowing streams, and from the Eocene marls upon which, and with which, it was deposited. The angular fragments were intermingled with the bones of land animals such as the tapir, horse, elephant, and mastodon, and amphibious ones such as the seal, dugong, and walrus.(*c*) These animal remains were subsequently buried with the rock fragments under Pliocene and post-Pliocene silts, and sometimes similarly associated they are found in Quaternary formations which contain arrowheads and (perhaps) human bones.(*d*)

It must be borne in mind that the shell imprints and vertebrate remains in these nodular layers are all of Eocene origin, and identical with those contained in the rock layer upon the marl and in the marl itself. In fact the phosphate deposit was originally of exactly the same age as that portion of the marl bed upon which it rests, and with which it was almost simultaneously formed. The following may serve to explain the method of formation of the Carolina and all similar phosphate beds:

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a Report of the commencement and progress of the agricultural survey of South Carolina for 1843, p. 7. Edmond Ruffin, Columbia, 1843.

b The Phosphate Rocks of South Carolina, Charleston, 1870, p. 20.

c Remains of Domestic Animals, etc., Discovered among the post-Pliocene fossils of South Carolina. F. S. Holmes, Charleston, 1858.

d The Phosphate Rocks of South Carolina. Holmes, 1870, p. 62.

The Eocene ocean was at one time depositing its marls over continental areas. These marls have been found by artesian borings to be over 700 feet in thickness. (*a*) Similar marls are now in process of formation along the coast. An ooze rich in phosphatic material has been taken from the Gulf stream by Count Pourtales. (*b*) This great body of warm water has a flow for a considerable depth below the surface. Captain Tanner, of the United States Fish Commission steamer "Albatross," has detected off the Bahamas deep submarine lakes of cold water which have settled and remain without apparent motion. In such basins a marl of great uniformity of composition could accumulate. Such is the Ashley marl at certain depths, consisting of a homogeneous mass containing from 70 to 80 per cent. carbonate of lime, 2 to 10 per cent. of phosphate of lime, 5 to 25 per cent. of siliceous matter, and the balance organic and inorganic substances.

Now, it is easily conceived that over quiescent areas the marl would form evenly by general slow sedimentation; but should a portion of the containing ocean be disturbed by moving currents, such as the Gulf stream, there the nature of the deposit would change. Only the coarser materials would settle from out the streaming water; the finer and finest parts held in suspension throughout the whole mass would be swept on into the retarding edges of the current, there to be deposited according to relative size and specific gravity. This secondary deposit would overlap the slowly settling ooze, would be at times mixed with it, and would contain exactly the same shell remains and chemical ingredients, though in greatly different proportions.

Such a condition of things probably existed in the Eocene sea from which the phosphate beds have settled; for on their extreme outskirts, and fringed by them, we find the analogous siliceous and infusorial beds of Coosawhatchie and of Orangeburg. These, being of lighter specific gravity, would have been further transported than the heavier phosphate of lime. Remarkably similar, too, to the phosphate nodules are layers of siliceous nodules lying upon the infusorial deposit and resembling them in form and bedding, pointing to a similar origin such as surface drying of the mud from which they separated. All these strata are found with and on the marl in the most intimate contact. At Bee's Ferry, on the Ashley river, the confluence of phosphate and marl is exhibited most clearly in a 50-foot wall at the great marl pit. The indurated phosphate near the surface grows gradually softer, and losing its nodular form imperceptibly goes over into the marl for the space of 10 feet or more, the phosphatic contents diminishing uniformly until the pure marl mass asserts itself.

Does not this point to a moving stream slowly changing its position (as does the Gulf stream in its progressions) as a probable source of the

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a Municipal Report of the City of Charleston, Artesian Wells, 1881.

b N. S. Shaler. Proceedings of the Boston Society of Natural History, Vol. XIII., March 2, 1870.

South Carolina phosphate beds and all analogous formations? That this condition of things reoccurred at intervals we have abundant proof. During the boring of the third deep artesian well under Charleston, Mr. Spangler cut through phosphate-bearing strata in the marl at depths of 80, 350, and 778 feet, respectively. The fragments of rock taken from the bore hole were determined by Dr. James Hall. (*a*) And from the artesian well sunk by the South Carolina Railroad Company at Sineath's Station, 13 miles from Charleston, Dr. Wamer analyzed phosphate nodules coming from the following depths: 26 feet, 58 per cent. phosphate of lime; 70 feet, 50 per cent.; 104 feet, 51 per cent.; 125 feet, 34 per cent.; 280 feet, 49 per cent.; 312 feet, 60 per cent.; and under the 110-foot stratum a layer of argillaceous marl containing 23 per cent. of phosphate of lime. (*b*)

An interesting hypothesis has been advanced by Professor Holmes to account for the phosphatic contents of the nodules. He conjectured that enormous quantities of animals had contributed by their decomposition to distribute the phosphate of lime of their bones and accumulated fæces into the nodular conglomerated beds which he assumed to have originally been chiefly carbonate of lime. (*c*) This view has been extended to account for the existence of successive underlying phosphatic layers which are thought to be the result of a "concentration by carbonic acid of the phosphates sparsely distributed through the overlying marls." (*d*) But neither of these hypotheses will explain the absence of fossilized shells from the exquisitely preserved casts in the phosphate rock. Had such a pseudomorphic action occurred, as assumed, it would have filled the casts with phosphate of lime; instead of which the shell casts are invariably empty. (*e*)

Another view, presented by Dr. Pratt, (*b*) would refer the origin of the phosphates to a disintegration of the marl by recent river action and subsequent deposition of the elutriated phosphates in quiet shallows. But the uniform thickness of the phosphate bed and the significant fact that the fossil casts in the nodules are identical with those of the underlying marls, and that they are undoubtedly of Eocene origin, (*g*) proves that the separation of the phosphate from the marl did not take

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(*a*) Letter to Rev. P. N. Lynch, Albany, June 20, 1880.

(*b*) Dr. C. U. Shepard, jr., in *Rural Carolinian*, August, 1873.

(*c*) Phosphate Rocks, Holmes, Charleston, 1870, pages 30, 42, and 46.

(*d*) Dr. C. U. Shepard, jr., in First Annual Report of the Commissioner of Agriculture of South Carolina, 1880, page 92; and also M. Tuomey in his Geology of South Carolina, 1846, page 138.

(*e*) One or two apparent exceptions to this characteristic of the nodules have been detected in the fossil collections of Col. W. H. Trenholm and Cowlam Gravely, esq., the cavities having been filled with a different colored phosphate, evidently of secondary origin.

(*f*) Ashley River Phosphates; History of the Marls of South Carolina and of the Development of the Native Bone Phosphates of Charleston Basin, N. A. Pratt, M. D., Philadelphia, 1868.

(*g*) Geology of South Carolina, M. Tuomey, 1848.

place subsequent to the formation of the marl, but simultaneously with it, as above set forth.

In a paper intended to be of a practical nature the foregoing theoretical considerations may appear out of place, but the following eminently practical deductions can be made from them:

1. The phosphate nodules are only the indurated fragments of the air-dried surface of a once thicker layer whose soft parts have been washed away in the river beds and in conglomerated land deposits.

2. It is not improbable that enormous deposits of rich soft phosphate many feet in thickness and closely resembling the contiguous and continuate marl, would reward a careful geological and chemical investigation (such as has not yet taken place) of all the upper layers of the great Carolinian marl bed, and analogous formations in Virginia, North Carolina, Georgia, and Alabama.

3. There need be no fear of an exhaustion of the supplies of phosphate of lime necessary to agriculture, as the quantities stored for future use in the Eocene marls alone will prove to be simply beyond computation.

Lithological.—Up to the present moment only the indurated parts of the phosphate beds are mined. The softer phosphate in which they are in many places imbedded is entirely ignored, either from not being known to have a value or from being thought too difficult of separation. The hard phosphate is generally found as breccia and conglomerate, although sometimes it appears in almost continuous sheets, as on Ashepoo and Back rivers. The three beds now being exploited are physically very different, and were it not for a certain fetid odor produced on friction (which becomes persistent to the sense of taste after strong inhalation), it would be impossible to find any resemblance between a mineralized rock from the Edisto region and a soft rock from Ashley river. Chemical analysis, and a study of the fossils, however, easily unite them into one and the same group. All phosphatic substances tend to become glazed by long exposure to air, water, and carbonic acid, and the upper portions of the phosphate by their combined action under varying circumstances have assumed a protean character—very hard, very soft, chalky, or flinty; of snowy whiteness to inky blackness, through every shade of color; from pieces of a few grains in weight to irregular masses of a thousand pounds. The usual size is from one to twenty pounds. It is not improbable that the once soft deposit when surface-dried and cracked furnished refuge to myriads of crustaceæ, such as now perforate the marsh muds which border the lowlands of the South Atlantic States, for nearly every nodule is bored in all directions by shallow holes filled with recent clays, sands, and gravels. The easy fracture of the rock along these hollows gives a peculiar jagged appearance to the nodules. At times they are smooth and polished, as if water-worn, a result due to the above-mentioned glazing influences. In some of the thinner beds on the outskirts of the deposit there are, however, evidences of tidal action in the pebbly character of the nodules, and on the Wando river there is a locality where they are flattened and show a ripple mark. These lumpy deposits are fine-grained and dense, and contain few shell prints. With these, and resting on them, are found vast numbers of phosphatized bones of Pliocene and post-Pliocene age, and some of undoubted recent origin. In fact, over 10 per cent. of the phosphates collected here are bones of land animals, indicating conclusively the secondary littoral origin of the hard phosphate rock conglomerate.

The finer soft rock in which the stony portions originally lay is a chalky cream-colored to yellowish substance, easily crushed between the fingers, and when kneaded uniting into a plastic mass and hardening on exposure to the air. Worked under water it separates into a silt of exceeding fineness, or when dried it is easily mashed into a dust as light as the so-called "floats" of commerce—an extremely comminuted powder prepared by air-separation from the ground phosphate rock. (*a*) While the chemical differences of the rocks mined in the three districts are not very great, there is a striking dissimilarity in their physical qualities. This has given rise to a commercial classification into "Coosaw" (Beaufort), "Edisto" (Colleton), and "Ashley" (Charleston) rocks, the first being hard and dark in color; the second of decided mineralized appearance and denser than the others; and the third (which includes the "Stono river" rock) lightest in color and weight, and most easily ground and decomposed in manufacturing processes. The land beds in their original position are found under the following layers:

Soil and clayey sand subsoil	1 to 2 feet.
Siliceous clay	1 to 2 feet.
Blue-marsh mud mixed with clay and occasional oyster shells	1 to 2 feet.
Thin sand or gravel	a few inches.
The nodules in a yellow or blue clay (or both)	1 to 1½ feet.
Soft phosphate mud (in places)	1 to 2 feet.
The marl.	

Sometimes these superincumbent deposits are entirely wanting, the nodules appearing on the surface of the land; or they increase as the rock bed is depressed. Their thickness is an important factor in the profitable mining of the rock, 7 feet of soil being as great a depth as present prices will permit to be removed. In England similar deposits, though not as rich in yield, have been mined at depths of 30 feet with a profit of over $1,000 an acre, even after replacing the top soil and preparing it for agriculture. (*b*)

Chemical and physical.—The composition of the phosphate rock of

a For a description of a somewhat similar deposit in England, consult Ansted's Applications of Geology, London, 1865, page 39.

b *Op. cit.*, page 40, and Journal of Royal Agricultural Society of England, second series, Vol. XI., 1875, Dr. A. Voelcker.

South Carolina, as determined by many hundreds of analyses of cargoes and samples taken from all parts of the bed, is:

	Per cent.
Phosphoric acid	20 to 30
Carbonic acid	2 to 10
Sulphuric acid	½ to 2
Fluoric acid	traces to 1
Lime	30 to 45
Magnesia	1 to 2
Alumina	— to 3
Sesquioxide of iron	traces to 5
Sand and silica	2 to 25
Organic matter	1 to 7
Moisture and water of composition	1 to 3
Ammonia	traces to ½

The average rock shipped contains:

	Per cent.
Phosphate of lime	53 to 60
Carbonate of lime	5 to 10
Moisture	1 to 10

The phosphate of lime is in tribasic form. In its normal condition it is finely divided, which assists its rapid subdivision by the solvents used in the manufacture of superphosphates. This quality (it is claimed by some) renders the powdered rock available in agriculture without further comminution. (*a*) Experiment, however, has not yet demonstrated the fact universally. If it should prove generally true, then the soft phosphate found under the nodules in some portions of the bed will prove of incalculable value to the owners and to agriculture.

The source of the objectionable carbonate of lime, occurring as it does in rock from which all shell remains have disappeared, is obscure. When mechanically mixed, as with adhering oyster shells or marl, it can be easily separated; but not so with that which permeates the mass. The most carefully selected specimen, showing nothing in the shell imprints, nevertheless invariably contains some carbonate of lime. Its presence may be accounted for by inverse infiltration and precipitation from the calcareous waters of the subsoil.

The silica is found in most cases in a finely divided state, partly as sea sand (insoluble), partly infusorial (soluble).

The organic matter is highly nitrogenous, and is analogous to the oils of bituminous shales. On heating it greatly assists combustion.

The fluorine is present in but very small quantity—a fortunate circumstance in manufacturing, as it does not greatly inconvenience the workmen, as is the case where apatite is used. The oxide of iron and alumina are in such small quantity as not to diminish values. The specific gravity of these rocks varies from 2 to 2.5. The hardness is 3 to 4.

Historical.—The first observer who discovered that phosphate of lime

a Report to Agricultural Society of South Carolina, committee on coast lands, R. N. Gourdin, Charleston, 1878; and An Essay on the Application of finely ground Mineral Phosphate as a manure, etc., A. R. Guerard, Charleston, 1879.

existed in considerable quantity (15 to 30 per cent.) in the rocks overlying the marl near Charleston was Dr. St. Julien Ravenel. The first person to determine that the rocks from the Ashley river region contained 55 to 60 per cent. of phosphate of lime, thus rendering them of merchantable value, was Dr. N. A. Pratt, of Georgia, whose attention was called to the phosphatic contents of the nodules by Dr. Ravenel, from whom he obtained the first specimen analyzed. It came from Goose creek, and contained 34 per cent. phosphate of lime. (*a*)

The localization of a large percentage of phosphate of lime in the "marl stones," as the nodules were originally called, was the result (and a striking example) of a gradual evolution of knowledge under the necessities of time and place.

Already in 1826 Lardner Vanuxem had called public attention to the marls of South Carolina by predicting the discovery of "the same kind of marl which has so greatly contributed to enhance the value of the poor lands of New Jersey." (*b*)

Edmond Ruffin, the eminent Virginia agriculturist, made a geological survey of the marls of South Carolina under appointment from the State. He accurately determined the superficial extent of the beds, and gave great numbers of estimations of the amount of carbonate of lime contained in them and for which they were chiefly valued. He described the "marl stones," and called attention to the fact that he found them exposed "on the banks of Ashley river from Brisbane's, nine miles from Charleston, to Bacon's bridge, four feet above high water." He noticed their resemblance in color to the underlying marl. Whenever they occurred in the course of his explorations and digging after the highly prized marl, he conscientiously chronicles their unaccountably small percentage of carbonate of lime (3 to 10 per cent.). This fact permitted the rapid location of the most available phosphate beds when their appointed time had arrived. (*c*)

Professor Holmes, while sinking marl pits at his home, near Brisbane's, was forced to remove the "marl rocks" which impeded his operations. He accurately described their bedding. (*d*) He also called attention to the similarity of the geological formations under London and Charleston. (*e*) It must be remembered that the Cambridge phosphate beds had not yet been discovered. "At that time marl and everything resembling marl was carefully scrutinized and analyzed by Professors

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a Phosphate Rocks of South Carolina, in a Statistical Statement of the Chamber of Commerce of Charleston, E. Willis, 1872; and an interesting unpublished report in their archives, On the Discovery and Development of the Charleston Phosphates, by N. A. Pratt, M. D., August, 1879.

b See his report in Mill's Statistics of South Carolina; also Tuomey's Geology of South Carolina, 1848, appendix, p. xxxi.

c Report of the Commencement and Progress of the Agricultural Survey of South Carolina for 1843, Edmond Ruffin, Columbia, 1843.

d *Southern Agriculturist*, Charleston, June, 1844.

e *Silliman's Journal*, May, 1849, on the Geology of Charleston.

Shepard, J. Lawrence Smith, and Wm. Hume, and some of the results were published." (*a*)

In 1845 Dr. C. U. Shepard, sr., found a marl (from Goose creek) to contain about 15 per cent. of phosphate of lime. (*b*) Professor Tuomey recognized the marl rock as "containing the same fossils as the marl, and that these fragments are only the surface of the marl torn up and then scattered." (*c*)

In 1859 Professor Shepard and Col. L. M. Hatch suggested the utilization of phosphatic marls in the manufacture of commercial fertilizers, and started a factory at or near Charleston, which was, however, soon abandoned. Remains of their compost heap were utilized by neighboring farmers with good effect long after the war.

At the close of the war Dr. N. A. Pratt, formerly connected with the niter bureau of the Confederacy, visited Charleston with the object of starting sulphuric acid chambers. About this time Dr. St. Julien Ravenel, of Charleston, who had mined marl extensively at Stoney's Landing, on Cooper river, for the manufacture of cements, noticed the nodules, analyzed some of them, and found them to contain much phosphate of lime. He became engaged soon after in the manufacture of commercial fertilizers from foreign phosphate rocks. Then followed the discovery (in August, 1867) which has been of such vital importance to agriculture and the prosperity of South Carolina. Pratt and Holmes (Charleston Mining Company), Ravenel and Dukes (Wando Company), then located territory. The value of the deposits became known; other available beds were discovered, and many persons and considerable capital were soon employed in developing the new industry by mining the crude rock and exporting or manufacturing it on the spot into superphosphates. Later on, the beds of many navigable streams were found to be largely paved with the valuable substance. Official attention was called to it, and the whole people of the State were made aware of the enormous extent and richness of the deposit belonging to them. (*d*) A large and growing revenue from royalties has since accrued, which considerably lightens the burden of taxation.

Mining.—Three methods of mining the nodules are employed—

1. Open quarrying and digging in the land.
2. Dredging and grappling with powerful steam machines in deep water.
3. Hand picking and "tonging" in shallow streams or in such deep-water strata as have been loosened by previous dredging, or where the nodules lie free and uncemented together.

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a Phosphate Rocks, Holmes, 1870, page 57.

b Geology of South Carolina, Tuomey, 1848, appendix, p. xxxvi.

c *Op. cit.*, p. 165.

d Message of Gov. R. K. Scott to the legislature of South Carolina, transmitting Report on Phosphates, by Otto A. Moses, February, 1872.—*Engineering and Mining Journal*, 1872.

Land mining.—Where the deposits have been denuded or come directly to the surface, it is easy to collect the nodules and by a slight washing from adhering sand to prepare them for the market. But where the layer runs deeper, a great quantity of superincumbent earth has to be thrown aside, often as much as six feet in depth. If excavation were not then systematically conducted all profit would be soon absorbed by too much handling of the bulky material. Fortunately the level nature of the country (there is scarcely an elevation of more than 30 feet in the whole region) allows the easy laying of tramroads into the midst of the fields or woods where mining is done. In open fields this is a regular and simple matter when all other conditions are favorable; but when the rock lies too deep or not at uniform depths, or is not thick enough, nor rich enough, nor near enough to transportation, the problem becomes more complicated, and great prudence and economy are necessary to leave a margin of profit. Much of the land owned by the companies was purchased at low prices—from $5 to $20 an acre; but some is mined under royalty leases of $1 a ton. It costs about $1 a ton to mine. Pits 6 by 12 feet are dug to the rock, which is then carefully laid aside. The usual price is 25 cents per vertical foot removed. Transportation and washing cost about $1, and all other expenses of handling, drying, storing, etc., $1 more, making the total cost of rock, clean, dry, and ready for shipment, from $3 to $4 a ton (of 2,240 pounds), and selling readily at from $5 to $7 a ton, according to demand and ruling price of freights. This leaves a good margin, with careful management. However, only those companies with abundant capital and sufficient available rock-beds can make any money. Some have been very successful, and their stocks are in demand owing to the ease with which their actual values can be determined. Good lands are such as yield at least 500 tons of cleaned rock per acre. The average now mined gives 700 tons, although some spots have turned out 1,500 tons per acre.

Where all conditions are favorable, as in the vast open fields of the Charleston Mining Company near the Ashley river, the following regular system of mining is adopted: A main trunk line leading from the washers (which may be miles away) is laid, dividing the rock field into equal parts on both sides of it. Alternate laterals curve out and run at right angles to the main track as far as the boundaries of the designated field, but conforming to the intermediate ground. The laterals are 600 feet apart, and the space between any two of them is subdivided by a line ditch parallel to and midway between them. At this ditch two sets of workmen start their lines in opposite directions and at right angles to the laterals. This gives each man a space of 300 feet long and 12 feet wide to excavate. Over this path he wheels his "stratum" in barrows to his portion of a platform running at the side of the road. Here his work is sharply scrutinized by a foreman before it is loaded on the cars for the washer. This material furnishes about one-third in weight of clean washed rock. When mining is carried on in wooded land it is difficult to keep the lines straight. Trees are undercut with mattocks and thrown behind upon the high ground, the rock being picked out from between the roots. Dynamite might here be used with advantage. The only tools employed are spades, shovels, and picks.

In undrained territory or old rice fields where the alluvial character of the soil makes deep ditching impossible, steam pumps are employed. Where their use is difficult, or where the water level is above a quicksand stratum frequently found just upon the rock layer, a struggle ensues between water and workman. The single pit system is then used, each pit being banked against the adjoining one. This method is often employed in marshes which are below the level of tidewater. There is room for improvement in the methods at some mines, where previous thorough drainage would save rock and labor, and allow of operations being carried on in wet and cold weather, a time that tries the patience of mine owners who have to depend on negro labor.

Recently Italians have been brought from New York during the winter, notably at Colonel Yates's works, where several hundred obtain profitable employment during the period when they are unable to find work elsewhere. The negro, however, furnishes most of the labor. He digs about three days in the week, and is not to be depended on for regular work; but, when he fancies, can accomplish a great deal more than a white man in the same time. He is docile, and not given to strikes. The hand can earn from $1 to $2 a day. Irregular habits and distrust prevent his co-operating in working gangs under contract, which would tend to improve his condition. It is a rare thing to find white men in the pits with them, the malarial climate during summer preventing. They have been gradually supplanted by colored labor, except in positions of great responsibility.

Washing.—From the mines the rock is carried to the washers in trains of dumping cars holding about 3½ tons each. The washers are always located near deep streams, if possible, for the sake of easy shipment, and to get an inexhaustible supply of water, and in some cases to allow of the escape of the immense amount of débris carried off in washing. They are raised 20 to 30 feet above the level of the ground. The cars are hauled up inclines about 100 feet long, and the contents are gradually dumped into cylindrical breakers armed with replaceable steel teeth. The rock is crushed into pieces about the size of the fist, and falls into half-circular troughs 25 feet long, resting in framework set at an incline of 18 inches rise in their length. In each trough is an octagonal shaft, also cased with iron, and set with blades distributed along each face in such a way as to form a screw system with a twist of 1 foot in six. These teeth force the rock up hill, while tumbling the fragments about against each other. A heavy stream of water, drawn from the river by steam or centrifugal pumps, pours into the trough and overflows at the higher end near where it enters. On issuing from the water the rock is pushed out upon a screen of ½-inch mesh. The fine rock is further sized on oscillating wire tables.

The washers are generally in pairs, and each can turn out from 40 to 50 tons of clean rock in ten hours. The loss by abrasion and by clay adhering to the rock varies from 50 to 60 per cent.(a) Much of the débris consists of gravel, but a considerable part of the soft phosphate from the stratum and abraded from the rock is sluiced off. This enormous waste could be prevented by settling tanks, and efforts should be made to save this mud, which may be at least as valuable as the rock itself. The solid portion of the dump is flowed upon adjoining marshes, or is allowed to run directly into the river.

Drying.—Nearly all the moisture expelled from the phosphate rock by heating (1 to 15 per cent.) is water absorbed in washing. It is very desirable, for obvious reasons, to get rid of it before shipment. About one-half of the rock mined is air-dried. Drying in the open air, however, is uncertain and unsatisfactory, as even the hottest summer weather, owing to the hygroscopic character of the porous rock, will not evaporate all the water, 1 to 4 per cent. remaining, as the surface only of the pile dries out completely. In fact, the rock heap acts like soil, which always contains abundant moisture a few inches below the surface. The advantages of thorough drying are, however, becoming recognized by both consumer and producer, aud within a short time all rock will be kiln-dried before it leaves the mine works. Burning is sometimes employed, the rock being built up on layers of pine wood, the organic matter of the rock assisting considerably in the combustion. This is a crude method at best; it has some disadvantages, as it sinters the porous mass, and it is more costly than the drying-shed method which is being adopted by all the larger companies. This in its turn will probably be superseded by some continuous, quicker, and more scientific method.

A drying plant consists (generally) of a Sturtevant blower revolving 2,000 times a minute, and drawing air through a wood-burning furnace. The heated products of combustion are carried through a large brick flue 100 feet long, and pass through regulating dampers to any or all of the drying l ins as may be desired by means of curved elbow pipes debouching into the perforated cast-iron sectional pipes through which the heated gases are driven.

The following is the method of arranging a drying bin (as seen at the works of the Charleston Mining Company, Ashley river): A bed of rock 18 inches thick is laid on a solid brick floor intersected at intervals of 10 feet by open drains intended to allow the excess of water collected in washing to flow away before the hot air is applied. Perforated sectional pipe runs from each opening to the branching pipe elbows which are inserted in the flues. Parallel rows of these sectional pipes are laid 2

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a Col. J. A. Yates, in Report of Commissioner of Agriculture of South Carolina, 1880, page 79.

feet apart. There are sixteen lines of pipe in each drying house. The rock is dumped from platforms above directly on the leveled pipe, to a height of 10 feet. The sheds are 100 by 400 feet. They contain each about 1,300 tons of dried rock, which is never handled again until loaded in vessels directly at the wharf, which touches the sheds.

River mining.—Powerful "dipper" dredges are used for mining rock in deep water, notably in Coosaw, Beaufort, Bull, and Port Royal rivers. They differ but little in construction from ordinary harbor dredges. Their lifting capacity is about 100 tons per diem. The rock is picked over to remove marl and oyster shells, and is then cracked and washed in appropriate apparatus.

"Grappler" dredges are preferably employed in Stono river by the Marine and River Company. In this locality the rock is so firmly imbedded as to render the "dipper" dredge of little value. These "grapplers" (Stone's patent), which suggest a resemblance to the talons of a bird of prey, weigh about five tons, and have eight claws closed by elliptic steel springs, each with a tension of 14,000 pounds, but normally, they are closed with 800 pounds' pressure. They surround a central heavy steel drop-chisel for breaking the stratum. There is such an enormous strain on the teeth of this instrument that occasionally they break. Another arrangement with replaceable teeth, intended to avoid this trouble, is now being constructed at the company's works by their efficient engineer, Major Waring, who has also just finished building a "tube" dredge of novel construction, which is now being operated by the same company in Stono river. It consists of an iron tube 18 inches in diameter and 45 feet long, with a jet arrangement for producing an upward current of water in the tube, supplied by two large expanding low pressure pumps. These pumps discharge through four orifices in the inner surface of the tube, and induce an upward current of about 20 feet a second, with a lifting capacity of four pounds to the square inch. The pumps are driven by two 100 horse-power Babcock & Wilcox boilers. This apparatus is said to have an astonishing capacity, and floats up anything which is smaller than the pipe opening, regardless of the specific gravity. Gold coins have been brought up by it from the river bottom.

The Johnson grappler, now operating successfully in the Beaufort district, is similar to the above in general appearance and principle; but instead of elliptical springs, direct acting pulleys are used to draw the scoop-shaped claws together. These "grapplers" have taken up considerably over a hundred tons in a working day.

The "grapplers" are lowered by chains, and it is claimed they could work, if required, in 50 feet of water—an immense advantage over the "dipper," which ceases to be efficient in water over 20 feet deep.

Hand-picking and tonging.—This method of collecting the rock is very simple and requires no great outlay of capital. The rock is grappled with oyster tongs and so-called "grabs," which resemble a series of huge crab claws. Only small rock is gathered, although occasionally hoisting gear is attached to the small flatbottomed boats and scows which are used by fishermen and others in this crude but very efficient way. Formerly many thousands of tons of rock per annum were thus raised, but since the organization of the dredging companies this industry has been much interfered with, and not having received any encouragement from the State, has dwindled into insignificance. But it is beyond doubt advisable to cull the mining grounds gone over by the dredges, which loosen more rock than they take up, and grapple more than they can hold.

Statistical.—Although there are at least 500,000 acres of the lowlands and streams of South Carolina underlaid by the phosphate beds, there are not more than 20,000 which it will pay to mine at present prices. This will give employment, however, for many years to come to the thousands of laborers engaged by the twenty-odd mining companies now at work.

The price of phosphate rock changes but little, the demand being comparatively constant, as is the supply of labor. With the exception of a sudden rise to $9 a ton a couple of years ago, there has been a uniform price of about $6 for clean-washed phosphates. This, of course, varies with freights, most of the rock being exported. As the prices abroad fluctuate but little, there is a comparative regularity in the output, which gives great stability to the trade. There is a growing demand in all directions, caused by the impoverishment of land and the increase of knowledge; so that there is no present probability of an interruption to the further development of this industry. In fact, it is apparent that South Carolina will henceforth take the place of Peru and the Pacific and Caribbean islands in the exportation of the phosphatic basis of commercial manures.

The rock is generally sold on a simple guarantee that it shall contain not less than 55 per cent. of the bone phosphate of lime ($3CaO, PO_5$), and irrespective of carbonate of lime or moisture. This rather loose method causes a uniformity of product, but does not encourage the miner to select his rock with a view to obtaining the highest yield of soluble phosphates of lime with given quantities of solvents—an object to be considered in the manufacture of fertilizers.

Since the discovery of the value of the phosphate rock bed of South Carolina, in 1867, to the present time, about 2,250,000 tons have been mined by land and river companies in about equal proportions.

The following tables, compiled from the annual estimates in E. Willis's valuable trade circulars and E. L. Roche's statements to the Commissioner of Agriculture, are to be relied on strictly as far as river mining is concerned (being obtained from official data); and approximatively with regard to the output of the land companies. (*a*)

a Thanks are hereby tendered to Major Willis for the privilege extended of examining his unique collection of pamphlets on South Carolina affairs, which contains everything of interest referring to the phosphate trade.

Phosphate rock (washed product) mined by the land and river mining companies of South Carolina.

[By fiscal years ending May 31.]

Years.	Land companies.	River companies.	Total.
	Gross tons.	*Gross tons.*	*Gross tons.*
1868	6	....	6
1869	12, 262	....	12, 262
1870	31, 958	....	31, 958
1871	63, 252	1, 989	65, 241
1872	56, 533	17, 655	74, 188
1873	36, 258	22, 502	58, 760
1874	33, 426	45, 777	79, 203
1875	51, 624	57, 716	109, 340
1876	54, 821	67, 969	122, 790
1877	50, 566	81, 912	132, 478
1878	36, 431	126, 569	163, 000
1879	112, 622	97, 700	210, 322
1880	100, 779	98, 586	199, 365
1881	125, 601	65, 162	190, 763
1882	142, 193	124, 541	266, 734
1883	191, 305	140, 772	332, 077

Detailed statement of total foreign, coastwise, and home shipments since June 1, 1874.

	Beaufort.	Charleston.	Other points.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
From June 1, 1874, to May 31, 1875:				
Foreign ports	44, 617	25, 929	....	70, 546
Domestic ports	7, 000	25, 560	....	32, 560
Consumed	....	19, 684	....	19, 684
Total	51, 617	71, 173	....	122, 790
From June 1, 1875, to May 31, 1876:				
Foreign ports	50, 384	25, 431	....	75, 815
Domestic ports	9, 400	28, 831	....	38, 231
Consumed	....	18, 850	....	18, 850
Total	59, 784	72, 842	....	132, 626
From June 1, 1876, to May 31, 1877:				
Foreign ports	73, 923	28, 844	....	102, 767
Domestic ports	6, 285	40, 768	....	47, 053
Consumed	....	13, 400	....	13, 400
Total	80, 208	83, 012	....	163, 220
From June 1, 1877, to May 31, 1878:				
Foreign ports	100, 619	21, 123	....	121, 742
Domestic ports	8, 217	60, 729	....	68, 946
Consumed	....	17, 635	....	17, 635
Total	108, 836	101, 487	....	210, 323
From June 1, 1878, to May 31, 1879:				
Foreign ports	97, 799	21, 767	....	119, 566
Domestic ports	8, 618	52, 281	....	60, 899
Consumed	....	18, 900	....	18, 900
Total	106, 417	92, 948	....	199, 365
From June 1, 1879, to May 31, 1880:				
Foreign ports	47, 157	14, 218	....	61, 375
Domestic ports	13, 346	94, 002	....	107, 348
Consumed	....	22, 040	....	22, 040
Total	60, 503	130, 260	....	190, 763

Detailed statement of total foreign, coastwise, and home shipments, etc.—Continued.

	Beaufort.	Charleston.	Other points.	Total.
	Tons.	*Tons.*	*Tons.*	*Tons.*
From June 1, 1880, to May 31, 1881:				
Foreign ports	62, 200	8, 568		70, 768
Domestic ports	65, 895	91, 929		157, 824
Consumed		38, 142		38, 142
Total	128, 095	138, 639		266, 734
From June 1, 1881, to May 31, 1882:				
Foreign ports	89, 581	22, 905		112, 486
Domestic ports	57, 465	111, 314	7, 875	176, 654
Consumed		42, 937		42, 937
Total	147, 046	177, 156	7, 875	332, 077
From June 1, 1882, to May 31, 1883:				
Foreign ports	94, 789	28, 251		123, 040
Domestic ports	36, 175	150, 545	26, 000	212, 720
Consumed		42, 620		42, 620
Total	130, 964	221, 416	26, 000	378, 380

The following companies and individuals are at present engaged in mining, with an aggregate capital of over $2,000,000:

List of phosphate mining companies of South Carolina.

River companies:	
Coosaw Company	Coosaw river.
Marine and River Company	Stono river.
Oak Point Mining Company	Bull river.
W. T. Seward	Beaufort.
Campbell & Wilson	Beaufort.
South Carolina Phosphate Company, limited	Beaufort.
Farmers' Company	Coosaw river.
Palmetto Company	Wando river.
J. B. & J. Seabrook.	
Land companies:	
Charleston Mining and Manufacturing Company	Ashley river.
C. C. Pinkney	Ashley river.
William Gregg	Ashley river.
Saint Andrew's Mining Company	Stono river.
D. Roberts	Stono river.
A. B. Rose	Ashley river.
Pacific Company	Bull river.
W. L. Bradley	Rantowle's creek.
Wando Company	Ashley river.
G. A. Trenholm & Son	Ashley river.
J. F. Fishburne	Ashley river.
F. C. Fishburne	Edisto river.
L. N. Chisolm	Ashley river.
Kiawah Phosphate Compauy	Cooper river.
Harleston & Cheves	Ashepoo river.

Manufacturing.—The manufacture of phosphates in South Carolina has been developed on an enormous scale, over $3,500,000 of capital being invested by twenty-one companies, which have a capacity of 250,000 tons per annum. Ashley and Cooper rivers, in the neighborhood of Charleston, are lined with the finest and most extensive collection of fertilizer factories in the world. Others of equal importance are being erected in the Beaufort district. Most economically arranged, and located in the heart of the phosphate region, on deep water and on railroads, they have such natural advantages of position as will give them control of the phosphate trade of the South and Southwest, and perhaps, in time, of the whole country. (*a*)

It is beyond the scope of the present article to include a detailed account of the manufacturing interest. It must suffice to give the names of the companies engaged in producing superphosphates and other fertilizers, with the capital employed, and a table of the number of tons of commercial fertilizers shipped during each year since 1871:

List of manufacturers of superphosphates and fertilizers in South Carolina.

Name.	Capital.	Location.
Wando Company	$300,000	Ashley river.
Atlantic Company	200,000	Ashley river.
Stono Company	160,000	Ashley river.
Pacific Company	1,000,000	Ashley river.
Etiwan Company	350,000	Cooper river.
Ashepoo Company	150,000	Ashley river.
Ashley Company	100,000	Charleston.
Edisto Company	250,000	Cooper river.
C. C. Pinckney Company	100,000	Ashley river.
H. Bulwinkle Company	....	Ashley river.
Charleston Phosphate Company	50,000	Ashley river.
Ebaugh's Marl Works	....	
Wilcox, Gibbes & Co	....	Charleston.
Woodstock Lime Company	100,000	Woodstock, South Carolina railroad.
Ashley River Lime Works	75,000	Ashley river.
Stoney Landing Company	....	Stoney's Landing.
Medway Company	100,000	Ashley river.
Sea Island Chemical Company	200,000	Beaufort.
Walton, Whann & Co	100,000	Beaufort.
Port Royal Fertilizing Company	200,000	Beaufort.
Mr. Hume's Works (now being built)	....	Beaufort.

Statement of manufactured fertilizers shipped from Charleston since 1871.

[Fiscal years ending May 31.]

	Tons.
1871	22,589
1872	37,759
1873	56,298

(*a*) The phosphate milling industry of Charleston owes much to the active labors in all departments of Mr. D. C. Ebaugh, who constructed the first fer ilizer works in Charleston in 1867 and many others subsequently. Messrs. Brotherhood and Dotterer have also erected fine works. Some of the recent innovations which promise to cheapen the cost of South Carolina fertilizers are the gradual introduction of the Glover tower and the burning of pyrites (Hume's new works at Beaufort) in sulphuric acid manufacture, and the use of Duc's attrition mill in the production of fine "floats," and the Lucop & Cook centrifugal roller mill in ordinary grinding.

	Tons.
1874	46,382
1875	50,837
1876	46,443
1877	45,756
1878	52,000
1879	60,000
1880	80,000
1881	102,525
1882	102,490
1883, to June 1	130,000

Grateful acknowledgements are due to the representatives of the phosphate mining and manufacturing industries of South Carolina for numerous courtesies.

APATITE.

By F. A. Wilber.

This mineral is found in small quantities at numerous localities in the United States. It commonly occurs with metamorphic crystalline rocks and in connection with metalliferous veins, but is sometimes found in the rocks of the later geologic periods, and occasionally occurs massive. The only known localities in this country at which massive apatite can be said to occur in even moderate quantity are the following: At Bolton, Massachusetts; at Crown Point, Essex county, New York (the deposit here is said to be extensive and the mineral was formerly mined for agricultural uses); at Hurdtown, Sussex county, New Jersey (mining was carried on here also some years since, but it is now abandoned). At several iron mines in New York and New Jersey apatite occurs in large amounts, but it is so mingled with the iron ore as to be useless, in the natural state, for agricultural purposes.

Most of the occurrences yet known are unimportant from an economic point of view, and the small amount used in the United States is imported from the Canadian deposits. These lie in the provinces of Ontario and Quebec, and are said to be extensive. The larger part of their product, which amounted in 1882 to over 17,000 tons, is shipped to Europe; but it is estimated in the report of the New Jersey State Agricultural Experiment Station for 1882 that about 5,000 tons were brought to the United States during that year, where it was used by the manufacturers of commercial fertilizers as a constituent in their products.

Apatite is used in the arts as a source of phosphoric acid and phosphorus, and its value to the manufacturers of fertilizers depends upon the amount of phosphate of lime which it contains. Since the discovery of the deposits of phosphatic marls in South Carolina the demand for it has decreased, and these latter deposits now furnish the supply of phosphates in the market.

MARLS.

By F. A. Wilber.

Occurrences.—The marls of the United States are found in the Cretaceous, Tertiary, and Recent geologic formations. In the Cretaceous formations we find greensand or glauconite and calcareous (marine) marls. In the Tertiary age occur greensand, calcareous (marine), phosphatic, and argillaceous marls; while only calcareous (freshwater) marls appear in the Recent age.

Marls of the Cretaceous and Tertiary formations occur in great deposits in nearly all the Atlantic seaboard and Gulf States. Their most northerly appearance is in New Jersey, where greensand marl of the Cretaceous occurs in a belt which crosses the State from the ocean and Raritan bay to the Delaware river in a northeasterly and southwesterly course. Its length from the Navesink Highlands to Salem, in Salem county, is about 90 miles; and its breadth is ten miles at the northeast, in Monmouth county, decreasing to six miles in Salem county. In 1881 the total shipments by the eight marl transporting and selling companies aggregated 73,900 net tons. The statistics for 1882 have not been reported. Assuming a slight increase, as was probably the case, the estimate for 1882 may be placed in round numbers at 80,000 net tons, or equivalent to 1,600,000 bushels. The total amount hauled by teams for application to lands in the vicinity of the pits can be roughly estimated at 1,000,000 net tons. All of this is greensand marl. The value per ton, at the pits, would average about 50 cents. This estimate is little in excess of that made in 1868, since which time the area of tillable land has increased slightly, perhaps 10 per cent. Many farmers in New Jersey use from 1,000 to 5,000 tons each every season. On the other hand, the wider use of commercial fertilizers has diminished the use of greensand marl outside of the territory in which it occurs. Analyses of greensand marls are given in the tables which follow. In the southern part of New Jersey calcareous marls of Miocene age are found in Cumberland county, and have a local use confined to a belt of country a few miles in area.

In Delaware, greensand and calcareous marls are found in Newcastle county. They are not carried to any considerable distance from the pits or banks—in fact, are not an exchange product—but are used here and there occasionally by farmers who may chance to have the marl upon their own lands.

In Maryland, marls of the same formations occur, the localities of occurrence being numerous. Greensand (Cretaceous) marls appear in a belt crossing from Delaware into Kent, Cecil, and Prince George's counties, and on the "eastern shore" the more recent and calcareous shell marls (Tertiary) are found. Neither variety has any extended use, beyond the local consumption in the immediate vicinity of the pits.

Marls, mainly of the Tertiary, abound in Virginia. The greensand variety in the Eocene or Lower Tertiary occurs in the coast region, mostly in a narrow belt (averaging 16 miles in width), crossing the State from north to south, near the head of tidewater. Outcrops are common along the numerous rivers which here reach tidal waters. Calcareous marls, belonging to the Miocene or Middle Tertiary, are more widely distributed in the whole breadth of the tidewater region east of the greensand belt.

The marl belt crosses into North Carolina, and its beds crop out at intervals quite to the South Carolina border. They are best seen along the eastward-flowing rivers and near the tide limit. Beds belonging to both formations occur, but they are mainly found in the Tertiary. Greensand (Cretaceous) occurs in the southeastern part of the State, between the Neuse and Cape Fear rivers. Cretaceous marls (of the Eocene age) overlie the former beds and are found in the same region. Calcareous marls (of the Miocene age) occur throughout the eastern counties of the State in scattered beds. Professor Kerr says of the use of marl in North Carolina: "There never has been any traffic in it. Every man digs what he wants, and it is spread much more widely than it is used. In fact, its use has not been general outside of a few counties—Edgecombe, Pitt, Greene, Wilson, and a few portions of other counties." Analyses of the calcareous marls of this State are given in the tables at the close of this paper.

In South Carolina the marls common to the Atlantic Tertiary and Cretaceous are recognized at many localities in the eastern portion of the State. But the great development of the phosphate deposits has so overshadowed the use of these more calcareous (or carbonate of lime) marls that very little information about their extent or use is accessible.

Hon. J. Henderson, of the department of agriculture of Georgia, replies to an inquiry concerning the marls of that State: "The marl beds of Georgia have been so little developed that the business has not arisen to the dignity of statistics. The practice of digging marl for local use and shipment for sale is hardly known in Georgia." According to the report of Dr. George Little, late State geologist, marl is found in all the central and southern counties.

In Florida we find calcareous marls, probably of the Tertiary formation, at Fort Brooke, near the head of Tampa bay, Manatee county. Phosphatic marls are said to occur in Clay, Alachua, Wakulla, Duval, and Gadsden counties.

Of Alabama, Prof. Eugene A. Smith, State geologist, reports: "Greensand shell marls (Cretaceous) occur in the lower beds of this formation at Pleasant Ridge, Green county, etc.; also in rotten limestone at Epes Station, Sumter county. Of Tertiary marls, several shell beds of the Lower Eocene formation in Choctaw, Marengo, Clarke, Wilcox, Monroe, Butler, Conecuh, Crenshaw, Pike, and Coffee counties contain notable quantities of greensand. The calcareous rocks of the Cretaceous and

Tertiary are often loose aggregations of shells, which serve as marls and are used as such in some localities."

In Mississippi, greensand of the Cretaceous age occurs in Tippah, Pontotoc, and Chickasaw counties, and Tertiary greensand in Carroll and Attala counties. Calcareous marls are found in a belt stretching eastward from Vicksburg to the Alabama line. They belong to the Jackson, Vicksburg, and (calcareous) Claiborne groups of the Tertiary. In the southern Lignite, or Grand Gulf group of the Tertiary, calcareous marls are reported from many localities. Gypseous marls, used to a very limited extent where they occur, are found in southern Carroll, Attala, Leake, Holmes, northern Madison, Hinds, Rankin, and Scott counties. Like its neighbor State Alabama, it is well provided with these natural fertilizers. No figures of amounts used have been received.

In Louisiana, greensand marl occurs in Grant and Natchitoches parishes, and calcareous marl on Sicily island. No other localities are mentioned.

In Arkansas, calcareous marl is found in Greene, Hempstead, Clark, Pike, Jefferson, and Saint Francis counties, and gypseous marl in Pike and Bacon counties. No mention is made of the use of any of these deposits, which in this State, as well as in Louisiana, probably belong to the Tertiary.

Calcareous marls are found in Texas in Tom Green, Concho, and Brazos counties, and undoubtedly occur elsewhere in the State.

Greensand marl is found in Tennessee, in the western part of the State, in McNairy and Hardin counties, and in the Cumberland valley.

Recent marls are found, usually in small deposits, in a number of the States of the Eastern division. They are all calcareous, freshwater shell marls. In the northern part of Maine and in New Hampshire localities are noticed; and others are found in Vermont, in the region adjoining Lake Champlain. In New York enormous deposits occur, chiefly in the central portion of the State, in what are known as the Montezuma marshes, and along the valley of the Hudson. These beds have only a local and limited use. In northern New Jersey beds occur in Sussex and Warren counties. Analyses of the marl of these beds are given. In Ohio these marls are found in the lakes and marshes of Summit, Lorain, Logan, Fulton, and other counties in the northern portion of the State. The deposits are extensive, but have only a local use. Small deposits occur in northern Indiana, and mention is made of some in Cook county, Illinois. In Nebraska beds occur in the western part along the Republican river and south of Culberson on the Niobrara; also on the Loup river.

Utilization.—Marl requires no preparation to fit it for use as a top dressing for the soil. It is hauled directly from the pit and spread upon the land. As a fertilizer its action is both mechanical and chemical. Being granular, it improves the texture of stiff soils by loosening them, thus rendering them pervious to the air and moisture. It furnishes the inorganic elements of materials for plant food. The most important of these elements are phosphoric acid and potash, the other constituents having only a small fertilizing value. Calcareous marl is frequently used as a substitute for limestone in the production of lime.

Composition.—The following tables of analyses are inserted to show the general character of the different varieties. The greensand marls of New Jersey are typical ones, while the calcareous (marine) marls of North Carolina may be taken to represent that variety. The marls of recent freshwater shell formation would generally class with those given in the table of Recent marls.

Analyses of greensand marls from New Jersey. (*a*)

No. of analysis.	Phosphoric acid.	Sulphuric acid.	Silicic acid and sand.	Carbonic acid.	Potash.	Lime.	Magnesia.	Alumina.	Oxide of iron.	Water.	Total.
1	1.14	0.14	38.70	6.13	3.65	9.07	1.50	10.20	18.63	10.00	99.16
2	1.33	0.00	46.03	......	5.67	2.01	3.47	7.86	25.23	8.40	100.00
3	1.02	0.27	50.23	......	6.32	1.40	3.45	7.94	20.14	9.00	99.77
4	2.24	0.39	50.80	......	5.18	2.13	3.54	8.77	17.63	9.66	100.34
5	2.69	0.26	49.40	......	6.31	2.52	3.24	8.90	17.11	9.10	99.53
6	2.56	0.22	51.50	......	4.62	1.26	3.95	6.01	21.04	7.39	98.55
7	3.58	0.97	53.15	......	3.75	3.27	1.75	8.79	15.94	8.98	100.18
8	3.87	0.31	54.75	......	4.11	5.46	2.99	6.46	15.20	6.85	100.00
9	2.58	1.89	59.80	......	4.25	2.97	2.00	6.00	11.98	8.32	99.79
10	2.30	0.00	57.67	......	3.53	1.26	3.67	10.10	14.16	7.25	99.94

Nos. 1, 2, 7, 8, and 9 are marls from Monmouth county, New Jersey.
Nos. 3 and 10 are marls from Burlington county, New Jersey.
No. 4 is marl from Camden county, New Jersey,
No. 5 is marl from Gloucester county, New Jersey.
No. 6 is marl from Salem county, New Jersey.

a From Annual Report of the State Geologist for the year 1878.

Analyses of calcareous (marine) marls from North Carolina. (*a*)

No. of analysis.	Phosphoric acid.	Sulphuric acid.	Silica.	Carbonic acid.	Potash.	Soda.	Lime.	Magnesia.	Oxides of iron and alumina.	Water and organic matter.	Total.
1	0.35	0.49	3.54	40.61	1.28	0.36	51.74	0.50	0.97	0.16	100.00
2	Trace	0.18	4.95	40.29	0.85	0.00	50.59	0.58	2.30	0.26	100.00
2	0.34	0.08	1.22	42.33	0.25	0.05	52.90	1.07	1.30	0.46	100.00
4	0.10	0.20	7.27	39.35	1.06	0.00	48.55	1.39	1.63	0.45	100.00
5	0.39	0.24	20.39	32.46	0.79	......	39.96	1.42	3.83	0.22	100.00
6	0.44	0.75	40.11	20.96	1.34	0.46	27.73	Trace	5.23	2.98	100.00

a From Geology of North Carolina, Vol. I., 1875.

Analyses of Recent calcareous marls from Warren and Sussex counties, New Jersey. (*a*)

No. of analysis.	Carbonate of lime.	Carbonate of magnesia.	Sand and clay.	Water, vegetable matter, etc.	Total.	Description.
1	98.93	....	0.90	0.67	100.50	White, pulverulent, no vegetable matter.
2	88.86	....	9.96	2.16	100.98	Precipitate from water, white.
3	97.73	....	0.60	1.59	99.92	White, dense, and fine.
4	95.34	2.18	0.98	1.50	100.00	Surface marl, white, solid, and fine.
5	96.32	1.57	1.16	0.96	100.01	Drab white, fine and with shells.
6	92.25	2.98	1.56	3.21	100.00	White, pure; some grass roots.
7	87.87	2.29	0.97	6.87	98.00	Ash-colored, many shells; light.
8	96.54	1.47	2.05	0.00	100.06	White, very fine, medium density.
9	84.52	1.76	8.46	5.26	100.00	Surface marl.
10	90.18	0.00	9.75	....	99.93	White, very dense, thick shells.
11	99.04	0.00	0.55	0.41	100.00	White, very light, pure.
12	68.73	0.00	23.99	7.28	100.00	Dark colored shells and vegetable matter.
13	94.75	0.00	0.71	4.54	100.00	White, very light, pure.
14	64.20	0.00	16.21	16.59	97.00	White shells and clay.

a From Annual Report of the State Geologist for 1877.

GYPSUM.

Eastern division.—This mineral occurs in large deposits in the following States of the Eastern division:

In New York there are beds of great thickness and extent in the central part of the State, in a line of counties extending westward from Oneida to Niagara. It is found here in what is known as the Salina formation. Plaster for agricultural use is manufactured at several localities in these counties.

Virginia has a noted deposit in Smyth and Washington counties, in the valley of the north fork of the Holston river. The gypsum is found here with a rock-salt deposit. The amount manufactured is at present comparatively small, about 6,300 net tons yearly, and it is chiefly used for local agricultural purposes.

Alabama is said to possess a large bed near Scotsborough, Jackson county.

Louisiana has no developed localities, but in borings made for oil 13 miles from Lake Charles, in Calcasieu parish, a bed 148 feet thick was discovered.

In Texas the gypseous formation is reported to extend for hundreds of miles along the headwaters of the Red river. Gypsum also occurs in quantity between Fort Quitman and Hot Springs on the Rio Grande, in the eastern part of El Paso county and the western part of Presidio county. These localities are unworked, but the occurrences will undoubtedly prove of the greatest importance in the future development of the State.

Arkansas has large deposits at Royston's Bluff on the Little Missouri river.

There are thick beds of gypsum on the Des Moines river in Webster county, Iowa. Gypsum is mined in this State for agricultural use and also for making plaster-of-paris.

Kansas contains a large amount of this mineral. It is found in Saline and Dickinson counties, in the central part of the State, and in Marshall county, in the northern part.

Ohio contains extensive beds. At Plaster Bed peninsula, Put-in-bay, Lake Erie, is a noted deposit; another bed is on West Sister's island. The gypsum is found in this region associated with the rocks of the Water-lime group. Plaster-of-paris is manufactured largely at Sandusky from this gypsum.

Michigan has very valuable deposits. Those of the western part of the State are situated on the Grand river, near Grand Rapids. In the eastern part the beds are found at Alabaster Point, Iosco county. Extensive beds underlie Bay City and Kawkawlin, Bay county, where their presence has been shown in borings for salt. The beds of this State belong to the Upper sub-Carboniferous formation. The following tables, taken from the "Mineral Statistics of Michigan for the year 1881" (the figures for 1882 being kindly furnished by Mr. C. E. Wright in advance of the publication of the report for 1882), give a very complete statement of the production in this State:

Amount of land plaster and of calcined plaster produced in Michigan.

Years.	Land plaster. Net tons.	Stucco. Barrels of 300 pounds.
Land plaster previous to 1866	100,000	
1866	14,604	
1867	17,439	
Stucco previous to 1868		(*a*)80,000
1868	28,837	34,966
1869	29,996	41,187
1870	31,437	46,179
1871	41,126	48,685
1872	43,536	59,767
1873	44,972	82,453
1874	39,126	82,449
1875	27,019	61,120
1876	(*a*)39,131	64,386
1877	(*a*)40,000	(*a*)55,000
1878	40,000	48,346
1879	43,658	50,800
1880	49,570	106,004
1881	33,178	112,813
1882	37,821	135,655
Total	701,450	1,109,810

a Partly estimated.

Amount of land plaster and calcined plaster produced by the several plaster companies in Michigan during the years stated.

	Land plaster—net tons.				Stucco—barrels of 300 pounds.		
	1879.	1880.	1881.	1882.	1880.	1881.	1882.
Godfrey & Bro (*a*)	9, 117	9, 000	6, 422	6, 080	23, 000	27, 500	30, 274
Grand Rapids Plaster Company (*a*)	8, 970	12, 000	6, 375	7, 512	23, 500	20, 400	32, 854
Geo. H. White & Co (*a*)	1, 900						
Wyoming Mills Company (*b*)	7, 000	10, 000	6, 093	6, 901			9, 643
Union Mills Company (*b*)	4, 500	7, 500	6, 716	8, 298	35, 000	34, 913	23, 074
Taylor & McRingolds (*b*)	10, 585	9, 570	6, 572	6, 037	24, 504	30, 000	27, 993
Smith, Bullard & Co (*c*)	1, 586	1, 500	1, 000	2, 993			11. 817
Total	43, 658	49, 570	33, 178	37, 821	106, 004	112, 813	135, 655

a Quarry, etc., at Grand Rapids. *b* Quarry, etc., at Grandville. *c* Quarry at Alabaster.

The price of land plaster is fixed by the companies above mentioned at $3 per ton at Grand Rapids, and that of stucco at $1.50 per barrel at the same point.

In addition to the stucco and land plaster produced in Michigan, Iowa, and Ohio, it is estimated by Mr. C. W. Sweet, editor of the *Real Estate Record*, of New York city, that in 1882 525,000 barrels (of 250 pounds each) of plaster-of-paris were made on the Atlantic seaboard from imported Nova Scotia stone. The value of this stucco was $1.20 per barrel. Although the State of New York has such large deposits it is still a fact that along the Atlantic tidewater the Nova Scotia stone supplies the market.

Rocky Mountain division.—Gypsum in large beds and of great purity occurs frequently throughout Montana, in the Black Hills of Dakota, and throughout Colorado and New Mexico. In Montana and in the Black Hills none has yet been mined, for lack of any demand whatever for plaster-of-paris. In Colorado heavy deposits of gypsum have been found in the South and Middle Parks, and along the base of the mountains, east and west. It is found along the line of the Great Hogback on the east of the Rocky mountains, and in economically available beds at Morrison, Jefferson county, and at Colorado City, El Paso county. The first mill for the manufacture of gypsum into plaster-of-paris was built by Mr. George Morrison, at Morrison, prior to 1875. In 1875 his property passed into the hands of the Denver Railway and Enterprise Company, who removed the standing mill and built another, which was designed and erected in such a poor manner that no marketable plaster has since been produced, and the mill now stands idle. In 1875, the Colorado Springs Plaster-of-paris Company erected at Colorado City, at an expense of $16,000, works with a capacity of 15,000 pounds daily, which is about three times the present demand in Colorado. Until 1879, practically no plaster was made. The product of the mill since 1878 by years has been as follows:

Plaster-of-paris made by the Colorado Springs mill, Colorado.

Years.	Sacks of 100 pounds.	Pounds.
1879	3,000	300,000
1880	8,100	810,000
1881	9,600	960,000
1882	10,350	1,035,000
Total for four years	31,050	3,105,000

This is less than the mill is capable of producing in one year. In the six months ending June 30, 1883, its production was 7,000 sacks, or 700,000 pounds net. The market for New Mexico, Wyoming, and Colorado is supplied by these works. The average price charged for the plaster at the mill is 85 cents per sack, and the amount manufactured in excess of the demand is estimated to be worth less than 10 cents per hundred pounds. The company are also prepared to supply any demand for land plaster which may arise.

In New Mexico, extensive beds of gypsum are of frequent occurrence. Rio Arriba, Bernalillo, Socorro, Grant, and Valencia counties contain large deposits of gypsum, which the lack of a market renders practically valueless. In the Sandia mountains, at the towns of Téjon and Una de Gato, quite a business is carried on by the native Mexicans, who make plaster and sell it at Santa Fé and along the upper Rio Grande at $1 per bushel. At Socorro, extensive beds occur on the western slope of the Socorro mountains, where it is mined in quantities by the Mexicans, by whom it is called "hasped" or "yeso," and is used as window lights, and as plaster in whitewashing the interior of their adobe dwellings.

Pacific coast.—Gypsum has been discovered at many points in California, Nevada, and Arizona. The heaviest deposits of this mineral yet found in California are in Los Angeles county, where it occurs in beds scattered along the foothills from Caliente to Long Tom, a distance of 20 miles or more. The deposits here seem to be abundant and of good quality. Small bodies of gypsum have been found at many points in the Coast range to the north of San Francisco, and in various other parts of the State. A deposit of the variety known as selenite occurs near Stockton, and within a few miles of the San Joaquin river. Heavy beds of gypsum exist in Nevada. This mineral is also abundant in many parts of Arizona. The gypsum-bearing localities of that Territory, as observed and remarked upon by Mr. C. P. Stanton, are the following: In the Carboniferous formations of Yavapai county, deposited in thin horizontal sheets; east of the Rio Verde, about 30 miles north of Camp McDowell; in the pine country, east of the Verde settlements; on the south side of the Gila river, 25 miles west from San Carlos, Pinal county, abundant and white as snow; in the Chiricahua mountains, southwest from Cabesa peak and nearly due south of the Apache pass; on the headwaters of the San Pedro, near to, if not over, the Mexican line; on the plains of Yuma county, about 35 miles southeast from the Vulture mine; in Mohave county, 18 miles southwest of the Santa Maria placers, a fine body of snowy gypsum. Prospectors report deposits of the mineral at many other points in Arizona. About ten years ago the manufacture of plaster from gypsum was begun at the Golden Gate mills in San Francisco, where the business has been continued, growing steadily ever since. The plaster sells in San Francisco at the following rates per barrel: hard, for finishing and general use, \$2.75; for casting ornaments, molds, etc., \$3; superfine, for sculptor's use, \$3.50; these being about 20 per cent. less than the prices paid for the imported article. Common plaster, now beginning to be ground extensively in California for use as a fertilizer, sells at the rate of about \$12.50 per ton.

Imports.—Notwithstanding the fact that the crude material is so abundant in California and regions adjacent, most of the gypsum ground into plaster there is imported from abroad. The importations at the port of San Francisco during the past nine years have been as follows:

Imports of plaster-of-paris at San Francisco.

	Barrels and casks.
1874	19,176
1875	22,782
1876	14,918
1877	14,487
1878	11,030
1879	5,408
1880	3,200
1881	3,285
1882	4,777

The diminished importations at San Francisco since 1878, as shown by the above table, are due to the considerable product made by the mills in California.

The following table gives the quantities and declared values of the total imports of unground gypsum imported into the United States during recent years:

Gypsum or plaster-of-paris, unground, imported into the United States during the fiscal years specified (specie values).

[Free of duty.]

Years.	Quantity.	Value.
	Tons.	
1872	106,459	\$99,205
1873	120,446	121,451
1874	123,172	130,192
1875	99,886	115,664
1876	116,125	126,587
1877	99,263	105,635
1878	107,947	106,703
1879	100,619	98,796
1880	120,615	120,736
1881	131,167	123,403
1882	128,421	127,060
Calendar year 1882	151,353	152,653

Uses.—The principal use to which gypsum is devoted is an agricultural one. The ground rock, or land plaster, is applied as a top-dressing to the soil; and although it does not enter directly to any extent into the composition of plants, it has still an extremely beneficial action upon plant life and growth, from the chemical changes which it induces in the soil. Stucco, plaster-of-paris, or calcined gypsum, is used for making cornices, friezes, and other forms of interior decoration, and its use in making walls themselves is rapidly increasing. A fine grade is used in taking casts of natural objects, making models, etc.

COMMERCIAL FERTILIZERS.

These embrace a wide range of mineral and organic substances. It is difficult to estimate, even approximately, the value of crude mineral thus consumed. The total annual product is about 700,000 tons, worth nearly $20,000,000. Maryland takes the lead in manufacturing; but much of the crude material there worked up is derived from other States. Other leading centers of manufacture are New Jersey, New York, Massachusetts, South Carolina, and Pennsylvania. The following table shows the product during the census year 1880:

Production of artificial fertilizers during the census year 1880.

States.	Quantity.	Value.
	Tons.	
California	1,000	$20,000
Connecticut	7,475	248,050
Delaware	37,917	998,165
District of Columbia	6,300	199,000
Georgia	11,287	341,500
Illinois	27,015	633,990
Indiana	1,574	44,877
Iowa	960	13,000
Kentucky	1,665	42,000
Louisiana	1,823	68,106
Maine	5,850	175,000
Maryland	191,571	5,457,258
Massachusetts	69,387	1,920,623
Michigan	900	27,000
Minnesota	600	12,000
Missouri	5,905	146,932
Nebraska	470	4,700
New Jersey	80,859	2,290,202
New York	88,336	2,636,159
North Carolina	12,000	300,000
Ohio	13,365	377,025
Pennsylvania	53,507	1,432,345
Rhode Island	11,979	156,427
South Carolina	64,794	1,537,230
Tennessee	314	12,670
Virginia	28,921	791,341
West Virginia	629	16,300
Wisconsin	1,050	19,500
Total	727,453	19,921,400

SALT.

Sources.—The localities where salt is produced, from one source or another, are widely diffused over the United States. It is made largely in Michigan, New York, West Virginia, and Ohio, by evaporation (by solar or artificial heat, mainly the latter), from subterranean brine. It is also produced from similar sources, but to a smaller extent, in Pennsylvania, Utah, Virginia, Nevada, Kentucky, Texas, and Kansas. In California a large amount is made from sea-water by solar evaporation; and in 1880 a small production was reported from Massachusetts from the same source. Louisiana has a very considerable production, and one which is rapidly increasing, derived from deposits of rock salt at Petite Anse, which are fully described by Professor Hilgard on subsequent pages.

Census statistics.—The census of 1880 furnishes a tolerably complete and correct statement of the condition of this industry at that time. It presents tables showing the capital invested, material employed, amount paid for labor, and the production during the census year, *i. e.*, from June 1, 1879, to May 31, 1880. These are here appended:

Salt product of the United States in the census year ending May 31, 1880.

States and Territories.	Establishments.	Capital.	Average number of hands employed.			Total amount paid in wages during the year.	Subterranean brines.		
			Males above 16 years.	Females above 15 years.	Children and youths.		Wells.	Average depth of wells.	Average strength of brine (degrees salometer). (*a*)
	No.						*No.*	*Feet.*	
California (*b*)	25	$375,650	188	....	....	$50,620	....	....	....
Kansas	1	6,000	2	....	....	700	1	93	24.0
Kentucky	3	20,500	34	....	....	8,750	3	560	34.0
Louisiana (*c*)	1	250,000	45	....	....	11,000	....	....	....
Massachusetts (*b*)	5	9,000	8	....	....	1,030	....	....	....
Michigan	86	2,147,209	1,416	....	52	541,852	209	882	92.3
Nevada	7	45,300	31	3	2	9,688	150	30	12.0
New York	69	2,286,081	962	11	39	274,087	42	322	69.5
Ohio	25	832,600	449	2	2	105,261	58	932	36.8
Pennsylvania	16	234,500	131	....	6	52,047	19	883	24.9
Texas	3	92,000	17	1	1	8,150	1	10	....
Utah	10	13,400	62	3	8	20,932	4	2	82.5
Virginia	1	1,000,000	76	....	....	14,219	2	272	90.0
West Virginia	15	910,500	702	....	34	160,227	57	1,042	35.6
Wyoming	1	3,000	2	....	....	1,460	....	....	....
Totals	268	8,225,740	4,125	20	144	1,260,023	546	....	....

a 4° salometer = 1° Baumé. *b* Salt made from sea-water. *c* Rock salt mined and ground.

Salt product of the United States, etc.—Continued.

States and Territories.	By artificial heat.								
	Machines.								
	Blocks or furnaces.	Kettles.	Aggregate capacity.	Pans.	Aggregate capacity.	Settlers.	Aggregate capacity.	Grainers.	Aggregate capacity.
	No.	*No.*	*Galls.*	*No.*	*Galls.*	*No.*	*Galls.*	*No.*	*Galls.*
California (*a*)	2	56	6, 750	2	500				
Kansas									
Kentucky	3	78	7, 600	4	3, 040	2	15, 484	1	12, 791
Louisiana (*b*)									
Massachusetts (*a*)									
Michigan	103	174	21, 352	54	231, 257	237	6, 160, 246	355	3, 295, 527
Nevada									
New York	134	8, 347	1, 086, 540			269	10, 331, 931		
Ohio	26	291	22, 265	359	150, 632	59	1, 202, 035	59	561, 484
Pennsylvania	16			21	66, 390	21	450, 062	24	174, 507
Texas	2	59	5, 600			2	400	9	500
Utah	2								
Virginia	4	340	37, 400						
West Virginia	16			614	215, 588	71	1, 576, 512	79	1, 133, 909
Wyoming				4	800				
Totals	308	9, 345	1, 187, 507	1, 085	668, 207	661	19, 736, 670	527	5, 178, 718

States and Territories.	By artificial heat—Continued.			
	Materials.			
	Coal.	Value.	Wood.	Value.
	Tons.		*Cords.*	
California (*a*)	13	$76	125	$300
Kansas				
Kentucky	3, 760	3, 408		
Louisiana (*b*)				
Massachusetts (*a*)				
Michigan			524, 655	377, 939
Nevada				
New York	136, 843	240, 112		
Ohio	133, 470	112, 044	207	293
Pennsylvania	55, 750	37, 141		
Texas			2, 900	6, 400
Utah			400	480
Virginia			12, 000	36, 000
West Virginia	124, 010	100, 178	162	269
Wyoming			730	1, 460
Totals	453, 846	492, 959	541, 179	423, 141

a Salt made from sea-water. *b* Rock salt mined and ground.

Salt product of the United States, etc.—Continued.

States and Territories.	Value of all other materials.	Total value of all materials.	By solar evaporation. Machines. Vats or ponds.	Aggregate area.	Total value of materials.	Products. Salt.	Total value of all products.
			Number.	*Square feet.*		*Bushels.*	
California (*a*)	$40	$416	203	17,713,602	$19,079	884,743	$121,650
Kansas			33	60,000	710	13,000	5,700
Kentucky	5,600	9,008				83,000	21,950
Louisiana (*b*)						312,000	56,160
Massachusetts (*a*)			456	316,420	20	9,575	3,800
Michigan	629,294	1,007,233	3,750	867,180	2,500	12,425,885	2,271,913
Nevada			54	543,953	5,800	182,408	92,640
New York	233,004	473,116	42,939	12,068,796	33,904	8,748,203	1,107,760
Ohio	90,206	202,543				2,650,301	363,791
Pennsylvania	36,906	74,047				851,450	177,415
Texas	1,200	7,600	8	16,640	1,500	50,600	29,700
Utah	20	500	18	43,645,075	3,500	483,800	60,280
Virginia	3,000	39,000				425,895	127,678
West Virginia	91,666	192,113				2,679,438	380,369
Wyoming		1,460	1	21,780		5,000	8,760
Totals	1,090,936	2,007,034	47,462	75,253,446	67,013	29,805,298	4,829,566

a Salt made from sea-water. *b* Rock salt mined and ground.

Ground salt made in the United States in the census year ending May 31, 1880.

States.	Establishments.	Capital.	Average number of hands employed. Males above 16 years.	Females above 15 years.	Children and youths.	Total amount paid in wages during the year.
	No.					
California	1	$85,000	8	2	2	$6,800
Maine	2	1,700	4			1,300
Michigan	1	7,000	7	7	6	5,000
New York	4	229,200	130	38		31,897
Totals	8	322,900	149	47	8	44,997

States.	Materials. Coal.	Value.	Wood.	Value.	Value of all other materials.	Total value of all materials.	Products. Salt.	Value.
	Tons.		*Cords.*				*Bushels.*	
California					$40,000	$40,000	66,600	$60,000
Maine					2,750	2,750	8,000	4,750
Michigan	500	$2,500	200	$500	16,000	19,000	50,000	30,000
New York	1,246	3,243			215,700	218,943	920,000	266,906
Totals	1,746	5,743	200	500	274,450	280,693	1,044,600	361,656

Production in 1882.—The returns of the production of salt during the year 1882 have been derived in part from the official returns of State inspectors, as in New York and Michigan, and in part from estimates made by persons extensively engaged in the business. These estimates, which are based in the main upon the statistics of production of the principal works, and are made by men familiar with the character and extent of the industry, can have but a very small probable error. The following table gives the production in 1882:

Salt product of the United States in 1882.

States.	Barrels of 280 pounds.	Value.
Michigan	3,037,317	$2,126,122
New York	1,668,036	834,018
Ohio	400,000	280,000
West Virginia	400,000	300,000
California	214,200	150,000
Utah	92,820	130,000
Other States and Territories	600,000	500,000
Total	6,412,373	4,320,140

The returns have been reduced to units of barrels of 280 pounds each, as being the measure in most common use. In some localities the bushel is the unit, in others, the ton (of either 2,000 pounds or 2,240 pounds). Expressed in other measures, therefore, the total is 1,795,464,440 pounds; 32,061,865 bushels, of 56 pounds each; 897,732 net tons of 2,000 pounds each; or 801,547 gross tons of 2,240 pounds each. It is hardly necessary to add that the term "barrels" is often purely arbitrary, as so much salt is sold in bulk.

EASTERN DIVISION.

Michigan.—The salt production of Michigan is derived from the following counties, known as the "Saginaw district": Bay, Saginaw, Huron, Iosco, Midland, and Gratiot, all lying on or near Saginaw bay, on the east side of the lower peninsula. Since 1881, Manistee county, on the west shore of the lower peninsula, has appeared as a salt producer to a limited but rapidly increasing extent. The salt of this district is produced from a strong brine obtained by artesian wells, near the base of the Coal Measures. The manufacturers have the advantage of very cheap fuel, the most of it consisting of the waste of the saw-mills, such as sawdust, slabs, etc. The proximity and easy and cheap transportation to markets are other elements in favor of the industry, so that it is not a matter of surprise that the Saginaw salt has become a powerful competitor of that of the Onondaga district of New York, and has already injured very greatly the business of the West Virginia salt fields.

The following is a statement of the salt product of Michigan, by counties, during the calendar years specified, as derived from official sources:

Salt made in Michigan during the past three years, by counties.

Counties.	1880.	1881.	1882.
	Barrels. (a)	*Barrels.* (a)	*Barrels.* (a)
Bay	1,081,841	1,107,617	1,158,279
Saginaw	1,148,644	1,083,990	1,287,273
Huron	256,841	326,852	255,012
Iosco	147,800	147,579	211,667
Midland	41,462	74,537	80,239
Manistee	....	1,642	41,562
Gratiot	....	....	3,285
Total	2,676,588	2,742,217	3,037,317

a Of 280 pounds each, as in each subsequent reference in this section.

The following table shows the amount of salt inspected in Michigan since 1869, the first year of the establishment of the State salt inspection, for the years specified:

Grades of salt made in Michigan as reported by the inspectors.

Years.	Fine.	Packer's.	Solar.	Second quality.	Total for each year.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1869	513,989	12,918	15,264	19,117	561,288
1870	568,326	17,869	15,507	19,650	621,352
1871	655,923	14,677	37,645	19,930	728,175
1872	672,034	11,110	21,461	19,876	724,481
1873	746,702	23,671	32,267	20,706	823,346
1874	960,757	20,090	29,391	16,741	1,026,979
1875	1,027,886	10,233	24,336	19,410	1,081,865
1876	1,402,410	14,233	24,418	21,668	1,462,729
1877	1,590,841	20,389	22,949	26,818	1,660,997
1878	1,770,361	19,367	33,541	32,615	1,855,884
1879	1,997,350	15,641	18,020	27,029	2,058,040
1880	2,598,037	16,691	22,237	48,623	2,685,588
1881	2,673,910	13,885	9,683	52,821	2,750,299
1882	2,928,542	17,208	31,335	60,222	3,037,307

Previous to 1869 the salt production of the State was as follows:

	Barrels.
1860	4,000
1861	125,000
1862	243,000
1863	466,356
1864	529,073
1865	477,200
1866	407,077
1867	474,721
1868	555,690

The average price which Michigan salt sold for in different years is as follows:

	Price per barrel.
1866	$1 80
1867	1 77
1868	1 85
1869	1 58
1870	1 32
1871	1 46

	Price per barrel.
1872	$1 46
1873	1 37
1874	1 19
1875	1 10
1876	1 05
1877	85
1878	85
1879	1 02
1880	75
1881	85
1882	70

New York.—The salt product of New York is derived principally from the Onondaga district, in the western part of the State. The source is a strong brine, ranging, at a temperature of 60° Fah., from 59° to 70° of the salometer. The brine is reached by means of artesian wells, from which it is drawn by pumping. Nearly all the salt-bearing district is the property of the State, by which tracts of land are leased to the manufacturers. A small revenue is thus annually gained to the State. In 1881 the returns from the leases amounted to $79,438, while the expenses connected with the administration were $59,428, leaving a balance in favor of the State of about $20,000. There are upon the reservations 316 water rights to manufacturers of fine salt; that is, salt produced by artificial evaporation, and 26 leases to solar salt manufacturers. During the season of 1881, 139 fine salt blocks were in operation, the balance having been discontinued; while, at the same time, all the solar works were in operation.

Production of salt at the Onondaga Salt Springs since June 20, 1797 (the date of the first leases in lots).

[The column headed "Solar" relates to the coarse salt made by solar evaporation, that headed "Fine" to that made by artificial evaporation.]

Years.	Solar.	Fine.	Total.
	Bushels of 56 pounds.	*Bushels of 56 pounds.*	*Bushels of 56 pounds.*
1797		25,474	25,474
1798		59,928	59,928
1799		42,704	42,704
1800		50,000	50,000
1801		62,000	62,000
1802		75,000	75,000
1803		90,000	90,000
1804		100,000	100,000
1805		154,071	154,071
1806		122,577	122,577
1807		175,448	175,448
1808		319,618	319,618
1809		128,282	128,282
1810		450,000	450,000
1811		200,000	200,000
1812		221,011	221,011
1813		226,000	226,000
1814		295,000	295,000
1815		322,058	322,058
1816		348,665	348,665
1817		408,665	408,665
1818		406,540	406,540
1819		548,374	548,374
1820		458,329	458,329

Production of salt at the Onondaga Salt Springs, etc.—Continued.

Years.	Solar.	Fine.	Total.
	Bushels of 56 pounds.	*Bushels of 56 pounds.*	*Bushels of 56 pounds.*
1821	....	526, 049	526, 049
1822	....	481, 562	481, 562
1823	....	726, 988	726, 988
1824	....	816, 634	816, 634
1825	....	757, 203	757, 203
1826	....	811, 023	811, 023
1827	....	983, 410	983, 410
1828	....	1, 160, 888	1, 160, 888
1829	....	1, 129, 280	1, 129, 280
1830	....	1, 435, 446	1, 435, 446
1831	....	1, 514, 037	1, 514, 037
1832	....	1, 652, 985	1, 652, 985
1833	....	1, 838, 646	1, 838, 646
1834	....	1, 943, 252	1, 943, 252
1835	....	1, 209, 867	1, 209, 867
1836	....	1, 912, 858	1, 912, 858
1837	....	2, 167, 287	2, 167, 287
1838	....	2, 575, 033	2, 575, 033
1839	....	2, 864, 718	2, 864, 718
1840	....	2, 622, 305	2, 622, 305
1841	220, 247	3, 120, 520	3, 340, 767
1842	163, 021	2, 128, 882	2, 291, 903
1843	318, 105	2, 809, 395	3, 127, 500
1844	332, 418	3, 671, 134	4, 003, 552
1845	353, 455	3, 408, 903	3, 762, 358
1846	331, 705	3, 507, 146	3, 838, 851
1847	262, 879	3, 688, 476	3, 951, 355
1848	342, 497	4, 394, 629	4, 737, 126
1849	377, 735	4, 705, 834	5, 083, 569
1850	374, 732	3, 894, 187	4, 268, 919
1851	378, 967	4, 235, 150	4, 614, 117
1852	633, 595	4, 288, 938	4 922, 533
1853	577, 947	4, 826, 577	5, 404, 524
1854	734, 474	5, 068, 873	5, 803, 347
1855	498, 124	5, 584, 761	6, 082, 885
1856	709, 391	5, 257, 419	5, 966, 810
1857	481, 280	3, 830, 846	4, 312, 126
1858	1, 514, 554	5, 518, 665	7, 033, 219
1859	1, 345, 022	6, 549, 250	6, 894, 272
1860	1, 462, 565	4, 130, 682	5, 593, 247
1861	1, 884, 697	5, 315, 694	7, 200, 391
1862	1, 983, 022	7, 070, 852	9, 053, 874
1863	1, 437, 656	6, 504, 727	7, 942, 383
1864	1, 971, 122	5, 407, 712	7, 378, 834
1865	1, 886, 760	4, 499, 170	6, 385, 930
1866	1, 978, 183	5, 180, 320	7, 158, 503
1867	2, 271, 892	5, 323, 673	7, 595, 565
1868	2, 027, 490	6, 639, 126	8, 666, 616
1869	1, 857, 942	6, 804, 295	8, 662, 237
1870	2, 487, 691	6, 260, 422	8, 748, 113
1871	2, 464, 464	5, 910, 492	8, 374, 956
1872	1, 882, 604	6, 048, 321	7, 930, 925
1873	1, 691, 359	5, 768, 998	7, 460, 357
1874	1, 667, 368	4, 361, 932	6, 029, 300
1875	2, 655, 955	4, 523, 491	7, 179, 446
1876	2, 308, 679	3, 083, 998	5, 392, 677
1877	2, 525, 335	3, 902, 648	6, 427, 983
1878	2, 788, 754	4, 387, 443	7, 176, 197
1879	2, 957, 714	5, 364, 418	8, 322, 162
1880	2, 516, 485	5, 482, 265	7, 998, 750
1881	3, 011, 461	4, 905, 775	7, 917, 236
1882	3, 032, 447	5, 307, 733	8, 340, 180
Total to Dec. 31, 1882...	59, 701, 823	237, 092, 987	296, 794, 810

The average price per bushel of 56 pounds in 1882 was 10 cents, or 50 cents per barrel of 280 pounds.

Within the last four or five years, two or three discoveries of rock salt *in situ* have been made in western New York, and it is reported that mining operations have been commenced at these localities. One of the recent strikes is near Warsaw, on the Rochester and Pittsburgh railroad, where an artesian well, which was being bored for oil, passed, at a depth of nearly 1,500 feet, through a bed of rock salt 45 feet thick. The salt is overlaid and underlaid by 14 or 15 feet of shales impregnated with salt. Another discovery has also been made at Wyoming, in Wyoming county, about 6 miles from the one just described. The New York producers are beginning to feel the competition of the Michigan salt fields, and active efforts are being made by individuals and by the State to extend the field and cheapen the methods pursued in production and evaporation.

West Virginia.—The principal points in West Virginia at which salt is produced are: Charleston, on the Great Kanawha river; between West Columbia and Hartford City, on the Ohio; Bulltown, on the Little Kanawha; Louisa, on the Big Sandy river; on New river, in Mercer county, and at some other points, where small quantities are manufactured for local use. At present, salt is manufactured on a commercial scale only at Charleston, and in Mason county, on the Ohio, where the pursuit is profitable, owing to the abundance and cheapness of fuel and the facilities for reaching markets. It is estimated by competent authorities that the total commercial production of the State in 1882 was 400,000 barrels of 280 pounds each. This had an average spot value per barrel of 75 cents, giving, as the total value of the product, $300,000. Out of this total production, it is estimated that three-fourths, or 300,000 barrels, came from Mason county, and one-fourth from Kanawha county. The salt is made from weak brine pumped from artesian wells. In Mason county, these wells reach the brine at a nearly uniform depth of between 1,150 and 1,200 feet below the surface. Those in Kanawha county are, in general, not as deep, ranging from 600 to 1,000 feet. These wells are located along the valley of the Great Kanawha river, extending from one-fourth of a mile above Charleston to several miles further up, on both sides of the river. The brine, both here and in Mason county, is found in a porous sandstone in the lower portion of the Coal Measures. These brines have a strength of only 9° to 10° Baumé, or about 40 per cent. of saturation, being, therefore, much poorer than those of Michigan and New York. The competition of these districts, especially the former, has had a very serious effect upon the production in West Virginia. Concerning this matter, Dr. J. P. Hale, a leading manufacturer in West Virginia, writes as follows: "The state of the trade here at present is at a very low ebb, owing to the immense development of the manufacture in Michigan, where they have stronger brines, cheaper fuel, and proximity to the great consuming markets of the West. I do not think the manufacture here will ever regain anything like its former importance."

The methods of manufacture in West Virginia, though differing in matters of detail, are, in general, similar to one another. Three or four different qualities of salt are made in this district, which are given different names by different manufacturers. They may, however, be characterized as coarse, common, fine, and dairy. There is no salt produced in this district by solar evaporation, so far as is reported. The fuel used for evaporation is almost everywhere coal, although, in time past, gas issuing from the artesian wells has been occasionally employed. The brine is first boiled in furnaces; then, when it has acquired a certain degree of strength, it is run off into settling and purifying tanks, in which it is heated by steam passing through copper pipes in the liquid; then it is run into granulating tanks, in which the salt is deposited; from them it is taken by shovels, and, after being thoroughly drained, is ready for packing and shipment. It is generally estimated that a bushel of coal will make a bushel of salt. The total cost of production, including all expenses requisite to preparing the salt for shipment, is estimated by a local manufacturer at 69 cents per barrel, leaving at the average price the past year (75 cents) but a very small margin for profit. Under these circumstances, it is not a matter of surprise that the salt works of West Virginia are producing, as a rule, only one-half of their capacity.

The following table shows the production of salt in Kănawha county from 1791 to 1875, with the exception of a few years in which no records were kept. This table has been abstracted from a paper on salt written by Dr. J. P. Hale, for the Centennial Exposition at Philadelphia.

Production of salt in Kanawha county, West Virginia.

1797	pounds per day	150
1808	bushels per day	25
1814	bushels per year	600,000
1827	do	787,000
1828	do	863,542
1829	do	989,758
1830	do	906,132
1831	do	956,814
1832	do	1,029,207
1833	do	1,288,873
1834	do	1,702,956
1835	do	1,960,583
1836	do	1,762,410
1837	do	1,880,415
1838	do	1,811,076
1839	do	1,593,217
1840	do	1,419,205
1841	do	1,443,645
1842	do	1,919,389
1843	do	2,197,887
1844	do	1,874,919
1845	do	2,578,499
1846	do	3,224,786
1847	do	2,690,087
1848	do	2,876,010
1849	do	2,951,492
1850	do	3,142,100
1851	do	2,862,676

1852	bushels per year..	2,741,570
1853	do	2,729,910
1854	do	2,233,863
1855	do	1,493,548
1856	do	1,264,049
1857	do	1,266,749
1858	No records.	
1859		
1860		
1861		
1862		
1863		
1864	bushels per year..	1,300,991
1865	do	861,973
1866	do	1,275,017
1867	do	1,321,066
1868	do	1,528,282
1869	do	1,822,430
1870	do	1,721,963
1871	No records.	
1872		
1873		
1874		
1875	bushels per year..	967,465

Ohio.—The leading salt-producing locality of Ohio is in the southeastern corner, near the Ohio river. The occurrence and methods of preparation are very similar to those of West Virginia on the other side of the Ohio river. In this part of Ohio it is estimated that about 300,000 barrels were produced during the year 1882, while 100,000 barrels were produced in other parts of the State.

ROCKY MOUNTAIN DIVISION.

Montana and Wyoming.—Salt is found in considerable quantity in various portions of the Rocky mountains from Montana to New Mexico, both in salt springs and as salt beds or deposits. In the Yellowstone valley salt springs occur frequently, but no effort has been yet made to utilize the brine in the manufacture of salt. In Wyoming rock salt is said to occur in extensive beds of great purity in various portions of the Territory.

Dakota.—In Dakota, at Jenny's Stockade, a number of springs furnish an excellent quality of salt, and the supply of brine is abundant. These springs are owned by Captain Davey, of Galena, Black Hills, who has evaporated a considerable quantity of the brine and used or sold the salt. He states that the springs are capable of producing about two tons of salt daily, enough to supply the entire Black Hills country.

Colorado.—In the South Park there are a number of salt springs. Before 1870, works with a capacity of many barrels of salt daily were erected, but for some reason they proved a failure and have not been running for years. It is not possible to ascertain how much salt has been produced and marketed.

New Mexico.--In New Mexico, on the great plateau of the Rocky mountains, southwest of Cañon Blanco summit, are the Salinas, which furnish a large quantity of good salt. The greater portion of New Mexico is supplied from here, it being freighted to Santa Fé, Las Vegas, to the towns along the Rio Grande, and even to Chihuahua. The only cost is that of transportation. It occurs in quantity in many places in New Mexico, often mixed with alkali, and also pure in lakes. The evaporation in the salt lakes annually makes a deposit of salt several inches in thickness, coarse, strong, and of the best quality. It has often been taken to the city of Chihuahua for sale, as the salt of that State is inferior, being mixed with alkali. The principal lakes are in the valley between the Organ and the Sacramento mountains, one lake on the Texas line, and the best one 60 miles northward, and another large and excellent one about 60 miles south of Santa Fé, near the town of Manzano, whence many wagon loads are regularly carried to Santa Fé and other distant points, the article forming quite a commodity of interior commerce. These salt lakes have been used as public property.

PACIFIC COAST.

Abundance.—Of all the useful minerals found in the Pacific States and Territories none occur in such abundance and wide distribution as the chloride of sodium—common salt. Besides numerous salt springs, ponds, and lakes, this mineral exists in crystallized layers interstratified with other substances, the whole forming great mountain-like masses, and in deposits occupying the beds of dry or nearly dry lakes, on wide extended marshes, alkali flats. etc. Besides the product of these natural salines large quantities of salt are made by the solar evaporation of seawater, not less than 50,000,000 pounds being produced by this process on the bay of San Francisco every year. The plan of producing salt by boiling in kettles or evaporating the brine in shallow pans by means of artificial heat, the common methods in most countries, and used extensively in other portions of the United States, is not practised here.

Local consumption.—The consumption of salt on the Pacific coast, by reason of the many uses into which it enters, has always been large. It is employed in a variety of industries, all having considerable and some of them very large requirements. In the reduction of silver ores and in other metallurgical operations, such as the chlorination of auriferous pyrites, between 20,000 and 30,000 tons of salt are disposed of annually. In dairying and meat-packing and for culinary and other domestic purposes, and for curing hides, fish, hay, etc., a great deal is used. In various manufactures and in the economic arts some is also needed, the consumption in the States and Territories of the Far West being exceptionally large for their population.

Nevada.—The largest deposits of salt on the Pacific coast are found in the State of Nevada, where they occur under all the various conditions mentioned. Of these deposits the most extensive and otherwise remarkable is that on the Rio Virgen, in the extreme southeastern corner of the State, and but a few miles north of the Colorado river. A formation exists at this point composed of rock salt resting on, and to some extent intermixed with, a sedimentary granite, and of such magnitude that it may be said to constitute a notable portion of the mountain in which it occurs. More than 60 per cent. of this entire mass appears to consist of hard rock salt, having the color and transparency of clear ice, and containing over 90 per cent. of the chloride of sodium. This formation extends along the eastern bank of the Virgen, presenting a bluff face to the stream for a distance of 25 miles or more, and reaching in some places a height of several hundred feet. This deposit is worked after the manner of an open quarry, the salt being removed in blocks weighing often many pounds each. Although blasting is sometimes necessary in breaking it out, large quantities of quite pure salt can be obtained here at very little cost. Twenty miles up the Virgen on its west side occurs another hill of salt, the formation at this point being similar to that on the east side of the river, except that it is much less extensive, while the color of the mineral, instead of a pale green, is here of a dazzling whiteness. In the same neighborhood, at a point 1 mile north of the Colorado river, on a mesa composed of small pebbles, earth, and boulders, occurs a circular opening 100 feet across, and of great depth, forming an immense natural well. This well, the sides of which are nearly vertical, is filled to within 50 feet of the top with water supersaturated with salt, this pool being apparently all that is left of the "dead sea" which once covered the entire region. These salines on the Rio Virgen, though exceedingly rich, and reported as practically inexhaustible, are of little present value, being far from railroad or river transportation, and there being no mines and but few settlers in their immediate vicinity. Should, however, the projected railroad up the Colorado be completed, it would impart to these deposits a large value, Coleville, the northern terminus of that road, being in close proximity to these immense salt fields. When the mines in the Mineral Park district, Arizona, were being worked several years ago, they obtained their supply of salt from this locality at a cost of $80 per ton; and there is little doubt but extensive mining districts on either side of the Colorado would receive their supplies of this mineral from the same source, were the railroad constructed.

The other more notable salines of Nevada consist of the salt springs on the line of the Central Pacific railroad, near White Plains, Churchill county, where the Desert Company have constructed 8,500 feet of vats, having a width of 55 feet, for making salt by solar evaporation. Into these vats, which consist of shallow excavations in the earth inclosed with low embankments, the brine is run, being lifted with pumps from some of the springs. A mill for grinding dairy and table salt has been put up here. At this locality an incrustation of impure salt an inch or two thick and overlying a stratum of blue clay filled with crystals of the same mineral extends over several hundred acres. Formerly salt was manufactured from this formation by the process of leaching. A large quantity of salt of good quality is made here, the silver mills at Virginia City, Gold Hill, and elsewhere throughout western Nevada being supplied mostly from this source.

Up to 1862 all the salt used in Nevada, both for the silver mills and for domestic purposes, was brought from San Francisco, at an average cost of $150 per ton laid down in Virginia City. In that year the mills running on Comstock ores began to obtain their supplies in part from from what is known as Rhodes's marsh, situated 160 miles to the southeast, transportation being effected by camels brought into the country for that purpose. Through resource to this expedient the price of salt was soon after reduced to nearly one-half its former rate. Owing to the discovery a year or two later of an extensive saline near Sand Springs, 80 miles east of Virginia City, from which much salt was brought in, the price underwent a further decline, finally dropping to the uniform rate of $60 per ton, about the cost of freight from San Francisco, whence importations had before been considerable. During the more prosperous era of the Comstock mines the salt from this Sand Springs marsh delivered for their use amounted to as much as $50,000 per month, some of the larger mills consuming each between 40 and 50 tons every thirty days.

As it fairly represents a large class of these deposits, a description of the general features of this Sand Springs saline will serve to convey a pretty good idea of the whole. The saliniferous land at this place occupies a depressed portion of an extensive alkali flat, this depression being always marshy and, during the wet season, covered with a few inches of water. Spread over it is an incrustation of impure salt from two or three inches in thickness, brought up by efflorescence from below. In collecting the salt this crust is broken up and scraped into heaps with broad wooden hoes, the ground being divided into long strips, which are gone over in regular order. These heaps, after being left to drain off for a few days, are carried out on wheelbarrows or cars and thrown on platforms, where, after undergoing some further drying, the salt is sacked and is ready for shipment. As soon as this surface incrustation has been stripped off, it begins to re-form, the process going on so rapidly that several crops can be gathered yearly. As the ground below is heavily charged with salt, the process of replacement, were the surface removed, would no doubt go on indefinitely. The salt collected here, though not very clean, being mixed with a small percentage of sand, soda, and other impurities, answers well for metallurgical purposes, the alkali present tending to clean the quicksilver and intensify its action. A large portion of the alkali flat outside of this depression is covered during the dry season with a thin coating of salt, generally too high and too much contaminated with foreign matters to justify being gathered.

Forty miles north of Sand springs, in what is known as Great Salt valley, occurs another and very similar saline. Under the top incrustation here comes in a stratum of blue clay 18 inches thick, underlaid by a bed of crystallized salt of unknown depth. Other than some small lots supplied to the Humboldt mines, but little salt has ever been taken from this marsh, the locality being remote from the settlements, and surrounded by rugged mountains and a wide extent of barren sage plains.

Situated in the easterly part of Esmeralda county, and having the town of Columbus for a center, is a series of immense alkali flats, each containing heavy deposits of salt, the mineral being quite as plentiful, and occurring here in much the same manner as at Sand springs. Not much, however, has been done towards turning these deposits to practical account, only enough salt having been taken from them of late years to supply the few reduction works, and the wants of the small population in the neighborhood. At Rhodes's marsh, one of this group, hundreds of acres are underlaid by a hard-pan of solid salt, more or less mixed with mud and sand. Into these holes, something like tanner's vats are dug, and soon fill with water holding salt in solution to its utmost capacity. This water evaporating, leaves in the course of five or six weeks, on the bottom of the pit, about two feet of clean crystallized salt. To fit it for table use this salt is ground in a mill on the premises. At none other of these marshes have works been provided for either producing or grinding salt, though small quantities are collected there every year by hoeing it together on the surface, or shoveling it up from the pools and shallow ponds where it is crystallized. The Carson and Colorado railroad having reached the vicinity of these salines, it is probable that their product will now come to be more extensively utilized.

At Silver Park, 40 miles southeast of Columbus, the surface incrustations of salt cover hundreds of acres, some of the deposits here being several inches thick, and quite pure. The mills of the Silver Park Mining Company, located near by, have this commodity in superabundance at their very doors. On the easterly margin of the Montezuma marsh, 10 miles farther north, the water standing everywhere within two or three feet of the surface is so saturated with salt that any of the mineral added is at once precipitated, the water being unable to hold it in solution. Pits excavated here soon fill with salt, evaporation in this hot and arid climate proceeding rapidly for eight or nine months in the year. The Shawmut Mining and Smelting Company procure here at little cost all the salt required for their reduction works, situated on the easterly border of this marsh.

Twenty miles south of the old overland stage road, near the Utah line, and 175 miles west of Salt Lake, is a flat, 4 miles long by $1\frac{1}{2}$ miles wide, which in the early summer, when the snow melts on the adjacent mountains, is covered with water to a depth of several feet. Later in the season this water evaporates, leaving a crust of salt from two to eight inches in thickness. This salt, having been scraped into heaps, is placed on cars and run out over a track laid to solid ground, and there transferred to wagons and hauled to the mills in that part of the State. From this marsh the Solar Salt Company gather and dispose of about 2,000 tons annually, 20 men, 7 white and 13 Indians, being employed at the works. This salt is worth $13 per ton on the ground, and from $20 to $40 delivered at the mining camps. The marsh is surrounded by hundreds of springs, some of them close on its border, and all affording pure, fresh water.

In Big Smoky valley, Lander county, and in the Cortez district, 60 miles farther north in the same county, large areas of ground are covered with a thin crust of salt, which is gathered and sent to the mills in its crude state. For table use, a salt is produced from this crust by leaching and then recrystallizing the brine.

To enumerate, however, all the localities in Nevada where salt occurs in the form of a thin incrustation on the surface, and sometimes in beds like those already described, would make a long list. Suffice it to say, workable deposits of this mineral exist in every part of the State, hardly any of the larger counties being without enough for home use, with much to spare, where there is a market for it.

While salt in Nevada is cheap enough at the point where produced, the price there hardly ever exceeding 1 cent per pound, it is apt to cost the consumer pretty dearly, transportation in that country, even for short distances, amounting often to two and three times as much as the cost at the salines. With the introduction of railroads into the country, the cost of transportation is growing less, and will probably undergo such reduction that great quantities of this commodity will eventually be exported from the State.

The salt companies of Nevada usually pay their employés the following wages: white men, $2 per day and found; Indians and Chinese, $1.50. They employ during the active season, extending usually from April to December, an aggregate of 60 hands, and have about $75,000 invested in the business.

The product of the Eagle Salt Works, in Churchill county, during the past four years, has been as follows:

Years.	Quantity.	Value.
	Net tons.	
1879	4,800	$86,400
1880	3,000	54,000
1881	2,500	45,000
1882	2,100	37,800
Total for four years	12,400	223,200

The average spot value of the ordinary salt is $18 per ton. At these works 200 net tons of table salt are produced annually, of a spot value of $40 per ton, or $8,000 yearly.

California.—California has from the first been a large producer of salt, the native races and earlier settlers in the country having obtained their supplies mostly from the natural deposits found in the lagoons about the bay of San Francisco, and along the sea coast, gathering some also from springs and pools in the interior. The first works in this State provided for facilitating the natural processes operating to produce salt were constructed more than 20 years ago on the east side of the bay of San Francisco, at a point 22 miles southeast of the city. These, though crude in form and of limited capacity, having answered a good purpose, were soon followed by larger and better works, until these establishments have become not only numerous but noted for their capacity and completeness, large quantities of salt of various grades, the most of it of excellent quality, being produced here annually. The evaporating reservoirs of these companies, some twenty in number, have an aggregate length of 16 or 18 miles, the whole covering an area of many thousand acres. The largest of these companies, the Union Pacific, own over 1,200 acres of salt marsh land, the most of it consisting of a flat low-lying island, traversed by sloughs, and indented by lagoons which at ebb tide contain little or no water. On the adjacent shore of the bay are immense tracts of similar lands on which the works of the other companies are situated. This island has been divided by dikes into numerous reservoirs, the larger containing from 100 to 300 acres each. Into the largest of these the sea water is let through many small gates, and is left there for three or four weeks, when it is discharged into the next, whence, after remaining for the same length of time, it is passed on to a third, and finally to a fourth and a fifth reservoir, the lime and magnesia being precipitated in these last two, and left on the bottom. After this the brine is drawn off into smaller ponds where further evaporation takes place and the salt crystallizes. When a finer grade of salt is to be produced, these ponds are provided with wooden floors, a few being also wholly inclosed with boards. When the deposit is completed the salt is raked into heaps, then shoveled into baskets and run out on cars to the edge of the yard, where it is piled in heaps which are left to weather through at least one rainy season, whereby the crystals are whitened, purified, and rendered fit for market or for grinding. Where a specially pure article is required, the cleanest of the brine is pumped up by windmills into wooden tanks, and the process of evaporation is there completed. As soon as the first reservoir is emptied it is again replenished, others being emptied and filled in the same manner, this procedure being kept up throughout the entire season, which usually lasts from about the first of May till the middle of November.

This company, which employs about 80 men, and has over $100,000 invested in the business, has of late years produced an average of 10,000 net tons of salt per annum, though the works have a capacity to make a much larger quantity.

The other companies operating in this locality proceed on much the same plan as the Union Pacific, all the salt made here, amounting latterly to about 25,000 tons per annum, being produced by solar evaporation. The product for 1882 was considerably larger, being estimated by competent judges at 30,000 net tons, and that for the first half of 1883 at 13,000 tons. These companies have not as yet made much use of their by-products. Some of them having found it profitable to recover the magnesia held in the mother liquor from the crystallizers, have supplied it in considerable quantities to the manufacturers of high explosives, who use it for the absorption of nitro-glycerine, in place of infusorial earth. Shipments of salt from San Francisco in 1882 were 248,200 pounds over the Southern Pacific railroad, and 48,280 pounds over the Central Pacific railroad.

Salt springs, lagoons, and marshes are met with in various parts of California, some of the marshes found in the southeastern part of the State being nearly as extensive as those in Nevada. But little salt has ever been taken from them, however, as they lie in remote and desert sections of the State. Holes dug in the moist lands bordering on the lakes of Tulare and Kern counties soon fill almost to the top with salt water. Some salt has been made at these places by lixiviation and crystallization. Salt springs are plentiful in Owen's valley, Inyo county, there being according to report a large body of pure rock salt in Saline valley, in the same county, but some distance to the east of Owen's valley. Salt from pools and springs has been made on a small scale at San Rafael, Marin county; in different parts of Santa Clara, San Bernardino and Los Angeles counties; and from sea water at Santa Monica, San Diego, and elsewhere on the sea-coast. Only enough has however been produced at these various places for local consumption.

Data relative to salt production in California, as shown by the census of 1880.

Number of works	25
Capital invested	$365,650
Average number of hands employed during the year	184
Amount of wages paid	$49,120
Number of vats in use	185
Aggregate area in square feet	14,228,802
Number of bushels of salt made from bay or sea water	878,093
Number from other sources	6,350

Wages in salt works on San Francisco Bay, California, May 1, 1883.

Classes of employés.	Per—	Rate.
Workmen (white)	Month	$50 to $60 and board.
Workmen (Chinese)	Day	$1.25 and board themselves.
Foremen	Month	$100 to $150 and board.

Besides the salt made in California, large quantities are imported, the total consumption of the State amounting to about 75,000,000 pounds, or 37,500 net tons. The imports in 1882 were:

	Pounds.
England	12,841,212
Carmen Island	761,600
Peru	1,200,000

As compared with previous years, the quantity of salt brought last year from Carmen Island, on the coast of Lower California, shows a great falling off, importations from that source having since nearly ceased. The importation quoted above is the first considerable lot ever brought from Peru.

The arrival of so much salt from Liverpool, brought by ships coming to San Francisco to load with wheat, has tended to keep the price of this staple greatly depressed in that market. Thus the year 1882 opened with Liverpool selling at $13.50 per ton; the price before the middle of the year, stocks on hand being considerable, and arrivals free with more on the way, dropped to $12 per ton. Ruling rates of salt per ton in San Francisco during the past ten years have been about as follows: California bay product, first quality (that made in wooden vats and ground), $12 to $15; second quality, $7 to $8; common bay, used for hide salting and other coarse curing, $5 to $6. The first grades of California salt, known as the "Rock Island" and the "crystal" brands, are highly esteemed for their strength and purity. They are bought exclusively by the Government, and are used more than any other kinds for meat curing and dairy purposes. Common Liverpool salt has usually sold at a dollar or two more per ton than first-class California, while Liverpool stoved and a few other fancy brands have commanded still higher figures. Occasionally when jobbers have been able to control the market, the prices of this commodity have been advanced to much higher figures than above quoted. The salt made on the Bay of San Francisco is as good as any in the world, being in strength and purity equal to the best French brands, and much heavier than that imported from England, weighing 58 pounds to the bushel, whereas the English weighs but 52 pounds. From California several thousand tons of salt are exported every year, the most of it going to Washington Territory, Oregon, and British Columbia, a little being also sent to other countries.

Utah.—Mr. J. M. Goodwin, of the Salt Lake City *Tribune*, furnishes the following information: "Salt is made from the waters of Salt Lake in such quantities as to meet the demand. By the rise of the lake in spring, and also by the banking up of the waters by winds, lagoons are filled; and the waters being held by dams evaporates by solar heat, a fair quality of salt crystallizing. It is used for domestic purposes, but chiefly for silver mills. Near Nephi, 100 miles south of Salt Lake City, 300 tons of rock salt were mined and marketed in 1882. In southern

Utah there are immense quantities of rock salt of excellent quality. The salt interest of the Territory is destined to become very important, as the supply is practically unlimited."

The Utah product during the past four years, as estimated by Mr. Goodwin, has been as follows:

Salt production of Utah.

Years.	Quantity.	Value.
	Net tons.	
1879	12,000	$60,000
1880	12,000	60,000
1881	14,000	70,000
1882	13,000	65,000
Total for four years	51,000	255,000

The average spot value is $5 per ton.

Oregon, Idaho, and Arizona.—Salt springs and pools are common in Oregon, Idaho, and Arizona, some of which have been utilized on an extensive scale. From a shallow lagoon in eastern Arizona a million pounds of salt are said to be taken yearly to supply the reduction works and the stockmen and other inhabitants of that part of the Territory. Wagons are driven into this lake, and the salt, which is precipitated on the bottom, is shoveled up and carted away.

The works in Salt Spring valley, Oneida county, in southeastern Idaho, make about 300 tons of salt annually, by evaporating the brine of the saline springs, which are very numerous in the neighborhood. The Utah and Northern railroad, which passes near these springs, has given a considerable impetus to the manufacture of salt, and the increase of population in the adjacent counties will tend to a further expansion of the industry.

FOREIGN COMMERCE.

The following tables present statements regarding the imports and exports of domestic salt, the exports of foreign production, and the average export price of salt. It will be seen that, in spite of the heavy duty upon salt (12 cents per hundred pounds), the protection thereby afforded to American production has by no means stimulated it so far as to supply our own markets. The imports in 1882 exceeded 3,000,000 barrels, or nearly one-half our total production. Further, it will be seen that the exports are but trifling in comparison. Under the new tariff the duty on salt, in bags, sacks, barrels, or other packages is 12 cents per 100 pounds; in bulk 8 cents per 100 pounds. Exporters of salted meats, and curers of fish, are allowed a drawback.

Salt imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

Years.	Quantity.	Value.
	Pounds.	
1872	617, 804, 664	$1, 214, 747
1873	778, 273, 855	1, 783, 184
1874	929, 373, 573	2, 339, 311
1875	825, 177, 945	1, 807, 587
1876	867, 087, 388	1, 773, 445
1877	961, 209, 894	1, 659, 521
1878	860, 589, 224	1, 632, 865
1879	906, 615, 313	1, 776, 741
1880	963, 970, 711	1, 837, 432
1881	1, 100, 510, 401	2, 090, 578
1882	845, 775, 945	1, 673, 515
Calendar year 1882	819, 142, 896	1, 614, 268

Salt of domestic production exported from the United States during the fiscal years specified (mixed gold and currency values).

Years.	Quantity.	Value.
	Bushels of 56 *pounds.*	
1872	42, 603	$19, 978
1873	73, 323	43, 777
1874	31, 657	14, 701
1875	47, 094	16, 273
1876	51, 014	18, 378
1877	65, 771	20, 133
1878	72, 427	24, 968
1879	43, 710	13, 612
1880	22, 179	6, 613
1881	45, 455	14, 752
1882	42, 085	18, 265
Calendar year 1882	50, 231	17, 086

Salt of foreign production exported from the United States during the fiscal years specified.

Years.	Quantity.	Value.
	Pounds.	
1872	5, 764, 606	$12, 933
1873	1, 848, 665	6, 997
1874	3, 563, 830	12, 920
1875	6, 804, 795	17, 579
1876	5, 771, 849	7, 993
1877	5, 231, 446	8, 893
1878	3, 745, 393	4, 411
1879	5, 017, 182	6, 816
1880	6, 630, 370	8, 861
1881	3, 017, 531	3, 517
1882	3, 375, 010	4, 790
Calendar year 1882	2, 930, 652	4, 301

Average export price of salt (fiscal years).

	Price per bushel.
1872	$0. 469
1873	0. 597
1874	0. 464
1875	0. 345
1876	0. 360
1877	0. 306
1878	0. 345
1879	0. 301
1880	0. 298
1881	0. 325
1882	0. 434

Consumption of imported salt.

[Statement showing the quantity and value of imported salt entered for consumption in the United States, with rates and amounts of duty collected thereon during each year from 1862 to 1882, inclusive, as compiled by the Bureau of Statistics.]

IN BAGS, SACKS, BARRELS, OR OTHER PACKAGES.

Fiscal year ended June 30.	Quantity.	Value.	Rate of duty.	Amount of duty received.	Additional and discriminating duty.	Total duty.
1862 ... bushels..	856, 426		6 cents per bushel	$51, 385 55		$373, 782 41
1862 ... pounds.	179, 109, 370		18 cents per 100 pounds	322, 396 86		
863 ... do	38, 961, 802		do	70, 131 23		444, 681 31
863 ... do	156, 062, 535		24 cents per 100 pounds	374, 550 08		
1864 ... do	138 523, 660		do	332, 456 77		332, 456 77
1865 ... do	122, 109, 133		do	293, 061 92		293, 061 93
1866 ... do	329, 897, 938		do	791, 755 12		791, 755 12
1867 ... do	254, 470, 862	$696, 570 15	do	610, 930 07		610, 730 07
1868 ... do	308, 446, 080	915, 546 51	do	740, 270 59		740, 270 59
1869 ... do	297, 382, 750	895, 272 13	do	713, 718 60		713, 718 60
1870 ... do	288, 479, 287	797, 194 08	do	692, 350 31	$2 04	692, 352 35
1871 ... do	283, 993, 799	800, 454 49	do	681, 585 16	255 00	681, 840 16
1872 ... do	258, 232, 807	788, 893 38	do	619, 758 77	2, 295 95	622, 054 72
1873 ... do	5, 028, 432	16, 022 40	do	12, 068 23	19 20	12, 087 43
1873 ... do	334, 465, 685	1, 238, 795 27	12 cents per 100 pounds	401, 358 72	56 80	401, 415 52
1874 ... do	358, 375, 496	1, 452, 160 74	do	430, 050 49	115 81	430, 166 30
1875 ... do	318. 673, 091	1, 200, 541 36	do	382, 407 65	139 51	382, 547 16
1876 ... do	331, 266, 140	1, 153, 479 80	do	397, 519 23	250 32	397, 769 55
1877 ... do	359, 005, 742	1, 059, 941 12	do	430, 806 79	5 15	430, 811 94
1878 ... do	352, 109, 963	1, 062, 995 47	do	422, 531 98	14 06	422, 546 04
1879 ... do	375, 286, 472	1, 150, 018 49	do	450, 343 74	284 69	450, 628 43
1880 ... do	400, 970, 531	1, 180, 082 42	do	481, 164 55	30 59	481, 195 14
1881 ... do	412, 442, 291	1, 242, 542 55	do	494, 930 73		494, 930 73
1882 ... do	329, 969, 300	1, 086, 931 62	do	395, 963 07	317 81	396, 280 88

Consumption of imported salt—Continued.

IN BULK.

1862 bushels	1, 577, 814		4 cents per bushel	63, 112 56		341, 760 49
1862 pounds	232, 206, 610		12 cents per 100 pounds	278, 647 93		
1863 do	61, 694, 825		do	74, 033 79		569,918 69
1863 do	275, 491, 612		18 cents per 100 pounds	495, 884 90		
1864 do	323, 650, 300		do	582, 570 51		582, 570 51
1865 do	263, 223, 699		do	473, 802 66		473, 802 66
1866 do	265, 745, 171		do	478, 341 29		478, 341 29
1867 do	229, 304, 323	336, 301 46	do	412, 747 78		412, 747 78
1868 do	219, 975, 096	365, 457 66	do	395, 955 17		395, 955 17
1869 do	256, 765, 240	351, 167 72	do	462, 177 43	612 83	462, 790 26
1870 do	349, 776, 439	507, 873 85	do	629, 597 48	77 58	629, 675 06
1871 do	274, 730, 573	355, 318 07	do	494, 515 01	482 64	494, 997 65
1872 do	257, 637, 230	312, 569 56	do	463, 747 03	712 15	464, 459 18
1873 do	18, 103, 215	20, 516 80	do	32, 585 77	7 62	32,593 39
1873 do	369, 908, 917	505, 068 00	8 cents per 100 pounds	295, 927 08	371 91	296, 298 99
1874 do	427, 294, 209	649, 837 96	do	341, 835 22	203 30	342, 038 52
1875 do	401, 270, 315	549, 110 67	do	321, 016 22	403 86	321, 420 08
1876 do	379, 478, 218	462, 105 79	do	303, 582 44	189 58	303, 772 02
1877 do	444, 044, 370	532, 830 68	do	355, 235 41	275 03	355, 510 44
1878 do	414, 813, 516	483, 908 52	do	331. 850 76	241 67	332, 092 43
1879 do	434, 760, 432	532, 705 90	do	347, 808 06	97 77	317, 905 83
1880 do	449, 743, 872	548, 425 24	do	359,795 12	357 94	360, 153 06
1881 do	529, 361, 042	658, 067 64	do	423, 488 77	18 28	423, 507 05
1882 do	399, 100, 228	474, 200 12	do	319, 280 06	60 74	319, 340 80

USED IN CURING FISH. (*a*)

1870 do	68, 597, 023	87, 048 25				
1871 do	64, 671, 139	66, 007 73				
1872 do	57, 830, 929	60, 155 05				
1873 do	86, 756, 628	86, 193 23				
1874 do	105, 613, 913	126, 895 72				
1875 do	110, 249, 440	119, 607 29				
1876 do	118, 760, 638	126, 276 00	Free of duty	Free of duty	Free of duty	Free of duty.
1877 do	132, 433, 972	140, 787 34				
1878 do	100, 794, 611	96, 898 00				
1879 do	94, 060, 114	95, 841 00				
1880 do	109, 024, 446	119, 667 00				
1881 do	133, 395, 065	144, 347 00				
1882 do						

a By act of July 28, 1866, salt withdrawn from bond and actually used in curing fish was exempted from duty. No data as to salt so withdrawn can be given for the fiscal years 1867, 1868, and 1869.

THE SALINES OF LOUISIANA.

By E. W. Hilgard.

A salt-bearing formation appears in Louisiana in two widely separated portions of the State, and under two different aspects. One is a group of salty flats, or "licks," in the northwestern part, in the parishes of Webster, Bienville, and Winn, northward of Natchitoches; the other is the great rock-salt mass of Petite Anse, or Avery's island, situated in the sea marsh on the shores of Vermilion bay. At first sight the phenomena in the two regions seem utterly unlike; but a close examination made by the writer in 1869 seems to connect them very distinctly as portions of one and the same formation, the (Upper) Cretaceous. As the data leading to this conclusion are mainly derived from the salines of Northwest Louisiana, these, though practically the least important, will be first described.

SALT LICKS OF NORTH LOUISIANA.

The "licks" mostly form part of the bottom or second bottom of the water-courses, and vary from a few acres to over one hundred in extent. They are usually destitute of trees, but are partially at least covered with the usual salt vegetation, including several species of sal-soda, samphire, and salt-marsh sedges; some red cedar also occurs. The soil is whitish and silty and often incrusted with salt; its level is usually above ordinary stages of water. Ordinarily, no outcropping rocks connected with the licks are to be seen; but, not uncommonly, roundish, gnarled calcareous concretions may be noted on the surface. In the surrounding, mostly hilly and sandy country, timbered with oaks and short-leaf pine, the body of the ridges is formed of dark-colored clays and sandy materials of the lignitic Tertiary, containing at times ledges of a ferruginous rock with Tertiary (Claiborne) fossils; while the crests are most commonly topped with the ferruginous sands of the southern stratified drift ("Orange sand"), frequently indurated into a ferruginous sandstone, void of fossils and frequently used for building fireplaces and chimneys, as the only available country rock.

From some of the licks, salt springs flow into the adjacent streams, and around these the Indians were in the habit of congregating for the purpose of boiling their supplies of salt, and their baskets and pottery are still found in digging. Of course the licks were also resorted to by wild, as they now are by tame, animals of all kinds, and numerous bones are found wherever pits are dug; some of the mastodon have been especially noted.

In early times the settlers of the surrounding country resorted to the licks annually to boil their supplies of salt; but for some time prior to the civil war, as at present, the localities were deserted, the old furnaces and pits alone indicating their previous occupancy. During the war they again became the scene of great activity, companies, neighborhood delegations, and families flocking to them for a supply of the much-needed article, which was not only distributed to the "trans-Mississippi" department of the Confederacy, but also crossed the Mississippi, going as far as Alabama and Georgia, alongside of the Petite Anse rock salt. The salt water, probably never exceeding from 2 to 3 per cent. in strength, was pumped from pits or wells dug to the depth of 15 to 20 feet in the flats, and was boiled in sugar kettles or farm boilers of all kinds and sizes, set in rude furnaces built of the ferruginous rock mentioned. The remains of scorces of such dot the flats. A royalty was usually paid the owner of the ground per bushel of salt. As these features are substantially the same in all of the licks, only a few details regarding each need be mentioned.

The most northerly of the licks lie on the eastern shore and near the head of Lake Bistineau; hence a not uncommon but very erroneous impression that the waters of that lake are salty. The writer has not visited the Bistineau licks, and has been unable to obtain any details regarding them, save that they form flats along the shore, overflowed at high water, the largest of which is near the point where the Vicksburg and Shreveport railroad crosses the lake near the northwest corner of township 17, range 22 west. Here, as elsewhere, the salt water has been obtained chiefly from pits or shallow wells dug in the flat. This locality was during part of the war regularly occupied by a manufacturing company.

An examination of a sample of Bistineau salt received by the writer in 1862 gave the following results. The salt was of a grayish tint, quite fine, having evidently been scooped out of the boilers during the process, and somewhat moist. On treatment with water about 5 per cent. of insoluble, apparently earthy sediment remained; the salt in solution consisted of:

Chloride of sodium (by difference)	99.68
Chloride of calcium	0.17
Chloride of magnesium	0.10
Sulphate of calcium	0.05
	100.00

Considering the rude appliances and primitive mode of operation by which this salt was produced, its purity is rather remarkable.

About 18 miles to the southwest, on section 34 of township 15, range 20 west, is "King's lick," on the banks of bayou Castor, a tributary of Black Lake bayou. It is about 10 acres in extent, and in the flat a number of pits have been dug, most of which do not reach beyond the silty alluvial material. Some, however, reached a soft calcareous marl, containing a multitude of small oysters, among them *Gryphæa pitcheri* and *Exogyra costata.* In the deepest pit a hard and partly crystalline limestone is laid bare, containing the same oysters and also a *Janira*, many fine specimens of which are said to have been carried off as curiosities. This is the first locality in which the existence of Cretaceous outcrops in Louisiana was demonstrated.

Eighteen miles due east of King's lick, on section 34, township 15, range 17 west, is Rayburn's lick, one of the most extensive. The phenomena here differ from those at King's only in this, that the limestone is of a peculiar banded structure, very crystalline and above frequently passing into similarly banded calcite masses; it is underlaid by a bed of gypsum rock; no fossils were noted here. The following is a section of the pits:

	Feet.
Gray or blackish alluvium	6
Gravel conglomerate, soft	6–7
Limestone with band of calcite	6
Massive gypsum, thickness unknown.	

It was from beneath the gypsum, through crevices, that the salt water seemed to rise.

About 11 miles south of Rayburn's, on section 26, township 13, range 17 west, is Price's lick, a horseshoe-shaped flat on Cypress bayou; resembling the others in every particular, with abundant saline flora and calcareous concretions on the surface, also some small globular or pisiform lumps of vivianite. The pits here were very shallow and the brine stronger than anywhere else. Limestone has apparently not been reached here, the dumps of the pits showing the gray laminated clays of the Tertiary lignitic only.

About six miles south-southwest from Price's, on section 22, township 12, range 17 west, is the locality of what is best known as Drake's salt works, on the banks of Saline bayou. The licks here extend for a mile and a half along the bayou, their character being the same as usual. At their northern end, on the east bank, a number of artesian bores have been made. One is 1,011 feet in depth, and runs a constant stream of from 18 to 20 gallons of weak salt water per minute; it is said to have been sunk in solid limestone all the way. The water rises to 35 feet above the mouth when in pipes. The dumps of these bores have disappeared, but some fragments remaining show a rock partly crystalline, partly substantially identical with the "rotten limestone" of Mississippi and Alabama. The salt water is said to have decreased rather than increased in strength as the bore deepened; but the detailed records cannot now be obtained. The borehole mentioned is one of eight bored here about 1845, all of which throw water above surface level when clear. Failing to obtain brine of adequate strength, Mr. Drake abandoned salt-making; but it was resumed during the war, when for awhile a considerable amount was made, largely by squatters, who actually destroyed the works and mills. An analysis subsequently made of the water of the flowing well showed it to contain about two per cent. of solid matters, consisting of:

Chloride of sodium	93.30
Chloride of magnesium	1.78
Carbonate and sulphate of calcium	4.92
	100.00

Some distance west of the bayou and licks, there are outcrops of fossiliferous rocks on bluff hillsides. These have been ascertained by Prof. F. V. Hopkins, then in charge of the Geological Survey of Louisiana, to be of Tertiary age.

Another, but quite small lick, called Cedar lick, lies about 3 miles soutwest of Winfield; it resembles the others in all respects, has a spring of pretty strong brine, but no pits have been dug and the presence of the limestone has not been ascertained. But about 7 miles west-northwest from this lick, on a direct line to Drake's lick, there is a rocky hill, rising some 60 feet above the drainage of the country, and consisting of precisely the same crystalline, banded limestone found in the pits at King's and Price's licks, strongly contrasted with the Tertiary rocks near its base. It is the highest point at which the Cretaceous rock appears in Louisiana; there are probably, however, some other points than those mentioned at which it comes near the surface, viz., the neighborhoods of Rochester and Louisville, located respectively in townships 13 and 14, range 16 west, northeastward of Price's lick. Here there are small calcareous prairies which may possibly be formed by Tertiary limestone, but are more probably due to the approach of the Cretaceous material to the surface.

The entire series of observations goes to prove the existence of a mostly subterranean and doubtless anticlinal Cretaceous ridge, extending from the Cretaceous area of Arkansas in a southwesterly direction into Louisiana, where it would strike Red river about or somewhat below Natchitoches, thus tending (as will be noted directly) towards Vermilion bay. On either side, marine and brackish Tertiary beaches adjoin north of Red river. (*a*)

This alone would of course be a mere conjecture, were there no intermediate outcrops to indicate the continuance of the ridge. One such, however, actually exists in the parish of Saint Landry, about 9 miles southwest of Chicotville. Here a limestone deposit, undistinguishable from that forming the hill near Winfield, banded, crystalline, porous, and, so far as seen, non-fossiliferous, and at the same time utterly unlike that of any of the Tertiary groups, appears in a hill near the banks of Boggy bayou, and supplies a limekiln. A comparative analysis has shown the rocks from the two localities to be strikingly alike in composition also, and to differ widely in this respect from the Tertiary rocks.

a See Second Annual Report of the Geological Survey of Louisiana, 1870, p. 4 and FF.

This outcrop again lies on a direct line between the licks of northwest Louisiana and Petite Anse island.

As a matter of course, the licks are at present, under ordinary circumstances, of little importance in an economic point of view. It is stated that in the deeper pits the brines were so abundant that the pumps never made any impression upon them; but their weakness would forbid the manufacture of salt without the aid of solar evaporation, save in the case of such emergency as that existing during the civil war. Their total product during the war can only be conjectured; but it is stated that at Rayburn's lick alone the daily output was for some time over 1,800 bushels daily, and the detailed consideration given them here is justified by the bearing upon the true character and possible extent of the remarkable rock-salt mass of Petite Anse.

ROCK-SALT MASS OF PETITE ANSE.

Topography and geology.—Petite Anse is one of a series of five "islands" extending from the eastern shore of lake Peigneur, in a southeasterly direction, to the mouth of the Atchafalaya, at intervals of from 7 to 22 miles. They are Orange island, Petite Anse, or Avery's island, Weeks's island, Côte Blanche, and Belle Isle, and from conspicuous landmarks on the otherwise level coast and marshes and Attakapas prairies, from which they rise abruptly from 85 to (in the case of Petite Anse and Côte Blanche) 180 feet. Belle Isle, the most southerly, is the smallest, having an area of only about 350 acres; the rest average over 2,000 acres. Geologically, all show the series of Quaternary and mostly paludal deposits, corresponding to the profile of the Port Hudson bluff, overlying (certainly in the case of Petite Anse and Weeks's island, and probably in all) a nucleus of semi-indurated sands and gravels (corresponding to the stratified drift or "Orange sand" of the southwest), the surface of which shows undulations as great as those of the present surface. Underlying these is found, at Petite Anse, the mass of rock salt.(*a*) The overlying paludal and fluviatile clays and loams frequently contain freshwater shells, or, in place thereof, bands and sometimes ledges of calcareous nodules or nodular limestone, which on the seaward face of Côte Blanche is very abundant and crystalline. Beneath this lies at this island a stratum of paludal clay, with lignite seams and cypress stumps; and a similar deposit is found at the seaward foot (mostly marsh) of the other islands. It should be understood that no cypress is at present ever found within the limits of the salt marsh; hence at the time these cypress swamps existed, the surrounding conditions must have been quite different from those now prevailing. It is not certain that all these swamps are older than the higher portions of the islands.

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a See general profile of this island in the writer's memoir, Smithsonian Contribution No. 248, where also a general map of this and detailed description of the other islands are given.

Petite Anse is of rounded bean shape, the longer diameter northwest and southeast, a concavity to the southeast. Its western half is closely hugged by the bayou Petite Anse, while on the east it touches the *cypres-mort* woods and cypress swamps, leaving more than two-thirds of the base surrounded by marsh, across which on the landward side (towards New Iberia) a causeway 2 miles in length has been built. The greater part of the island is hilly, but on the east there is a considerable tract of level cultivated fields. The main ridge is of a U-shape, with its vertex and highest point (Prospect hill, 180 feet) toward the north, falling off rather steeply into the marsh; opposite, near the concavity on the south, and in a small valley but a few hundred yards from the edge of the marsh, is the flat or lick beneath which, in May, 1862, the rock-salt mass was found by Mr. J. M. Avery, at the bottom of a pit sunk for salt water.

That the place has been resorted to for the same purpose from ancient times is obvious from the numberless vestiges of the visits of both men and animals that have been found in such pits. "Mastodon, buffalo, deer, and other bones; Indian hatchets, arrow-heads, and rush baskets; but above all, an incredible quantity of pottery fragments have been extracted from the pits. The pottery fragments form at some points veritable strata 3 to 6 inches thick; this is especially the case where Mr. Dudley M. Avery found what appeared to have been a furnace for baking the ware (a process very imperfectly performed), and near it three pots of successive sizes, one inside the other. The pots must be presumed to have served the purpose of salt-boiling, for although human handiwork has been found so close to the surface of the salt as to make it probable that its existence was once known, yet the boiling process alone has been resorted to within even traditional times." (*a*)

Subjoined are profiles of the strata found overlying the salt: one from the record of an air shaft recently sunk in the detrital portion of the valley, as reported by the superintendent, Mr. Crooks; the other, that observed in the shaft sunk in 1868 by Mr. Charles Chouteau, at a point on the hillside to the eastward:

I.—*Profile of Chouteau's upper shaft.*

	Feet.
6. Soil	¼
5. Yellow and brown loam	2
4. Ferruginous sand, rather loose above, more coherent below; grains rounded, and white pipeclay intermixed	18
3. Gravel, small above, large below	2
2. Bluish pipeclay and sand, interstratified	6
1. Rock salt	

II.—*Profile of new air shaft.*

9. Sandy surface soil, of many layers	6
8. Black waxy earth, free from sand below	2¼
7. Soil and sand mixed	2

a See memoir 248, p. 14, *op. cit.*

	Feet.
6. Light-colored sand	2
5. Black waxy earth, like marsh mud, with fragments of burnt and ornamented pottery	4
4. Light drab-colored sand	1½
3. Yellow sand, with some clay	½
2. Dark sand, with gravel up to fist size	½ to 6
1. Rock salt	

Profile No. II. is fairly representative of the varied layers and materials usually found in the salt flat itself. They frequently correspond strikingly to those constituting the adjacent hillsides, from which they have evidently been gradually washed down. The remains of animals are found most abundantly in the layer of shingle and earth immediately overlying the rock salt itself, which has therefore probably been once licked by mastodons. It is stated that mastodon bones have been found in contact with rush baskets; but in detrital deposits manifestly full of old pits, little importance can be attached to such proximity as proof of contemporaneousness.

Profile I. represents properly the geological position—the rock salt overlaid by the characteristic deposits of the stratified drift (including large Palæozoic pebbles), and this again, as elsewhere in the island, by the Port Hudson beds. The formation of the salt mass therefore antedates the drift period at least, nor is there within the Quaternary age any epoch to which we could with any show of probability assign the evaporation of sea-water during the long periods of time required for the production of such large masses of pure salt, unmixed with any of the usual by-products of such a process. Our only choice lies between the Tertiary and Cretaceous formations. Of these, the former has not anywhere in the Southwest shown any signs of salt deposits; while the latter, as has been shown, is strongly thus characterized in northern Louisiana, and the outcrops of its rocks reach to within 60 miles of Petite Anse, with a trend in that very direction. Moreover, the same rock precisely, associated again with gypsum, is found in the same latitude as Petite Anse, in the boreholes sunk for petroleum on the west fork of the Calcasieu river. It here overlies the great sulphur bed, and is itself overlaid by the well-characterized sandy fossiliferous limestones of the Tertiary, which crop out on the Sabine river 80 miles to the northward, and are there as completely devoid of gypsum, salt, sulphur, and crystalline limestones as they are from Vicksburg to South Carolina. From direct indications, then, as well as by exclusion, the Cretaceous age of the Petite Anse salt is almost beyond question.(*a*)

Historical data.—Upon the discovery of the solid salt in 1862 there quickly came a rush for a supply. The confederate government caused examination to be made, which resulted in the establishment of a very

a See for details the writer's "supplementary and final Report of A Geological Reconnoissance of Louisiana," New Orleans, 1873.

irregular system of exploitation by numerous pits, intended to supply as quickly as possible the pressing wants of the blockaded section.

For some time these works, together with the brine pits of northwestern Louisiana, supplied the whole of the southwest; until in April, 1863, the taking of the island by the Federal forces put an end to operations. It is impossible to form an estimate of the total amount then extracted (a); but it was found that the surface of the salt is very undulating (ranging from 7 feet above to 25 feet below sea level), conforming in a measure to the inequalities of the present surface.

The first scientific observer who afterwards visited the island, so far as known, was Prof. Richard Owen (November, 1865). He ascertained the sedimentary character of the formations, as against the theory of a volcanic origin, previously mooted. He attributed the formation of the rock-salt mass to inundations from storm tides. (b)

In November, 1866, Prof. Chas. Goessmann made an examination of the deposit, mainly from a practical standpoint, under the auspices of the American Bureau of Mines. His able report (c) is exhaustive on the technical part of the subject, and the notes and specimens furnished to the writer by him were of essential assistance in his subsequent explorations.

In November, 1867, the writer was enabled to respond to an invitation previously given by the Secretary of the Smithsonian Institution, to undertake a full exploration of the region with a view to the determination of the geological relations of the salt deposit. This exploration only determined, so far as the age of the deposit was concerned, that its formation antedated the drift period, and could not well be ascribed to local causes, (d) no more definite conclusion being warranted by what was then observable on the spot. At that time the regular workings consisted of a shaft 8 by 8 feet, 83 feet in depth, of which distance 58 feet was in the solid salt. From this shaft galleries 8 to 10 feet high by 25 feet wide had been driven east and west to distances of about 150 feet each way. The work had been prosecuted for some time under the auspices of Mr. Chas. Chouteau, of Saint Louis, but was finally abandoned by him, chiefly on account of the difficulties of transportation, the bayou Petite Anse being obstructed by a bar at its mouth, and the bayou Teche being 10 miles distant, Morgan's Texas and Louisiana railroad then terminating at Brashear City. When it was subsequently extended so as to pass within 7 miles of the mine, no satisfactory arrangement for a branch road and transportation could be made. The work in the mine thus languished, though resumed at intervals in efforts to bring the salt into

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a It is estimated by Mr. D. M. Avery as high as 30,000 tons.

b *American Journal of Science*, July, 1866, p. 120.

c Report of the American Bureau of Mines on the rock-salt deposit of Petite Anse, 4to, New York, 1867.

d See the writer's paper on the Geology of Lower Louisiana and the rock-salt deposit of Petite Anse island, *American Journal of Science*, January, 1869.

market demand, and always supplying the families on the island. A company took up the work in 1878 and 1879, but did little additional work, only deepening a part of the existing galleries. The total output from the shaft and galleries may be estimated to have been about 5,000 tons up to 1880.

The American Salt Company, now holding the lease of the mine, began work in July, 1880, and after a careful survey adopted a regular plan, which has been pursued ever since. (*a*)

Plan and details of work.—Two large blocks, about 180 by 280 feet each, are left on either side of the working shaft for the support of the buildings above. Beyond this the mass is to be worked by a system of chambers and cross-headings 35 to 42 feet wide by 65 feet in height, leaving a roof of 55 to 60 feet of solid salt above, and pillars of the same diameter as the chambers (42 feet square) for its support. In pursuance of this general plan, the work has now been pushed to a distance of 270 feet east and 370 feet west from the shaft, with no perceptible change in the salt mass. The cross-headings have reached a distance of 190 feet each way (north and south) from the center line of the main gallery on the west, and 80 feet north on the east. The block of rock salt thus presumably outlined up to the present time is therefore a rectangle 640 by 380 feet. At the same time the shaft has been sunk to the depth of 190 feet from the surface, or through 165 feet of solid salt, still unchanged in character. This brings the estimate to over 40,000,000 cubic feet, or about 2,800,000 tons of salt. If we suppose all the present headings to be close to the limits of the salt mass, the latter still exceeds 2,000,000 tons, now in sight. So far, however, there is no indication of a change in character, such as would be expected to indicate any natural termination. On the other hand, surface explorations by pits have demonstrated the existence of the salt over an area of 144 acres, or more than ten times the area now outlined by the workings, so that if the mass should prove to be continuous over that area in thickness as well, the above estimate would have to be multiplied by ten. Accordingly the company's engineer in his report estimates the amount of salt in sight to be in round numbers 28,600,000 net tons.

The only indication of structure shown by the coarsely crystalline mass (*b*) is a nearly vertical lamination, similar to the rings of a tree, and three to four inches apart. This lamination does not, however, manifest itself very perceptibly in the splitting of the mass in blasting,

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a For an interesting and full report of the work of this company and of the present condition of the mine I am indebted to Mr. William Crooks, general manager. What follows is chiefly abstracted from his report.

b The remarkable solidity and uniformity of the rock-salt mass is well demonstrated by the fact that the mine is practically dry, so long as water is prevented from entering the shaft, and this notwithstanding the abundance of water existing at its surface and entering the pits dug for brine, amounting in some cases to lively streams carrying quicksand. Only a trifling ooze has occasionally come in through obscure seams.

which is now done by means of dynamite, so as to prevent the objectionable blackening of the salt.

The headings are worked by first undercutting on the level of the floor to a height of about 8 feet, to the full width of the gallery, and always considerably in advance of the face, so as to be prepared for any sudden large demand. The undercutting consumes on an average about four pounds of powder per cubic yard, while the blasting away of the overhanging salt requires only about one pound for the same quantity. This work is carried on entirely by hand by means of borers operated by two men, on the principle of the "drill press." These machines were imported from Germany in deference to the preferences of the Stassfurt miners, who constitute almost the entire force. These drills seem to be no better in operation, however, than those used in the anthracite mines of Pennsylvania. Two men bore and fire 12 holes of 5 feet depth during a shift of eight hours. The uncertainties of tariff legislation have thus far prevented the employment of power drills, which would be especially advantageous in the undercutting. The miners work by the piece (*i. e.*, cubic yard), earning $2.50 to $3 per day, or even more, according to skill. The laborers who break up the salt work by the day, making $1.50 to $1.75.

After blasting, the salt is broken with sledge-hammers to a suitable size for loading into the mine cars, which are then hoisted bodily to a platform about 70 feet above the surface, then dumped into a chute which screens out the small and conveys the larger lumps to Blake crushers, working some feet below. These crumble the salt to about the size of coarse solar or Turk's Island salt, say from the size of a bean to that of a hen's egg. From the crushers the salt falls into a bin which feeds the mills. These are French buhrs, underrunning, such as are used in grain-mills, 36 inches in diameter, and making 350 revolutions per minute. They will each grind nine tons per hour to a grade corresponding to Liverpool coarse salt; by closing or opening the mills the salt can readily be ground to any desired degree of fineness. From the mills it passes directly into packages for market, which are most commonly sacks holding 200 pounds, and barrels of 280 pounds, which can be at once delivered to the cars. For the use of farmers and stockmen it is also shipped in large lumps.

Shipment.—Unable to make satisfactory arrangements with Morgan's railroad, the present company cut a canal from the bayou through two miles of marsh to the deep water of Vermilion bay, the work occupying a year. Since its completion the salt has been shipped by a fleet of steamers and coasting vessels to Galveston, New Orleans, and Mobile. Lately, however, arrangements have been perfected with the new management of the railroad, a branch of which was to have been completed to the mine May 1, 1883, thus connecting it with the entire Huntington system and its connections. Last year large quantities of a grade corresponding to the Turk's island salt were shipped to the extensive packing houses at Chicago, Milwaukee, and Kansas city. The article was found to be especially adapted as "heading" salt for packer's use, both on account of its purity and the slowness of its dissolution. Large orders from these points have been renewed, and it is hoped that hereafter it will be extensively employed in the packing business of the West. On account of its freedom from bittern and consequent dryness, it is especially liked for table and domestic use. This purity, apparent on mere inspection, is more definitely shown in the analysis made at different times of samples from different parts of the mine. Of these the two given below are extremes, showing from 98.73 to 99.88 per cent. of chloride of sodium; while others, made successively by Professor Riddell, Dr. Goessmann, and others, range from 98.88 to 99.60, the impurities being chiefly gypsum and small amounts of the chlorides of magnesium and calcium.

Analysis by E. W. Hilgard, 1863.

Chloride of sodium	99.880
Chloride of calcium	trace.
Sulphate of calcium	0.126
	100.006

Analysis by Mr. F. W. Taylor, analytical chemist, Smithsonian Institution, March 10, 1882.

Sodium chloride		98.731
Calcium sulphate		1.192
Calcium chloride		trace.
Magnesium chloride		0.013
Silica	Insol.	0.024
Iron sesquioxide	Insol.	0.010
Water		0.030
		100.000

Production.—The total output by the present company up to March 20, 1883, was 60,000 tons. During 1883 it is expected to average 200 tons daily.

Origin and probable extent of the salt mass.—The great thickness and uniformity of the salt mass, both vertically and horizontally, points to its origin in the long-continued evaporation of some very large body of sea water. Nothing like a mere lagoon could have produced a mass so large and so little contaminated with the accompanying ingredients, gypsum, bittern, etc. This is especially striking if the vertical lamination reported by Mr. Crooks may be regarded as lines of successive deposition, so that the horizontal dimensions are to be taken as representing the thickness of the deposit. There is no phase of the Tertiary history of the Gulf of Mexico—its gradual shallowing and regular recession from the head of the estuary near Cairo—that seems to admit of any such process taking place in the locality where we find this mass. The Cretaceous period, on the contrary, witnessed the laying dry of inland ocean beds on a stupendous scale; so that brines freed from their gypsum by concentration elsewhere may have been subjected to evaporation in many minor basins. The gypsum occurs abundantly in the saline strata of north Louisiana, associated with manifestly non-zoögene limestone;

and similarly in the bored wells of Calcasieu. Most of the corresponding salt brine doubtless reached the ocean; some may have been retained in basins on the plateau of the Cretaceous ridge, and the Petite Anse mass may be the remnant of such a basin.

But how did this mass escape solution in the Tertiary ocean, and in the great floods of the drift? We know that the latter scoured its surface into hills and valleys, and finally covered the salt with its own deposits. Prior to that time the submarine ridge now marked by the Cretaceous outcrops above described, jutting out diagonally across the axis of the Tertiary embayment, would have naturally received an extra share of slackwater deposits, such as would soon protect the salt mass from rapid solution. If the latter should actually prove to be "set on edge" that position might be inferred to have resulted from tilting, caused by undermining, with at least as much probability as would attach to the theory of upheaval. But for this indication of the banded structure, we might hope that the salt mass were still conformable to the rest of the formation and connected with it, and, therefore, likely to be continuous over a long distance. The failure of borings made in the other islands to disclose any saline deposit or older rocks, can hardly be held to be conclusive, on account of their shallowness. In any case it seems reasonable to suppose that the "Stassfurt salts" belonging to the salt mass have long ago been washed into the general ocean, and that so far as it reaches, it will (apart, perhaps, from gypsum) continue to be found as pure as now.

BORAX.

Limited area.—Nowhere in the United States have any considerable deposits of this valuable salt been found except in California and Nevada, where it occurs at a number of localities, in some of which it is found sufficiently concentrated to render them available for working. In some of the hot springs in the Yellowstone valley, Montana, boracic acid forms occasionally as much as 6 per cent. of the residue on evaporation, but generally the tenor is less than 1 per cent.

Discovery of borax in California.—The first discovery of this mineral in California is due to the late Dr. John A. Veatch, a close student and careful observer, who, as early as 1856, having detected the presence of boracic acid in the waters of certain mineral springs, followed up this clew, visiting many similar springs and various salines, until at last, after much search and many disappointments, he came upon quite a large deposit of borax resting in the bed and about the margin of a marsh or pond situated on the easterly border of Clear lake, in Lake county, California.

The finding of this deposit was not the result of mere luck or accident, as has so often been the case in the discovery of valuable mineral deposits. Dr. Veatch, being thoroughly informed as to the conditions under which the salt is apt to occur in nature, after having his interest awakened by meeting with some traces of it in his travels, sought long and diligently for those peculiar salines which usually constitute its habitat. Many months were spent in going from one alkali flat or group of thermals to another before his researches were rewarded with even a partial success, for such, in the light of subsequent events, is all that can be claimed for this first find on the border of Clear lake.

The more available portions of this deposit consisted of solid, semi-opaque crystals imbedded in the mud at the bottom and around the edge of this pond, the mud itself and the marshy soil in the vicinity being also impregnated with borax, both in the form of minute crystals and as boracic acid. Only near the center of the pond, however, were the crystals found of large size and in great abundance. Here they occur to a depth of 10 feet in a tenacious blue clay covered with a foot of softer mud. In this stratum of clay the crystals varied from a few grains to ten or twelve ounces in weight. Elsewhere they were found much smaller, the most of them being of microscopic fineness.

First attempts at working.—Following the Veatch discovery, the California Borax Company was formed for working these deposits, the only material attempted to be utilized consisting of the larger crystals imbedded in the mud near the center of the lake. The method of operating employed by this company was as follows: The mud from the bottom of the pool was lifted by a dredging machine and emptied into large vats, through which a stream of water, raised by Chinese pumps, was kept constantly flowing. This stream, carrying off the mud, left only the large crystals freed from all impurities behind. The crystals thus obtained were then dissolved in boiling water and afterwards recrystallized in lead-lined vessels, producing, without further manipulation, an article fit for the market. Although this was a most wasteful method of collecting the crude material, all the finer crystals and much boracic acid contained in the mud flowing back into the lake, the company found no economy in attempting to save it more closely. Had they not been misled on one or two vital points, the company would probably have worked their deposits more carefully than they did from the outset. In the first place they greatly overestimated the quantity of these larger crystals at the start; then, too, these crystals, after the original crop had been removed, reproduced themselves much more slowly than had been expected. Between these two sources of error the company, as time wore on, found their stock of the crude material shortening at a rate which would eventually have forced them to curtail operations, an event that was precipitated by the heavy rains of 1866 and 1867, which so filled up the lake that but little was done thereafter. The discovery of the more prolific Nevada deposits a few years later so reduced the price of borax that the California Company, soon after the mishap mentioned, ceased operations altogether, being unable to manufacture the salt at the low rates so brought about. During the period of their active existence this company produced about 300 tons of refined borax annually, which was sold in San Francisco at an average of 25 cents per pound.

THE PRINCIPAL BORATE FIELDS OF NEVADA.

General characteristics.—The borate fields are situated in the extensive salines known as Teel's marsh, Rhodes's marsh, the Columbus marsh, and Fish Lake valley, all in the southeasterly part of Esmeralda county. These salines consist of oval-shaped alkali flats occupying the centers of immense basins, and cover from 10,000 to 20,000 acres each. These basins are surrounded for the most part by a broad margin of sage plains which rise gradually to the base of the hills and mountains which inclose them on every hand. They have no outlets, and, receiving the drainage of the country around, retain everything brought into them, including the borates and other salts of various kinds. From midsummer till late in the spring, when the snow commences to melt on the mountains, these saliniferous lands are, as a general thing, apt to be dry, only shallow lakes occupying sometimes their points of greatest depression. At other seasons of the year portions of them are covered with water to the depth of a foot or two. Heavy rains, though these seldom occur in this region, convert these alkali flats into beds of tenacious mud, even a slight shower rendering their passage by teams difficult for the time being. Water can be obtained on these salines almost anywhere by digging from 2 or 3 to 10 or 15 feet below the surface. It is generally brackish, however, often so much so as to be scarcely fit for drinking. By digging to much greater depths good water is obtained a short distance back from the edge of the marsh. Over large sections of these flats exist deposits of common salt, carbonate of soda, and borax. This latter mineral does not, however, occur here, as at Clear lake, California, in the shape of compact, semi-opaque crystals inclosed in mud, but generally in the form of the borate of lime or soda. The former is found at many spots imbedded in these marshes from 1 to 4 feet below the surface. It crystallizes in long, silky fibers which gather into balls from an eighth of an inch to 2 or 3 inches in diameter. These globular masses have the luster of white satin, and when dug up readily separate from the inclosing earth. The borate of soda mixed with sand and other impurities accumulates on the surface in the shape of a dark colored incrustation an inch or two thick. This crust when dry, being hard and brittle, can be easily detached from the moister ground beneath and broken into fragments.

Fish Lake marsh.—This is the most southeasterly saline of this group, and covers an area of some 10,000 acres, occupying the center of a basin three times as large. Commencing at the northern end of this marsh, or, rather, alkali flat, we come first upon a cluster of small mounds covered with a white incrustation from 6 to 8 inches thick, and carrying about 20 per cent. boracic acid and 45 per cent. of other soluble salts, the surface soil in this portion of the flat being also slightly charged with similar substances to the depth of several feet. A good deal of the crude material could be, and, in fact, has been, collected here without much labor. A little farther on is found a patch of nearly 100 acres covered with an efflorescence of the various salts, borates included, and which, being moist, flaky, and of a dazzling whiteness, might easily be taken for fallen snow, the illusion being strengthened by the manner in which this stuff can be compressed into balls that harden, still retaining their forms after the moisture escapes. At this spot the borates mixed with the chloride of sodium, soil, and other impurities can be gathered up without much trouble.

Proceeding south, a patch of 40 or 50 acres is crossed, where the borates of lime and soda lie on the surface, but so mingled with the grass roots and earth that much worthless stuff would have to be taken up in the process of gathering them. This, when attempted, is usually done with a broad wooden hoe. Continuing in this direction, we arrive successively at several large tracts, the whole embracing 400 or 500 acres, where the borates occur, either in the form of an efflorescence on the surface or imbedded in the ground. On some parts of these tracts and over large areas outside of them a thin crust of borate of soda covers the surface; the most of it, however, is of too low grade to be of present value. Scattered over this saline are numerous small spots, rich in the borate of lime, and from which a good deal of this material has already been taken. What is here said of the borate deposits in Fish Lake valley will apply largely to those elsewhere in the great Utah basin, to which they are mostly confined, the general features of these salines being much alike. This valley is, however, marked by this peculiarity: It contains several thousand acres of good farming land and natural meadows, whereas the other marshes are wholly barren. This exceptional fertility is due to a number of small creeks, which, flowing from the mountains, make their way out into the middle of the flat. Aided by artificial irrigation, fair crops of grain and vegetables are raised on this land.

The Columbus marsh.—This lies 12 miles north of Fish lake, with which it is connected by a narrow valley. While a large portion of this marsh is covered with a thin crust of common salt, it affords but comparatively little borate of soda. At its lower and northerly end, however, where the drainage has brought in and left the various salts leached from the immense watershed around it, a heavy bed of borate of lime has been formed. During the dry season this deposit, through accumulations of the salt coming up from below, suffers marked enlargement, swelling up as if undergoing a process of fermentation. With the advent of wet weather, the moisture dissolving and scattering the salt, the mass suffers a corresponding shrinkage. Under a bed of clay about 2 feet thick a layer of sulphate of soda occurs, beneath which come in alternate strata of clay and sand, both barren of the borates or other valuable minerals. In 1872 the Pacific Borax Company put up a refinery here, at which a good deal of marketable borax was afterwards made. At a later period the company transferred these works to Fish Lake valley, where they have since been operated for a good portion of the time.

Rhodes's marsh.—This marsh is located 12 miles northwest from the Columbus marsh, the mineral deposits of both salt and borax at these two places being much alike. Rhodes's marsh is at all times quite soft, the water coming within a foot or two of the surface, and in wet weather covering the most of it to a depth of a few inches. At the works of the Nevada Salt and Borax Company erected here about one ton of refined borax is made daily. The method employed in manufacturing the salt is as follows: The crude material as collected from the marsh is placed in large receivers and is there dissolved with steam, after which the mass is run into galvanized iron tanks, inside of which are suspended plates of like metal. Here the borax crystallizes on the surface of the iron, a process which is effected in about six days. When completed, the fluid is drawn off with syphons, after which the crystals are removed and packed for market. With some slight variations, the method of manufacture here in use is the one adopted by the other companies.

Besides borax, the company collect here a good deal of common salt, the best of which is ground for table use, the more impure being disposed of to the silver reduction works in the neighborhood.

Teel's marsh, situated 15 miles south of the town of Columbus, is owned by Messrs. Smith Bros., who have put up on the spot a capacious refinery. The deposits here, which are very extensive, have been largely utilized, the aggregate production of these works exceeding that made by any other in the State.

Other borax marshes in Nevada.—Several other marshes exist at other and widely separated points in Nevada. One of these is located near Sand Springs, Churchill county, distant from Columbus over 100 miles. Here a refinery was put up by the American Company in 1870. It contained six tanks holding 2,000 gallons each, and had a capacity to make one ton of borax daily. These Sand Springs deposits, however, proved to be of such low grade that the company gave up the business after continuing it at a loss for several years. At the Hot Springs, 50 miles farther to the northwest, in the same county, occurs another and similar deposit of the borates, and at which a like attempt was made a few years later with like results reached at Sand Springs. In the region of the Mud lakes, in the northwestern part of the State, extensive beds of the borates are reported, though nothing definite is known as to their fertility. They will need to be rich to warrant any effort being made at working them, as this will involve the necessity of wagon transportation for nearly 100 miles over an absolute desert. Besides these marshes, in which this salt occurs in the form of mineralized earths, the waters of certain lakes and springs in different parts of the State have been found to contain a notable percentage of boracic acid. One of these lakes, in the vicinity of Ragtown, Churchill county, was the site of the pioneer enterprise in this branch of production in Nevada. Here, as much as 15 years ago, the manufacture of borax was essayed through the plan of pumping up the water and carrying it out on the adjacent alkali flat, and there leaving it exposed to solar evaporation, which process it was expected would proceed with sufficient rapidity to render the undertaking profitable. But in this there was disappointment, and the scheme, otherwise radically defective, met with early abandonment, the projectors losing much money and producing very little borax.

SALINES AND REFINERIES IN CALIFORNIA.

San Bernardino Borax Company.—On the Slate Range marsh, San Bernardino county, California, and at a point of about 200 miles south from the principal borate field of Nevada, are situated the works of the San Bernardino Borax Company. The deposits at this place, except that they are of rather more than average richness, do not differ materially from those in the vicinity of Columbus, Nevada. The works put up here, in themselves very complete, have been supplemented by every auxiliary that could expedite operations, or otherwise add to their effectiveness. Of all the companies in the field, this is the only one which has been able to run its refinery continuously through the year; such being the mildness and aridity of the climate here that no interruption of operations from wet or cold has ever been made necessary. The company employ a working force of about 50 men the year through, teamsters and mechanics included.

Amargosa Company.—In Inyo county, about 100 miles to the northeast of the Slate Range district, are the borate-bearing deposits of the Amargosa Company, consisting of two tracts; one at the mouth of Furnace creek in the northerly part of Death valley, and the other near Resting Springs, 50 miles to the southeast. The two tracts comprise several thousand acres of land, and are supposed to cover the principal deposits of this salt in this region. A short distance to the south of the Amargosa Company's Furnace creek ground, and in the vicinity of Bennett's spring, are the claims of the Inyo and the Greenland Companies, also in Death valley. The Amargosa Company have already commenced the erection of extensive reduction works on both of their claims, it being their intention to refine borax on a large scale. One, and perhaps both, of the other two companies mentioned, will also put up small refineries during this summer, should the prospect of the business warrant. The works of these several companies will be distant from 120 to 140 miles from the railroad. The intervening country is dry and barren in the extreme.

New discoveries.—Latterly some additional deposits of borax have been discovered in San Bernardino county, near the sink of the Mojave. They are much nearer the railroad than either of the other deposits mentioned. Though probably valuable, neither their richness nor extent have yet been more than partially determined.

Refineries closed.—A number of small refineries in the Slate Range district which suspended operations several years ago, still remain closed, nor will any of them be likely to resume work for the present, their deposits being for the most part of rather low grade.

G BAL STATISTICS, ETC.

Production.—The following table shows the annual and total production of refined borax made in California and Nevada during the past ten years:

	Pounds.
1873	2,000,000
1874	4,000,000
1875	5,433,658
1876	5,180,810
1877	3,727,280

	Pounds.
1878	2,802,800
1879	1,584,966
1880	3,860,748
1881	4,045,405
1882	4,236,291
Total	36,871,958

Adding to the above an estimate of 1,000,000 pounds, made prior to 1873, gives a total product to the close of 1882 of 37,871,958 pounds, equivalent to 18,935 tons of 2,000 pounds each.

The census authorities reported the product for the year ending May 31, 1880, as follows:

Production of borax in the census year 1880.

	Quantity.	Value.
	Pounds.	
California	1,422,443	$107,333
Nevada	2,270,000	169,900
Total	3,692,443	277,233

Of the production made in 1882 the quantities produced at the different leading refineries were as follows:

	Pounds.
The San Bernardino Company	1,540,000
The Teel's Marsh Company	2,099,539
The Pacific Company	251,000
The Nevada Company	82,200
Various small companies	263,552

The production of this salt for 1883 promises to equal, and may slightly exceed, that of 1882, say 2,800,000 pounds (1,400 net tons) for the first six months of the current year.

The borax made in this country finds its chief market in London and New York. Small lots are also exported to Germany, China, Japan, and various other countries, and of these the larger portion goes to Germany.

Exports.—The shipments of borax by sea from San Francisco in 1882 were as follows:

Exports of borax from San Francisco by sea in 1882.

To—	Quantity.	Value.
	Pounds.	
Central America	2,090	$213 35
Japan	32,476	4,225 50
Mexico	2,716	499 64
British Columbia	22,824	2,178 72
Hawaiian Islands, 1 case	232	38 00
China, 3 cases		45 00
United Kingdom	488,518	51,070 00
New York	510,000	56,020 00
Panama, 2 cases		20 00
	1,058,856	114,310 21

In 1882 there were 998,518 pounds carried east by the railroads.

Domestic receipts of borax at San Francisco in 1882.

	Pounds.
January	272,562
February	305,543
March	309,898
April	284,494
May	287,675
June	288,491
July	377,338
August	419,725
September	433,347
October	373,888
November	386,222
December	497,108
	4,236,291

Domestic receipts of borax at San Francisco since 1876.

Total 1882	4,236,291
1881	4,000,200
1880	4,008,600
1879	1,638,400
1878	2,663,000
1877	3,530,300
1876	5,143,000

Composition.—An analysis of a sample of California refined borax, from San Bernardino county, the production of the San Bernardino Borax Mining Company, was made by Mr. Edward Booth for the California State Mining Bureau. It is as follows:

Borax	Water	47.05	99.85
	Biborate of sodium	52.80	
Chloride of sodium			Trace.
Sulphate of sodium			Trace.
Insoluble residue			Trace.
			99.85

An analysis by the same chemist was made of a sample of concentrated borax from the works at Esmeralda county, Nevada, and of the insoluble residue which interferes with its crystallization, as follows:

Borax	Water	46.25	98.93
	Biborate of sodium	52.68	
Chloride of sodium			.50
Sulphate of sodium			.25
Insoluble residue			.38
			100.06

The insoluble residue consists of—

Water	9.00
Organic matter	6.40
Silica	73.32
Sesquioxide of iron	1.42
Lime	3.87
Soda	5.51
	99.52

History of the borax industry on the Pacific coast.—In considering the industrial and commercial history of borax on the Pacific coast, it is found that it has been marked by disappointment and loss almost from the first. Prior to any production being made in Nevada, the price of this salt ruled everywhere at 28 to 35 cents per pound, figures that held with but little variation up till 1872, when the price dropped during the next two years as low as 6½ cents in the San Francisco market. After touching this low figure the price of refined borax underwent some slight improvement and, advancing slowly, reached, about two years since, present rates, 11 to 13 cents per pound in New York, the controlling market in the United States. This sudden, extreme, and long-continued depression in the price of borax was due to the following principal causes, not to mention others of minor import:

As did the pioneer company in California, so did their successors at a later period greatly overestimate the extent and richness of their deposits as well as the rapidity with which the original stock, when removed, would be likely to replace itself. Spreading abroad, these exaggerated reports caused the foreign dealer, fearing an overproduction, to buy sparingly, a course that soon began to work a reduction of prices. The manufacturer, alarmed at this new rival in the field, began also to mark down the prices, making arrangements to enlarge his production at the same time, and thus the market became badly demoralized before these salines had as yet made any large output or any overproduction had actually occurred, this latter being, in fact, an event that never came to pass. Meantime the Nevada producers met with disappointment on every hand. Their deposits were by no means as fruitful as they had anticipated. Being inexperienced in the business, they failed to put their borax upon the market in presentable shape, from which they suffered some discredit. The product of their refineries was disposed of hastily, and through such diverse channels as soon placed them in the attitude of mutual competitors, the hope of each company that they would, through the superior excellence of their deposits or their sharper management, be able to undersell their neighbors, having prevented them from entering into any concerted action. Having been persistently kept up, these evils and errors developed such obstacles as, in the course of a few years, forced every one of these companies to greatly curtail or wholly suspend operations; the production of borax on the Pacific coast having fallen off before the end of 1879 more than seventy per cent. from the largest amount previously made. With some advance in the price that took place in 1880, several works started up again, others having followed as prices further improved, until the present complement was got under way.

In calculating their chances for success, the Pacific coast manufacturers made the double mistake of overestimating their own and underestimating the resources of the foreign producers. It was supposed by these novices that the previously prevailing high prices of this commodity the world over were due to a scarcity of the raw material, or the difficulty of obtaining it in the countries where the principal supply was drawn—a manifest error, inasmuch as the borate deposits of Europe, India, and Peru, at the time the new industry was striving for a foothold on the west coast of the United States, were ample to meet all the requirements of commerce, the high prices that had always before obtained being the result of well-perfected combinations through which the entire business was controlled by a few persons who, besides controlling the trade, were able to supply any increased demand that might arise, and do so at reduced prices, were this necessary. These parties were therefore in a position to become dangerous competitors of any new rival entering the field.

The manufacturers of borax on the Pacific coast labor under many disadvantages as compared with producers elsewhere; labor and the other factors of production are dear; the borate fields are located in desert regions which afford few facilities for carrying on the business of refining, being at the same time distant several hundred miles inland from San Francisco, the principal entrepôt and shipping point for the entire country. After shipment at San Francisco, the borax has to make long journeys by sea or land to reach the great marts of the world.

The recent discovery of heavy deposits of borates near the sea of Marmora, Asiatic Turkey, has also had a depressing effect.

Wages, etc.—The following statement of expenditures made by the San Bernardino Borax Company on account of labor and supplies for the month of March, 1883, fairly represents expenditures of the other borax companies, both in California and Nevada, on account of these items:

Scale of wages in borax mining and manufacture in San Bernardino county, California, March, 1883. Reported by the San Bernardino Borax Company.

WHITE LABOR.

Classes of employés.	Wages.		
	Per day.	Per month.	
Clerk at mine		$125 00	And board, at cost of $1 per day.
Agent (at Mojave)		100 00	Do.
Blacksmith, first	$5 00		Do.
Blacksmith (helper), second	3 00		Do.
Engineer	4 00		Do.
Teamster		100 00	Do.
Swampers or helpers	1 95		Do.
Fuel teamster	3 25		Do.
Coopers	3 25		Do.
Boilermen	2 31		Do.
Watchmen	2 31		Do.
Laborers	1 95		Do.
Cook		50 00	Do.

Scale of wages in borax mining, etc.—Continued.

CHINESE LABOR.

Classes of employés.	Wages.		
	Per day.	Per month.	
Foremen		$50 00	Board themselves.
Laborers	$1 25		Do.

Total white labor list, 25 men, 31 days, March	$1,804 96
Total Chinese labor list, 35 men, 31 days, March	1,400 03
Total monthly expenditure for labor	3,204 99

Forage consumed duriny the month of March, 1883, *at the works of the San Bernardino Borax Company.*

Horses and mules.	Hay.		Barley.		Total cost.	Remarks.
	Pounds.	Value.	Pounds.	Value.		
Two large teams, 40 animals.	16,050	$228 71	19,595	$391 90	$620 61	50 cents per day cost per animal; two transportation teams; 85 miles wagon haul.
35 animals	15,000	213 75	15,636	312 72	526 47	Teams at the works.

Average wages in borax manufacture in Nevada in May, 1883.

Classes of employés.	Per—	Rate.
White laborers	Month (average)	$45 and board, which is equal to $75.
Chinese	do	$40; board themselves.
Superintendents	do	$60 to $75 and found.
Teamsters	do	$50 to $60 and found.
Blacksmiths	do	$75 and found.
Mechanics	do	$75 and found.
Engineers	do	$100 and found.
Firemen	do	$50 and found.
Tinsmiths	do	$75 and found.

The Eastern market.—Inquiry among refiners and dealers in New York City developed the fact that the domestic borax is generally preferred to that imported, being usually superior to corresponding grades. For jewelers' uses, however, English refined borax has been imported. The chief impurities in the American borax are organic substances and excess of water and soda. For many uses the refining is rather to produce a better-looking product than because of absolute necessity. Refining consists simply in dissolving the crude or half-refined borax in water, settling, and slowly recrystallizing.

The leading uses of borax are in welding (for which the greater part is consumed, in iron and steel manufactures); in refining metals, as a crucible flux; in enameling; by packers, in preserving meats; and as a detergent for household purposes.

The price of American borax in New York at the close of 1882 was as follows: California refined, 13½ cents; New York refined, 13½ to 13¾ cents; crude, 10½ to 11 cents.

Tincal (crude borax) comes from the neighborhood of Calcutta, India; crude borate of lime from the west coast of South America; boracic acid from Tuscany. Refining is carried on to a considerable extent in England.

Tariff.—The new tariff rates are as follows: Refined borax, 5 cents per pound; pure boracic acid, 5 cents per pound; commercial boracic acid, 4 cents per pound; borate of lime, 3 cents per pound; crude borax, 3 cents per pound.

SULPHUR.

Occurrences.—Native sulphur is found in Nevada, California, Utah, Virginia, Louisiana, and other portions of the country, occurring in beds of considerable size in Uintah county, Wyoming, near Evanston, where it is said to be quite pure; and also in some quantity in the Yellowstone Park, Montana, and in various localities in New Mexico. Sulphur springs are of common occurrence throughout the Rocky Mountain region.

Production.—Sulphur is only worked to any extent in California and Nevada, and not on a very large scale in these States. In the census of 1880 the whole production of the United States for that year, 1,200,000 pounds, worth $21,000, is credited to Nevada.

Sulphuric acid.—In the census year 308,765,432 pounds of sulphuric acid, worth $3,661,876, were made, by far the greatest proportion of which was made from Sicilian sulphur, with a little from pyrites. New Jersey and Pennsylvania lead in manufacture of sulphuric acid, followed closely by Maryland, New York, and Ohio. Sulphuric acid is made in almost every State to a greater or less extent. It is certain that the manufacture of sulphuric acid from pyrites for making superphosphates will become a very important industry in the Southern States, while the use of pyrites in works in the neighborhood of New York City is steadily increasing. It is thought by some persons that in time all or nearly all of the sulphuric acid made in this country will be manufactured from pyrites, and that acid made by burning brimstone will not be able to compete with that produced from the cheaper source, at least in the market for common commercial acid.

Foreign sulphur.—Nearly all of the imported sulphur comes from Sicily. A small quantity has been sent from Japan by way of sample; and perhaps 1,000 tons of sulphur recovered from the waste of chemical works in England are imported annually. Dealers report that as yet the Nevada sulphur has not been able to compete in price with the foreign in the market of the Eastern States on account of the high cost of transportation, which, in the case of Sicilian sulphur, is comparatively a small item, as the mineral is often brought as ballast in vessels carrying cargoes of lighter goods. The price of domestic sulphur in San Francisco is about the same as that of Sicily brimstone of the same quality laid down in New York. American sulphur appears to be irregular in point of quality. Some samples handled by Messrs. M. Kalbfleisch & Sons, New York, are stated by them to have been fully equal, if not superior, to the Sicilian, while on the other hand some of the refiners who prepare sulphur for pharmaceutical purposes report that the domestic sulphur sometimes contains traces of arsenic, which would render it unfit for this special use. The price of Sicilian per ton of 2,240 pounds at the close of 1882 was $27.50 for best unmixed seconds, and $26 for best thirds. The price fluctuates considerably, and has declined from the rates ruling earlier in 1882.

The following tables show the extent of the foreign trade during recent years:

Crude sulphur or brimstone imported into the United States during the fiscal years specified. (Specie values.)

[Free of duty.]

Years.	Quantity.	Value.
	Tons.	
1872	27,596	$765,024
1873	45,340	1,300,626
1874	41,539	1,260,140
1875	39,584	1,255,100
1876	48,966	1,473,678
1877	43,443	1,242,788
1878	47,922	1,173,156
1879	65,919	1,487,698
1880	83,236	1,927,502
1881	105,438	2,713,494
1882	97,956	2,627,402
Calendar year 1882	101,595	2,674,449

Refined sulphur imported into the United States during the fiscal years specified. (Specie values.)

[Dutiable.]

Years.	Quantity.	Value.
	Cwts.	
1872	2,027	$4,795
1873	2,117	5,180
1874	1,709	4,129
1875	535	1,399
1876	2,375	5,668
1877	29,039	48,868
1878	6,628	14,924
1879	5,126	10,963
1880	3,180	5,530
1881	3,072	6,121
1882	7,891	15,651
Calendar year 1882	6,895	13,578

Sulphur exported from the United States during the fiscal years specified.

Years.	Crude.		Refined.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Cwts.*	
1872			103	$270
1873	5	$362	224	1,062
1874				
1875			130	344
1876				
1877			1,086	2,688
1878				
1879			39	98
1880			94	221
1881				
1882			587	1,221
Calendar year 1882			979	1,973

BARYTES.

Productive localities.—The leading producing localities in the United States are in the States of Virginia, East Tennessee, Missouri, Connecticut, and North Carolina. Illinois, Kentucky, Maine, and Pennsylvania also produce barytes. It was formerly mined in New York, but the industry has latterly declined, as the cost of mining was too high to meet competition. The mineral commonly known as "heavy spar," "barytes," and sometimes as "baryta," is the barium sulphate (barite). Carbonate of barium (witherite, bromlite) is not mined in this country.

Mode of manufacture.—Messrs. Page & Krause, of Saint Louis, who own important mines near the Osage river, Miller county, Missouri, report their process of manufacture as follows: (1) sorting the ores; (2) refining with sulphuric acid; (3) "floating" the refined product; (4) packing. The Marion Barytes Works, Smyth county, Virginia, produced 2,000 net tons in 1882. The mineral is here prepared for market by (1) separating from it the gray limestone and ferruginous inpurities; then (2) washing and scouring in revolving cylinders; (3) hand-sorting and grading; (4) grinding in buhr mills; (5) "air-floating," and finally (6) packing in barrels. The picking and sorting are performed by boys, of whom 50 are employed. The spot value of the crude barytes in this locality is, averaging all grades, about $12 per ton of 2,000 pounds.

The business of grinding barytes is an extensive one. German stone is imported and powdered here. Messrs. Burgess & Newton, of New Haven, Connecticut, report grinding 4,000 tons of German barytes in 1882.

Production.—The following table shows the production of ground barytes in the census year 1880. It includes, however, the foreign stone which was treated in this country:

Production of ground barytes during the census year 1880.

States.	Quantities.	Values.
	Tons.	
Connecticut	6,000	$150,000
Maine	2,200	50,000
Missouri	4,425	100,094
Pennsylvania	1,500	20,000
Tennessee	465	10,685
Virginia	4,575	41,050
Total	19,165	371,829

The production of crude mineral in the United States in 1882 is estimated by Messrs. Page & Krause at 20,000 tons, and that of Missouri alone at 8,000 tons; and it is stated that the production could be largely increased to meet an augmented demand. The mine owned by Messrs. Davis & Hewitt, near Irvington Station, Campbell county, Virginia, reports a capacity of from 100 to 200 tons per day, and other mines also could produce more largely than at present. It is difficult to fix the average spot value for the crude mineral. Ground barytes in 1882 averaged about $22 per ton, and the value of the crude may roughly be placed at $8 per ton, at the point of manufacture, making a total value for the crude mineral of $160,000.

Utilization.—Barytes is used very extensively in the arts, but almost altogether for purposes of adulteration, for which its leading use (about 90 per cent.) is in replacing to a greater or less extent white lead in paint. One firm claims that a mixture of one-third white lead, one-third oxide of zinc, and one-third "floated" barytes makes a better paint than pure white lead. Paint works, however, do not generally advertise the fact that their product contains barytes, although this is, of course, well understood in the wholesale trade. It is also employed as a "filling" for general purposes, in pulp, and in making putty.

Tariff.—The duty under the new tariff on crude barytes is 10 per centum ad valorem, and on manufactured barytes one-fourth of 1 cent per pound. Of the imported carbonate 75 per cent. is used in the paint trade, and the remainder chiefly in pottery making.

STRONTIA.

Occurrences.—The strontia minerals have been identified at many points in the United States, and probably occur more frequently than is generally supposed, as systematic search for them has not been prosecuted to any extent. Strontianite (strontium carbonate) has been found at Schoharie, New York, in hydraulic limestone; at Muscalonge lake, New York; at Chaumont bay and Theresa, Jefferson county, New York; and in Mifflin county, Pennsylvania. Celestite or celestine (strontium sulphate) occurs at Green or Strontian island and North Bass island, Lake Erie, where it occurs in magnesian limestone of the Water-lime group, at the former locality being found in large masses of beautiful crystals; and at Chaumont Bay, Schoharie, Lockport, the Rossie lead mines, Depauville, and Stark, in the State of New York, and also at Bell's Mills, Blair county, Pennsylvania. The blue fibrous variety found in Pennsylvania is the celestite originally taken to Europe by Schütz and named by Werner.

Small lots of American strontia have been offered in the market from time to time, but have not met with a ready sale.

Uses.—Nitrate of strontia is used in this country to a considerable extent by the makers of fireworks. It is made here by the chemical manufacturing works from imported carbonate. An increased demand has recently sprung up in Europe, owing to the introduction of a new and successful process for treating beet sugar, which promises to absorb large quantities of strontia in comparison with the former consumption. Strontia has also been recently utilized in the manufacture of tuyeres for blast furnaces. These new applications will undoubtedly lead to active prospecting for and mining of strontia minerals, and will tend to develop localities which heretofore have not been productive.

The amount of celestine mined in Sicily, the principal source of this mineral, is reported to have been about 4,000 gross tons in 1881.

MICA.

Occurrences.—Muscovite mica, varying greatly in quality and the size of sheets, occurs in nearly all of the granitic, gneissoid, and schistose areas of the country. At present North Carolina takes the lead in point of production. In that State, since 1868, mica has been mined in many places, and has been obtained in plates sometimes over 3 feet in diameter. Numerous localities exist in Macon, Jackson, Haywood, Buncombe, Ashe, McDowell, Yancey, Alexander, Cleveland, and other counties. Merchantable mica is also found in many other of the South Atlantic States. A considerable amount is mined in Maine and New Hampshire. A recent discovery, said to be important, is announced to have been made in Salisbury township, Pennsylvania. At South mountain, in the same State, a new mine has been opened, which is said to have produced pieces of good mica weighing from 19 to 27 pounds, some of which could be split 160 times to the inch.

Mica is found in numerous States and Territories contiguous to the Rocky mountains. In a few localities it occurs in medium-sized plates of good quality; but in this region only the mines of Deadwood, Dakota, and one mine near Las Vegas, New Mexico, have shipped any mica to market. The McMaken mine, near Deadwood, had sold up to May 140,000 pounds of merchantable mica, and the Sundog, Black Hills, and other mines have shipped small quantities. The mica from these mines is of excellent quality, and plates are sometimes produced 12x18 inches in size. The main ledge is said to be 14 feet wide, and to consist of a central mass of feldspar and "porphyry," with a casing of mica, which varies in width from 3 to 4 feet, on each side. The country rock is granite. These mines have hitherto been developed only by open cuts, and until recently have never been steadily worked.

In Wyoming mica occurs occasionally in plates 4x6 inches in size, and of good quality; but the supply is extremely limited. In Colorado good plates of mica have been found in Boulder, Jefferson, and Fremont counties, but only in very small quantities. In New Mexico, near Las Vegas, it is said to occur in considerable amount, some of the plates being 8x14 inches; but although found in large quantity only a few small pockets produce sheets of marketable size. One small shipment has been made.

Mica of excellent quality has also been discovered on the Payette river and in other localities in Idaho. Local excitements about mica claims are frequent in Nevada; but thus far there has been no actual production. A number of claims were located in the southern portion of Nye county during the past winter.

Deposits of mica are found in nearly every county in California, and in many of the mining districts and at various other points on the Pacific coast. As a general thing, however, it is of somewhat inferior quality, though some quite clear and in large sheets has been discovered. No regular mica mining is done in this portion of the country, though several deposits have been opened with the hope that systematic developments would ultimately be made. Still, the local market is quite limited, and there has been no encouragement for miners to open the deposits they have found.

Prospectors in search for gold and silver in Alaska report that deposits of mica are numerous in that Territory.

Production.—The total production in 1882 is estimated by Messrs Munson, Rolls & Co. at 75,000 pounds of sheet mica, with a total value of $250,000, which would give an average of $3.33 per pound. There is little doubt that the product will be largely augmented by the recent important discoveries, especially those in the Black Hills region.

Uses.—The clear, transparent, and tough mica plates are used in various ways, the principal utilization being for stove and furnace doors. A small amount of specially fine mica is used for compass plates. Mica generally occurs in plumose or scaly forms, rendering it valueless for its best known uses. These varieties are pulverized and used as an absorbent in one variety of nitro-glycerine explosives, and enter also into a patented lubricating composition for axles and bearings. Ground mica is also employed for various ornamental purposes. Scrap mica and trimmings from the better kinds are pulverized and utilized in the same way as the inferior varieties. The demand for ground mica, however, is comparatively small, and the supply of mineral suitable for the purposes to which ground mica is applied is abundant.

Value.—The price ranges from 25 cents to $5 per pound, according to the size of sheets and quality. Some exceptionally large and clear sheets from North Carolina have been sold at $10 per pound; but mica of this grade rarely comes on the market.

TALC.

Occurrences.—Talc is mined in many States on the Atlantic seaboard, and is known to occur in many scattered localities of the West. Pennsylvania is a principal producing center. A bed has recently been opened in Georgia which produces an article that by samples is said to be much superior to the imported talc. When this mine is reached by a railroad now being built, it is expected to make a large output.

Production.—No reliable statistics were obtained as to the product of this mineral in 1882. Some dealers estimated it as high as 50,000 net tons; but probably half that amount would more than cover the actual output. The average spot value is about $12 per ton. The imported talc, of which $20,960 worth was received in the fiscal year 1882, is of generally superior quality, and the average price is about $22 per ton. Our importations come from Italy, Austria, and France.

Uses.—Talc is used extensively in soap-making, and also for dressing fine sheep-skins, leather, gloves, etc. The domestic talc is used in the manufacture of paper, replacing terra alba for this purpose. A small amount of talc enters into the composition of some lubricating compounds

QUARTZ.

Various uses are made of quartz in the arts. Fine rock quartz is used extensively in glass and pottery making, and as a grinding and polishing powder. It is estimated that above 75,000 tons are annually consumed in the United States for these purposes. A considerable quantity of fine quartz sand is used for glass-making, and is included in the foregoing estimate. Ground quartz, especially of the flinty variety, as well as powdered glass, are used extensively in the manufacture of sandpaper. Twenty-seven thousand two hundred and eighty-seven dollars' worth of quartz sand was imported in the fiscal year 1882. There is also a small importation of "flint stone." Our exports of quartz are insignificant.

FLUORSPAR.

Fluorspar is found in more or less quantity in almost every State and Territory, but not very frequently in workable amount. No statistics of production are accessible, and the estimates of dealers vary widely; but the amount annually mined is very considerable, possibly reaching 5,000 net tons per annum. Fluorspar is used as a flux and as a glaze in the pottery trade, and in the production of hydrofluoric acid for etching. The greater part consumed in this country is from home sources, little now being imported; and the domestic mineral is reported to be superior. Its spot value ranges from $10 to $20 per ton. Indiana and Ohio are said to lead in point of production. New York, Delaware, New Hampshire, and Kentucky also contain fluorspar in noteworthy amount.

Fluorspar in the Rocky Mountain region.—Fluorspar occurs massive in wide metalliferous veins near Bear creek, in Jefferson county, and on James creek, Boulder county, Colorado. The white, green, pink, and purple colors are common, and often all these colors occur in a single specimen. The mines at Bear creek have produced some 600 tons of fluorspar, which was sold to the Boston and Colorado Smelting Works at Black Hawk before they were removed to Argo. The supply from this point is exhausted. On James creek the veins of fluorspar are undeveloped, as there is no demand for it as a flux. Fluorspar occurs frequently in the ores of Montana, Wyoming, Colorado, and New Mexico, but only in small quantities. It is used as a flux in local smelting operations, but is not much in demand. Fine cabinet specimens come from Crystal Park, El Paso county, some showing crystals 10 inches across.

ASBESTUS.

Occurrences.—Asbestus is found, usually in small quantities, in very many localities in this country. The great difficulty connected with the economical mining of this substance has been that the deposits are generally small pockets. Both hornblende and pyroxene asbestus occur, the former being the more common, though it is often difficult to distinguish between these varieties. Most of the bisilicates, excepting those containing much alumina, pass into fibrous varieties, all of which are known as asbestus, though the term "amianthus" is sometimes applied to the finer and more silky kinds. The leading localities at which asbestus is or has been mined are Rabun and Fulton counties, Georgia; also localities in northern Georgia, western North and South Carolina, Staten Island, Long Island, and other localities in New York State, Maryland, northern New Jersey, Pennsylvania, and Virginia. Small quantities of good quality have also reached the market from Colorado, and the occurrence of the mineral is noted in many of the Territories.

There are very many places in California and Nevada where asbestine deposits are found. In San Bernardino county, near Agua Caliente, San Diego county; Salt Spring valley, Calaveras county; Placer county, and at several other points in California deposits have been opened. While the mineral in some of these localities occurs in great masses and is remarkable for its length of fiber, it has generally been lacking in fineness, flexibility, or other desirable properties. For these and other reasons, such as the cost of mining and transportation and the limited local demand, the home product has not been able to compete with imported and Eastern asbestus in the San Francisco market, notwithstanding its lower price, that of the raw material varying from $30 to $35 per ton. Deposits of the different varieties of the mineral have been found at a number of other places in the Pacific States and Territories, but so few of them have ever been developed that in regard to their value or character little is known. Asbestus seems to be abundant enough in this region, but it is difficult to find it in such a form as to be acceptable to the purchasers.

Production, etc.—The production in the calendar year 1882 is estimated at 1,200 tons, of an average spot value at the mines of $30 per ton. It is expected that larger quantities will be mined in the future, and that the product can be put upon the market at a lower cost. The price at New York reaches from $15 to $60 per ton, according to purity and length and strength of fiber. The imports of crude asbestus during the fiscal year 1882 were 383 tons, invoiced at $14,235. The exports of manufactured asbestus were $18,923.

Relative value of asbestus from different countries.—As a rule American asbestus is inferior in textile quality, being more brittle and harsh in fiber, as well as shorter than that imported, and is therefore not so well adapted to the manufacture of spun and woven goods. It is stated that the quality of the domestic is constantly improving, new sorts being found almost every month. There appears to be little difference between the domestic and foreign in point of fireproof qualities, though some manufacturers report that as a general thing the domestic asbestus will stand a higher degree of heat. The American is better adapted for making fireproof cements and paints, for which purposes it is generally used, length of fiber being unessential. The greater part of the imported mineral comes from the province of Quebec, Canada. The Canadian asbestus sells in New York at from $25 to $90 per ton, the usual range being between $40 and $75. The Canadian is said to be the best for general use. Asbestus is also brought from Italy and Austria. A little exceptionally fine Italian asbestus has sold as high as $250 per ton, though the price is usually about $100. The Italian is the finest for textile purposes, but on account of its higher price it cannot compete with either the Canadian or the domestic.

Uses.—Asbestus is used in making liquid and fireproof paints, roofing, piston packing, valve packing, flat packing, covering steam pipes and boilers, fireproof cements, sheet and roll millboard, flooring, felt, etc. It is often used in combination with hair felts and other substances.

GRAPHITE.

BY JOHN A. WALKER.

Occurrences.—As a mineral, graphite is widely distributed in the United States; as an ore, it is found in but few places in sufficient quantities and purity to be profitably worked. It is found in the older rocks of the Appalachian chain from Alabama to Canada. Several discoveries of it have been reported from Michigan. Mr. F. F. Chisolm reports its occurrence in "great purity in five different localities in Albany county, Wyoming Territory, in veins from 18 inches to 5 feet thick. In Colorado it is found in various parts of the State. At Pitkin, in Gunnison county, it occurs in beds 2 feet thick, but very impure. In New Mexico pure graphite is found in small quantities in the Coal Measures, where it is probably the result of metamorphism. Graphite occurs sparingly in the Black Hills of Dakota." It has been mined at the Sonora mine, Tuolumme county, California.

Of the Eastern deposits those of Pennsylvania, New Jersey, New York, and Canada are of the crystalline or foliated variety, are the best known, and are the only ones which are at present being worked. The deposits occurring in Alabama, North Carolina, and Virginia are of the amorphous variety. These are of such a nature that purification is economically impossible. They can be used only in the crude state and for but few purposes. The Western deposits are still undeveloped. Samples of graphite have been received and reported on by the Joseph Dixon Crucible Company from the following localities:

Date.	Received from—	Locality.
Oct 26, 1877	B. B. Van Deusen....	Big Horn, Wyoming Territory.
May 1, 1878	A. S. Oliver..........	Pottersville, New York.
Sept. 23, 1878	H. Campbell	Los Angeles, California.
Sept. 25, 1878	E. H. Brown.........	Portland, Pennsylvania.
Oct. 23, 1878	J. P. Hartman.......	Chester Springs, Pennsylvania.
Oct. 25, 1878	J. H. Simpson	Richmond, Virginia.
Oct. 28, 1878	B. L. Peel............	Los Angeles, California.
Oct. 28, 1878	Rev. M. Harvey	St. John's, Newfoundland.
Feb. 12, 1879	G. Ayer & Co.........	Marlboro, New Hampshire.
Mar. 15, 1879	D. J. Maguire........	Vallecito, California.
Nov. 22, 1879	L. Kise	German Valley, New Jersey.
Nov. 25, 1879	M. Reed & Co.......	Baltimore, Maryland.
June 1, 1880	W. Glenn..........	York Mills, Pennsylvania.
June 1, 1880	J. B. Painter.........	Lancaster, Pennsylvania.
June 1, 1880	J. B. Painter.......	Lancaster, Pennsylvania.
Sept. 8, 1880	Peacock & Thomas..	Lowell, Massachusetts.
Feb. 4, 1881	C. G. Fraser..........	Eagle Bridge, New York.
Mar. 22, 1881	A. H. Elliott..........	——, Canada.
Apr. 16, 1881	J. E. Burchell........	Sydney, Cape Breton, Nova Scotia.
Apr. 22, 1881	L. F. Rollins.........	Mountain creek, Alabama.
May 9, 1881	F. King..............	Marietta, Georgia.
May 18, 1881	Dr. J. S. Ord, U. S. A.	Fort Bowie, Arizona.
May 23, 1881	S. V. R. R. Co.......	Waynesboro, Virginia.
Nov. 10, 1881	N. P. Pratt	Atlanta, Georgia.
Nov. 14, 1881	G. W. Hall	Ouray, Colorado.
Nov. 19, 1881	L. Eckhart...........	Salt Lake City, Utah.
Nov. 23, 1881	G. L. Beck...........	Big Horn, Wyoming Territory.
Nov. 28, 1881	A. Z. Ryerson........	Bloomingdale, New Jersey.
Dec. 1, 1881	J. B. Mason	Mansfield, Connecticut.
Dec. 20, 1881	F. P. Bishop.........	Litchfield, Michigan.
Dec. 30, 1881	W. S. Beatty.........	Crook City, Black Hills, Dak. Ter.
Jan. 2, 1882	C. H. Swain..........	Silver City, Colorado.
Jan. 3, 1882	S. D. Sealsbury	Yarmouth, Maine.

Origin and characteristics.—Graphite is now generally conceded to be of organic origin—the result of the metamorphism of some of the products of destructive distillation of vegetable tissue. It occurs in veins, beds, and disseminated through strata (graphitic schists). The veins occur principally in New York, Canada, and the Far West. They are true fissures in gneissoid rock. The vein graphite is usually associated with calcite and quartz. Pyroxene, mica, and apatite are sometimes found with it. Crystals of calcite are found which, on being split, show scales of foliated graphite along the planes of cleavage. Graphitic schists are found in the same regions as the veins, and also in New Jersey and Pennsylvania. These are metamorphosed sandstones with foliated graphite very evenly disseminated throughout in small flakes. The graphite found in beds is amorphous, and occurs principally in the South. It is in a sedimentary formation, is quite impure, and on account of its fineness cannot be successfully purified. Geologically, graphite occurs from the Coal Measures back to the oldest rocks. (See article by Professor Frazer, Transactions American Institute of Mining Engineers, Vol. IX., page 732; also Prof. J. S. Newberry's pamphlet on "The Origin and Relations of the Carbon Minerals," Annual Report New York Academy of Sciences, Vol. II., No. 9, 1882.)

Productive localities.—The only place in the United States where graphite is now mined successfully is at Ticonderoga, New York. This property, owned originally by the American Graphite Company, now belongs to the Joseph Dixon Crucible Company, of Jersey City, New Jersey. The American Graphite Company worked the vein deposits to a depth of 600 feet. The Dixon Company now mine a graphitic schist 15 feet thick, carrying from 8 to 15 per cent. of graphite, practically an inexhaustible supply.

Numerous attempts have been made to work the similar deposits of Pennsylvania and New Jersey, with only partial success. The parties interested in these attempts are:

The Pennsylvania Plumbago Company, the Eagle Plumbago Company, and the Phœnix Plumbago Company, all of which have worked deposits in the Pickering valley, Pennsylvania; the American Chemical Manufacturing and Mining Company, of Rochester, New York, which has worked the deposits of northern New Jersey; Mr. A. Z. Ryerson, who in 1882 worked the deposit at Bloomingdale, New Jersey. Mines of merit are known in Georgia and California, but these cannot now be worked on account of expensive transportation.

Ore dressing.—Several methods (both wet and dry) of dressing the ore have been attempted. In Vol. IX., page 732, Transactions American Institute of Mining Engineers, Professor Frazer, of Philadelphia, gives a description of the process adopted in the Pickering valley. The process used by the Dixon Company at Ticonderoga owes its success to careful supervision. It is a wet process in which the ordinary practice is reversed, the "tails" being the useful product, while the "heads" are thrown away. All attempts at dry concentration have failed.

Production.—In 1882 the output of the Ticonderoga mine was 400,000 pounds. The outputs from the other mines have been so spasmodic that it is impossible to give them accurately. Probably 25,000 pounds would cover them all, making a total output in 1882 of 425,000 pounds. For 1883 the Dixon Company have arranged to produce 500,000 pounds; and again estimating the product of the others at 25,000 pounds, we have for 1883 a total output of 525,000 pounds. The average spot value may be stated at eight cents per pound.

Kinds.—On account of the peculiar advertising it has had, graphite is commercially known as German black lead, Ceylon plumbago, and American graphite. German black lead is a product of Bavaria. It is of the amorphous variety, and is dressed chiefly by washing. Its price depends on its percentage of graphite and the nature of its impurities, varying from $1 to $10 per hundredweight in cargo lots. It is used in the manufacture of pencils, stove polish, and foundry facings. Ceylon plumbago is mined at Travancore, Ceylon, and is shipped from Colombo to all parts of the world. It occurs in immense veins of great purity. Cobbing and sizing are the only preliminary operations it undergoes. It appears in the market graded according to size, as large lump, small lump, chip, and dust. Its price varies from $2 for dust to $10 per hundredweight for prime lump, in cargo lots. It is used for all the purposes of the trade, except the manufacture of pencil leads. American graphite, from the nature of its occurrence, appears in the market only in the dressed condition. Its price ranges from $2 to $10 per hundredweight wholesale, according to purity and fineness. Fineness exercises considerable influence on the price of graphite, on account of the difficulty of pulverizing it. American graphite is used for all purposes of the trade, and excels all kinds as a lubricant. It is the same geologically, etc., as the Canadian. Before the development of the American and Canadian mines the Ceylon mineral was the standard.

Analyses.—In 1876 the Canadian Government authorized an extended survey and investigation of the comparative merits of the Ceylon and Canadian varieties. The following table of analyses of carefully-prepared samples is from the report of the survey:

Analyses of Canadian and Ceylon graphites.

Locality.	Specific gravity.	Volatile matter.	Carbon.	Ash.
		Per cent.	*Per cent.*	*Per cent.*
Canada, Buckingham; vein graphite; variety, foliated	2. 2689	0. 178	99. 675	0. 147
Canada, Buckingham; vein graphite; variety, columnar	2. 2679	0. 594	97. 626	1. 780
Canada, Grenville; vein graphite; variety, foliated	2. 2714	0. 109	99. 815	0. 070
Canada, Grenville; vein graphite; variety, columnar	2. 2659	0. 108	99. 757	0. 135
Ceylon; vein graphite; variety, columnar	2. 2671	0. 158	99. 792	0. 050
Ceylon; vein graphite; variety, foliated	2. 2664	0. 108	99. 679	0. 213
Ceylon; vein graphite; variety, columnar	2. 2546	0. 900	98. 817	0. 283
Ceylon; vein graphite; variety, foliated	2. 2484	0. 301	99. 284	0. 415

These analyses prove the oft-repeated claim of the dealers in Canadian and American graphite that it is equal to the best Ceylon.

Manufactures.—The properties of graphite make it useful for the following general purposes: The manufacture of refractory articles, lubricants, electrical supplies, pigments, and pencil leads. A detailed table of the articles made from it is annexed, with an estimate of the percentage used for each purpose:

Proportionate amounts of graphite used for different purposes.

Manufactures.	Kinds of graphite used.	Per cent.
Crucible and refractory articles, as stoppers and nozzles, crucibles, etc.	Ceylon, American	35
Stove polish	Ceylon, American, German.	32
Lubricating graphite	American, Ceylon	10
Foundry facings, etc	Ceylon, American, German.	8
Graphite greases	American	6
Pencil leads	American and German	3
Graphite packing	Ceylon, American	3
Polishing shot and powder	Ceylon, American	2
Paint	American	½
Electrotyping	American, Ceylon	¼
Miscellaneous—piano action, photographers', gilders', and hatters' use, electrical supplies, etc.		¼
		100

The earliest use of graphite was for pencil leads. La Moine cites a document of 1387 ruled with graphite. Its use for this purpose has become so extended that in 1882 over 150,000,000 pencils were made in the world. Previous to 1827 black lead crucibles were made only in Germany. In that year the late Joseph Dixon began their manufacture in this country, using graphite from New Hampshire. He afterwards saw samples of Ceylon plumbago, and appreciating its value he secured a shipment from Ceylon in 1829. This was the first importation of Ceylon plumbago into this country; since that time its use has steadily increased. In the fiscal year 1882 16,047,100 pounds of plumbago were imported, most of which was from Ceylon; the rest from Germany.

Graphite has long been used as a lubricant. This is one of its most useful applications, and one which promises most for the future. Formerly it was offered to the engineer only in the form of a dry powder; now it is compounded, or mixed with fats and oils in many ways, some of which are patented. This use of graphite is attracting the attention of all interested in the problem of the reduction of friction, and promises to outstrip all others. The barriers which have prevented its extensive use in this direction have been the price and the difficulty of securing purity and freedom from all grit. These are now both overcome, the price being now less than 25 per cent. of what it was fifteen years ago. The purity, which now is absolute, was then only approximate. For all heavy work graphite is undoubtedly the lubricant of the future.

The growth of the graphite industry has kept pace with the age, each new development in metallurgy and engineering offering some new field of usefulness for graphite. For instance, it furnishes the pots for the manufacture of cast steel, and the nozzles and stoppers used in the Bessemer process. It is used in the manufacture of electrical supplies, etc. Fifty years ago graphite was little known and misnamed. Now it is of constantly increasing importance. From an insignificant beginning in the present century the industry has grown to its present proportions. The principal houses engaged in the graphite industry are as follows: (*a*)

List of American manufacturers.

House.	Location.	Articles made.	Estimated number of hands.
Joseph Dixon Crucible Company.	Jersey City, New Jersey	Everything for which graphite is used.	500
Phœnix Crucible Company	Taunton, Massachusetts	Crucibles	20
Taunton Crucible Company	do	do	12
J. H. Gautier & Co	Jersey City, New Jersey	do	25
R. Taylor & Co	Philadelphia, Pennsylvania	do	25
Seidell & Co	do	do	12
Ross & Co	do	do	10
A. W. Faber	New York City	Lead pencils	150
Eagle Pencil Company	do	do	500
American Lead Pencil Company.	do	do	75
Cutter & Brown	do	Foundry facings	....
Variety Iron Works	Cleveland, Ohio	Facings, etc	....
S. Obermayer & Co	Cincinnati, Ohio	Facings, lubricants	....
Morse Bros	Canton, Massachusetts	Stove polish	40
J. L. Prescott & Co	North Berwick, Maine	do	25
American Chemical Manufacturing and Mining Company.	Rochester, New York	do	15
Ransom & Co	Albany, New York	Facings	35
W. H. Colebrook	Syracuse, New York	Stove polish	5
G. A. Moss	New York City	do	5
Lustro Company	do	do	10
H. A. Bartlett & Co	Philadelphia, Pennsylvania	do	....
Willard & Lane	Taunton, Massachusetts	do	5
I. X. L. Stove Polish Company.	Grand Rapids	do	5
Phœnix Mining Company	Philadelphia, Pennsylvania	Stove polish and lubricants (mining).	....
A. Z. Ryerson	Bloomingdale, New Jersey	(Mining)	....

a In arranging the matter for this paper I take pleasure in acknowledging the kind assistance of Mr. W. F. Downs, E. M., chemist of the Dixon Company.—J. A. W.

LITHOGRAPHIC STONE.

American stone.—Lithographic stone is not, as yet, mined to any considerable extent in the United States. Although an abundance of stone which answers some purposes of the lithographic art has been found in a number of localities, thus far none has been discovered which in the estimation of lithographers can supersede the Bavarian stone, excepting for cheaper, coarser work and for transfers. Generally speaking, the American stone appears to be harder, heavier, more siliceous and brittle, coarser-grained, and less uniform in texture than the Bavarian stone. Still, as the price of the latter is rapidly increasing, while, as is reported, the quality is deteriorating, it is very possible that our American stone may soon be drawn upon the market, in spite of its present inferiority. It is probable that the reputation of the American stone has suffered to some extent by reason of the want of experience of our quarrymen in taking out, selecting, and properly dressing the stone. It is thought by some that the best strata have not been reached in quarrying. Lithographic stone has been reported as occuring in the following localities in the United States:

Alabama.—Talladega county.

Iowa.—Anamosa, Jones county; Van Buren county.

Kentucky.—Near Elizabethton, Hardin county; Estill county, Kenton county, Clinton county, Rowan county, and Wayne county.

Missouri.—Saverton, Ralls county.

Tennessee.—Clay county; Overton county.

It is also reported in a general way as occurring in Illinois, Virginia, West Virginia, and in southeastern Tennessee.

The stone found in Talladega county, Alabama, is reported as bright gray in color, rather hard, and as being easily quarried. The deposit in Van Buren county, Iowa, has thus far produced only specimens. The quarry in Estill county, Kentucky, has been worked to a small extent, about 50 tons having been taken out in 1881. The stone has been tested by lithographers, and is said to have been found equal to the second quality of German stone. That from Kenton county, Kentucky, is reported by lithographers as being too hard and brittle to engrave upon, and valuable only for certain classes of work. The stone from Hardin county, Kentucky, has been on the market, but has not been able to compete with the German stone in quality. Stone from the quarry in Rowan county, Kentucky, was given the gold medal at the Centennial Exposition in Philadelphia, over, as is reported, the Bavarian stone. This stone has been quarried to a small extent, and preparations are now being made for a more extensive output. It is said that a slab 5½ by 10½ feet has been taken from this quarry.

Apparently one of the most promising of the American stones is that found at Saverton, Ralls county, Missouri. The specific gravity of this stone, like all the American stones, is greater than that of the Bavarian stone, being 2.70, while the latter averages 2.45. As shown by the following analysis made by Hoen & Co., lithographers, the chemical composition does not differ materially from the Bavarian stone, the principal difference being in the proportion of silicates, in which the American stone has the advantage:

Analyses of Missouri and Bavarian lithographic stone.

	Missouri stone.	Bavarian stone.
Silicates	31.2	44.5
Calcic carbonate	817.7	814.7
Magnesic carbonate	151.0	138.3
Iron oxide	.1	2.5
	1000.0	1000.0

The difficulty with this stone, as with some other American stones, appears to be mechanical and due to the presence of fine seams of quartz. This stone has been tested by lithographers and is reported to have given satisfaction, but it does not appear to be extensively upon the market.

The quarries in Clay and Overton counties, Tennessee, produce a buff and a blue-gray stone, equal, as reported by the manager of the quarries, "to the German prima and secunda." Slabs 24 by 32 inches and 3½ inches thick can be produced. The specific gravity of the buff stone, as determined by Professor J. S. Newberry, is 2.67, and that of the blue-gray is 2.74. Small samples of fine appearance were kindly sent to this office. These quarries were worked to some extent prior to March, 1881, but have been idle since that date.

Foreign stone.—At present the supply of lithographic stone is derived almost exclusively from Solenhofen and Pappenheim, Bavaria, where it is found at and near the surface. The stone is a fine-grained, compact siliceous limestone. It comes from the quarry dressed and surfaced ready for the use of the lithographer. The stones are originally 3 inches thick; cleaning and redressing them reduces their thickness about one thirty-second of an inch. They are sold by weight, the price depending on size and quality. A fair blue-gray stone 6 by 8 inches is worth 5 cents per pound, while a buff stone of the same size will bring but 3 cents. Larger stones command proportionally higher prices. The largest stones practically used are 40 by 60 inches, and these to but a small extent. The greatest demand is for slabs from 22 to 28 by 40 inches of the blue-gray variety.

The imports of lithographic stone (unengraved) for the year ending June 30, 1882, amounted in value to $112,083.

Lithographic stone is found in England, France, Italy, Canada, and the West Indies, but not of a quality equal to the Bavarian stone. A recent discovery of some importance is said to have been made near Puerto Principe, Cuba.

NITER.

Native niter.—Niter (saltpeter) is found native in many of the Western and Southwestern States, and in the Territories of the Far West. During the war some native niter was utilized, but its quality was poor, and it is said that loss would be incurred in refining it here now.

Saltpeter yards or "plantations" were worked on the eastern seaboard in the early history of this country; and it is noteworthy that at that time the principle of germ fermentation (by mother-of-peter or seed-peter) was well understood, for in preparing a new yard it was customary to "salt" it with the earth from an old yard, the effect, if not the reason, being clearly appreciated.

Artificial niter.—At present the greater part of the saltpeter used in this country is converted from Peruvian sodium nitrate and German potassium chloride, the two by interchange forming a pure potassium nitrate or saltpeter. This process is a comparatively new one, having been used only during the past twenty years. As the supply of sodium nitrate and potassium chloride is almost unlimited, and the artificial saltpeter made from them is so superior in quality, being nearly chemically pure, it is preferred to the natural article, and has, to a large extent, supplanted the latter.

Foreign niter.—Rich deposits exist in India, from which nearly all the crude substance is imported, some of it (refined) coming by way of England.

Imports and exports.—The following tables show the foreign commerce in niter of the United States during recent years. The new tariff rate is 1 cent per pound on crude and 1½ cents on refined saltpeter:

Saltpeter imported into the United States during the fiscal years specified (specie values).

[Dutiable.]

Years.	Quantity.	Value.
	Pounds.	
1872	5,137 241	$233,857
1873	10,489,395	502,394
1874	12,121,447	550,463
1875	9,495,182	364,140
1876	6,129,857	216,843
1877	13,846,670	512,327
1878	6,760,984	292,990
1879	9,376,734	384,827
1880	14,155,481	553,595
1881	10,044,367	385,745
1882	12,282,334	450,954
Calendar year 1882	10,450,272	391,532

Saltpeter exported from the United States during the fiscal years specified.

Years.	Quantity.	Value.
	Pounds.	
1872	568, 005	$27, 032
1873	101, 198	5, 278
1874	237, 985	11, 435
1875	178, 827	8, 139
1876	321, 576	13, 249
1877	743, 900	27, 543
1878	126, 063	5, 997
1879	None.	None.
1880	113, 385	4, 842
1881	181, 502	8, 881
1882, and calendar year 1882	None.	None.

NITRATE OF SODA.

Occurrences.—Slight deposits of this salt (Chili saltpeter) have lately been found in Humboldt county, Nevada, the site of this "find" being located on what is known as the "Forty-mile desert" and at a point about 25 miles east of Lovelocks Station, on the Central Pacific railroad. This salt occurs here in a crystallized form deposited in the crevices of the rocks, also imbedded in the earth from 2 to 30 inches below the surface. As the deposit at this point has not yet been much developed, nor the district about even thoroughly explored, how much of the mineral exists here is unknown. As the geological and climatic conditions of this region greatly resemble those about the district of Tarapaca, near the northern frontier of Chili, in Peru, where the dry pampa for 40 leagues is covered with a bed of this salt several feet thick, it may reasonably be expected that this valuable mineral will be found on these desert lands of Nevada, in considerable quantity. Here, as at Tarapaca, the nitrate of soda occurs in an arid and almost rainless region, the annual rainfall on this Nevada district amounting to scarcely more than 4 inches, while on the coast of southern Peru it is still less. Both localities occupy what was once the bed of the ocean or inland sea, both have about the same mean temperature and elevation above tidewater, and on both are found heavy deposits of common salt, the sulphates of lime and soda, magnesia, alumina, etc., some of the borates of lime and soda being also found in the Nevada field. An organization known as the Nevada Niter Company has taken up an extensive tract of land covering what is considered the best of these Nevada deposits, with the purpose of exploring and utilizing them, should enough of the crude salt be found to warrant their doing so. In April, 1833, a deposit of nitrate was found near Calico, San Bernardino county, California. Fine samples were sent to San Francisco for examination. As yet, however, the extent of the deposit is undetermined, and no operations tending to its development have been commenced. The Central Pacific railroad carried eastward from San Francisco 64,640 pounds of nitrate in 1882.

Nitrate of soda is said to occur in the extreme southern portion of New Mexico in considerable quantity. It is deposited here by a few springs, the greater number being in Chihuahua, Mexico, just across the boundary line. No disposition is made of the product, beyond the shipment of a limited quantity to Chihuahua by Mexicans.

Imports and exports.—The following table shows the imports and exports of nitrate of soda during recent years:

Imports and exports of nitrate of soda.

Fiscal years.	Imports (specie values; free of duty.)	Exports.	
		Quantity.	Value.
		Pounds.	
1872	$928, 079	3, 100	$124
1873	1, 452, 730	....	....
1874	1, 338, 141	....	....
1875	968, 615	....	....
1876	1, 055, 360	....	....
1877	1, 323, 457	....	....
1878	973, 322	....	....
1879	1, 348, 572	91, 940	2, 988
1880	1, 805, 110	153, 936	5, 773
1881	2, 356, 183	10, 564	370
1882	*a*3, 911, 545	429, 988	14, 435
Calendar year 1882	*b*3, 045, 127	....	....

a Quantity imported, 184,554,374 pounds.
b Quantity imported, 150,297,385 pounds.

CARBONATE OF SODA.

This mineral abounds throughout most parts of the Great basin, the extensive alkali flats which form a feature of that region constituting the principal sites of these deposits, which occur usually in the form of an efflorescence an inch or two thick on the surface, but sometimes in strata a foot or more thick imbedded in the earth, and separated from each other by thin seams of clay. When found in the form of a thin incrustation on the surface it is never pure, being always admixed with salt, borax, lime, magnesia, and other minerals. The heavier deposits are comparatively free from foreign matter, carrying generally about 90 per cent. carbonate of soda. One of the most remarkable repositories of this mineral known consists of a circular basin, the bed of a former lake, situated on the southerly margin of the Forty-mile desert, Churchill county, Nevada. This basin, which covers an area of ten or twelve acres, is depressed 60 feet below the common level of the country adjacent. Its bottom, usually dry, though in wet seasons covered with a few inches of water, is composed of a compact mass of the carbonate of soda so hard that it has to be broken out with crowbars, and so pure that it can for many purposes be used to advantage in its natural state. This substance occurs here in layers about one foot thick, separated from each other by thin seams of clay. Large quantities of the crude material are extracted every year. Some of this is used as it comes from the mine in the beneficiation of silver ores, much the greater portion however being refined and sold for other purposes. The process of refining is effected by placing the raw soda in reverberatory furnaces and subjecting it to a heat of about 500° Fah., whereby most of the moisture and excess of carbonic acid it contains are driven off. This deposit has been worked over an area of several acres to a depth of 10 or 12 feet without showing any signs of exhaustion. The receipts at San Francisco during the two years ending with June 30, 1882, amounted to 16,457 centals.

Bicarbonate of soda, nearly pure, is said to occur in a large bed 30 feet thick and covering an area of over 300 acres, in Carbon county, Wyoming. No analyses of the soda are published, and in the absence of positive evidence it seems probable that the soda is in the form of sulphate, containing some bicarbonate. From the lake near Pacific springs, Carbon county, a portion of the salt showed:

Sodium sulphate	81.23
Sodium bicarbonate	14.82
Sodium chloride	3.95
	100.00

From two miles east of Independence Rock, in the Sweetwater valley, the deposit contained:

Sodium sulphate	73.17
Sodium bicarbonate	22.98
Sodium chloride	3.85
	100.00

Mr. Bailey, territorial geologist of Wyoming, states that in a distance of 75 miles from Independence Rock there are over 100 soda lakes, which vary in area from 20 to 300 acres and in depth from 15 to 45 feet, and that the soda occurs as a mixed carbonate and bicarbonate.

SULPHATE OF SODA.

Sulphate of soda is of frequent occurrence in the Sweetwater valley, Wyoming, and is found in quantity at Burdsall's soda lake at Morrison, Colorado, and in small quantities in New Mexico.

In Wyoming the principal lakes and beds are owned by the Union Pacific Railroad Company, and up to the present time but little has been shipped. The Dupont Powder Company have recently purchased of the Union Pacific Railroad Company the soda lakes near Laramie city, and are erecting works upon the spot for the manufacture of gunpowder.

At the Denver Exposition in 1882 the Union Pacific Railroad Company had on exhibition a pillar of mixed sulphate and bicarbonate of soda 15 feet in height. No soda was shipped over the Union Pacific railroad in 1882.

The following are analyses of different specimens of the mineral. From the lake 2 miles east of Independence Rock:

Sulphate of soda	73.17
Carbonate of soda	22.98
Chloride of sodium	3.85
	100.00

From the lake 7 miles west of Saint Mary's Station, in the Sweetwater valley:

Sulphate of soda	88.93
Chloride of sodium	11.63
	100.56

From near Pacific springs:

Sulphate of soda	81.23
Carbonate of soda	14.82
Chloride of sodium	3.95
	100.00

The three following analyses are from the alkaline pond near Big Sandy river:

	No. 1.	No. 2.	No. 3.
Sulphate of soda	64.95	94.92	100.00
Chloride of sodium	35.46	5.23	None.
	100.41	100.15	100.00

The soda from Burdsall's lake, at Morrison, contains:

Water and organic matter	19.10
Silica	5.20
Alumina and oxide of iron	14.40
Chlorine	2.40
Sulphuric acid	25.80
Lime	8.80
Magnesia	3.90
Soda	19.10
	98.70

Glass works are being now erected in Denver to utilize the soda and silica from Morrison.

ASPHALTUM.

Domestic asphaltum.—Asphaltum is mined to a small extent in California, has been found in West Virginia (grahamite), and recently has been reported in Colorado; but the production in this country has hitherto been very limited. About 3,000 tons of domestic asphaltum are used in California annually. Most of this comes from Santa Barbara county, from deposits near the coast, and this is said to be the best material, as it is the hardest and does not shrink. Some asphaltum is also shipped from San Luis Obispo county, and some from Santa Clara county. It is used for sidewalks and for street pavement, and also for coating water pipes. Some 18 miles of the 26-inch pipe of the Spring Valley Water Company, which supplies San Francisco with water, is coated with this substance. The asphaltum costs $3 to $4 per ton at the coast landings where produced, and $8 to $10 per ton in San Francisco.

Foreign asphaltum and asphalt rock.—The asphaltum used in the Eastern States is almost exclusively imported, and comes mainly from the pitch lake at La Brea, in the island of Trinidad. The price is about $14 per ton on the Atlantic seaboard. The use of the Trinidad asphaltum is increasing, some 10,000 gross tons of the crude substance having been used in the city of Washington alone, in paving the streets. In preparing it for paving, the asphaltum is tempered with heavy petroleum and mixed with sand and powdered limestone, thus imitating the natural asphalt rock. Messrs. Louis Monjo & Co., of New York, report an importation of Cuban asphaltum of 650 tons in 1882, the price ranging from 1¾ cents per pound up. There is a considerable importation of rock asphalt from Switzerland, one prominent locality being the Val de Travers, canton of Neuchatel. This rock is manufactured into a mastic known as rock asphalt mastic, which is used for laying the wearing surfaces of sidewalks, roofs, and floors. With the crude rock asphalt the wearing surfaces of carriageways are prepared. This crude rock asphalt is a carbonate of lime, naturally and evenly impregnated with bitumen. It sells for $18 per ton of 2,000 pounds; and the manufactured mastic at $23 per ton. The importations of foreign asphaltum during the fiscal year 1882 amounted to 30,686,333 pounds, invoiced at $105,152. Crude asphaltum and bitumen are on the free list. The exports of asphaltum during the period mentioned amounted to only $400.

ALUM.

Native alum.—Alum appears in the form of an efflorescence on argillaceous rocks in the Silver Mountain district, Alpine county, California, but the deposits are too light to be of much practical value. In the early part of 1875 the discovery of what was termed an alum lode was reported to have been made on Howell mountain, Napa county, California. As is often the case with these reported finds, much was claimed for the extent and purity of this deposit; but as a very little alum from that locality ever found its way to market, the first accounts of this discovery were presumably much exaggerated. Some of the springs of the Geyser group, Sonoma county, also small springs near Owen's lake, carry a small percentage of alum. Certain clays found in Santa Clara and Calaveras counties in the same State show a strong taste of alum; but if any valuable deposits of this mineral have ever been found in the Pacific division, the fact has not become generally known.

Alum occurs in small quantity at Mount Vernon and in Jefferson county, Colorado. In other parts of the Rocky mountain region small quantities of the mineral are found, but nowhere in economically available bulk.

Artificial alum.—The alum of commerce is a manufactured commodity, and the supplies consumed in this country are both of the imported article and that made in a few chemical works in the Eastern States, chiefly in Pennsylvania, New York, and New Jersey, from alum shale, clay, etc. In the census year ending May 31, 1880, the production of artificial alum in the United States was 39,217,725 pounds, valued at $808,165.

The production of artificial alum in 1882 amounted to between 16,000 and 20,000 tons, which at 2 cents per pound would be worth from $640,000 to $800,000. Nearly all was made from alum clays brought from France and England, but the manufactured product is said to be superior in quality to that imported from England. The process of manufacture is very simple, consisting in mixing the clay with sulphuric acid, dissolving the sulphate of alumina thus formed, and then adding a solution of sulphate of ammonia and crystallizing the resulting salt. The leading manufacturers are Messrs. M. Kalbfleisch's Sons, of New York City and Buffalo; Chas. Lennig & Co., Harrison Bros. & Co., and Powers & Weightman, of Philadelphia; and the Pennsylvania Salt Company, of Philadelphia and Pittsburgh.

COPPERAS.

Production.—The estimated production of copperas (sulphate of iron) in this country during the year 1882 was 15,000,000 pounds, having an average spot value of three-quarters of a cent per pound.

Sources.—This material is largely made from the waste oil of vitriol from wire and galvanizing works, with scrap iron. It is also made from alum shale. The principal centers of production are as follows: Worcester, Massachusetts; New Haven, Connecticut; Buffalo, New York; Philadelphia and Johnstown, Pennsylvania; Cleveland and Steubenville, Ohio; and Saint Louis, Missouri.

Uses.—Its principal uses are in paper and print mills, bleacheries, dyeing establishments, chemical manufacturing establishments, paint and ink manufactories, and for sanitary purposes as a disinfectant.

CRYOLITE.

Cryolite, with its associated minerals, gearksutite, thomsenolite, etc., occurs sparingly in the crystal beds near Pike's peak in Colorado. Its occurrence elsewhere in the West is not known. Cryolite is used for making soda, in the manufacture of a white porcelain-like glass, and to a very small extent in the manufacture of aluminum. The main supply comes from the cryolite bed at Evigtok (or Iviktoh), in Greenland.

OZOCERITE.

A deposit of native paraffine or mineral wax (ozocerite) was discovered in southern Utah during the summer of 1877. This find was considered so valuable that a company, having headquarters in Boston, was formed the next year for working the deposit, which has since been mined quite extensively and with some profit. The crude material is said to be of good quality, samples sent to England to be tested having been pronounced equal to the best Turkish. Other samples analyzed in San Francisco were found to contain a large percentage of white wax, of the kind used in making paraffine candles. It is said that this substance can be mined and delivered in Boston at a cost of 4 cents per pound.

Ozocerite occurs in beds of coal, or associated bituminous substances. It is found at Slanik, Moldavia, and at the foot of the Carpathians, but is not common. It is like wax or spermaceti in appearance and consistency, ranging in color from an impure white to black; frequently brown or green.

MISCELLANEOUS CONTRIBUTIONS.

THE DIVINING ROD.

BY R. W. RAYMOND.

Circumstances having recently drawn my attention afresh to the alleged virtues of the divining rod, the still-continuing use of it in civilized countries, and the mass of evidence concerning it which has accumulated during the last three centuries, I was led to execute an old plan, often postponed, and to prepare a somewhat elaborate discussion of the rod and its literature. The result was a paper of considerable length, presented at the Boston meeting of the American Institute of Mining Engineers, in February, 1883, and now awaiting publication in the transactions of that society. The subject is one of general interest; and, moreover, as it is one of those subjects which are periodically revived by enthusiastic believers or superficial students ignorant of history, it seems to me that an account, abridged from the paper referred to, may be in this place neither inappropriate nor unwelcome.

The extent to which the divining rod is still used in this country for the detection of hidden treasure, mineral veins, or springs is much greater than educated persons would be likely to suppose. For many years wells have frequently been located by its aid in New England, where the belief is widely extended among the farmers that in the hands of peculiarly gifted persons this instrument possesses special virtue. Large numbers of the oil wells of Pennsylvania have been bored at points designated by the so-called "oil-smellers." More than one adept with this instrument is practicing now in the western mining region. I encountered, a few months ago, in southern Colorado, a party of capitalists, who were accompanied by such an expert, and whose purpose was to discover a mine by his aid, and to buy the property thus made valuable. Still more recently, a paragraph in the Tombstone *Epitaph*, of Arizona, announced that a party of gentlemen from Chicago, whose names were given, had been scouring over the hills in the neighborhood of Tombstone for over a week, in company with an expert of Colorado, who had been employed to ascertain, "with his well-known divining rod," the localities of mineral wealth, and who had declared the existence of large bodies of ore in at least two places not yet developed. It is also reported, with what truth I do not know, that the Central Pacific and Southern Pacific Railroad Companies have employed the divining rod successfully in the discovery of water, and have located by this means their artesian wells in the desert. Last, but not least, a small book, entitled "The Divining Rod," and published in Cleveland in 1876, contains an essay on this subject read before the Civil Engineers' Club of the Northwest, at Chicago, in 1875, by Mr. Charles Latimer, a well-known engineer, who has had charge of several important railways, and who testifies in the most unqualified manner to the virtues of the divining rod as a means of determining the position and the depth of subterranean water courses, and claims to have discovered certain new and important laws of its operation connecting, if not identifying, it with the force of electricity.

These circumstances, taken together with the fact that the "dowsers," or experts with the rod, still enjoy considerable local authority in Cornwall, and that believers in its efficacy may still be encountered among the German miners (although I think in that country the faith is more nearly extinct than elsewhere), certainly justify me in regarding this subject as one not solely of historical interest. Yet a consideration of its history and literature will throw important light upon the question whether the phenomena which it has presented, and continues to present, are to be ranked under the head of self-delusion, deliberate deceit, or both; or, on the other hand, indicate, after all reasonable deductions for human error and credulity, a residuum of important scientific truth.

Before sketching the history of this instrument, it will be well to say a few words concerning its form, material, and use. Yet this is a work of no little difficulty. The immense literature of the divining rod shows nothing more clearly than the boundless confusions and contradictions of its advocates and professors. Of the dozen different schools of practice, each is necessarily obliged to reject half of the asserted principles and certified facts put forward by the rest.

The most common divining rod, perhaps, has always been a forked branch of witch-hazel in the shape of the letter Y. This wood may have been selected because it forks in such a way as to give two branches of equal size, or because of its supposed affinity for springs of water. But other woods, such as peach, ash, pitch-pine, and even metals, have been recommended at different times, and different professors of the art have also varied the shape of the rod, employing sometimes a straight twig with a small fork only at one end, or an elastic twig or whalebone without any fork. The dowsing rod used by the expert mentioned in the Tombstone *Epitaph* is, I believe, an instrument made of two prongs of whalebone united in a stem which terminates in a case similar to a rifle-cartridge. The contents of this case are a secret. (Similar cases, used in the Middle Ages, are said to have contained mercury.) This rod, like the ordinary forked hazel switches, is held in the two hands, each grasping the extremity of a prong, with the fingers closed not too tightly and the palms upward, the shank or stem of the rod being horizontal or vertical, or variously inclined, according to the principles of the practitioner. When carried in this manner by the operator, walking over the surface of the ground, the rod is said to turn or dip above treasure, mineral veins, springs, etc., and there is an elaborate and complicated science based upon the various degrees, directions, and force of this dipping. Unfortunately the rules as determined by one or another celebrated operator have been found not to work for his rivals or successors, so that each authority lays down rules of its own. The straight rods were either balanced in various ways on one or both hands or sprung bow-like between the two hands. The most peculiar rod described in ancient books was made of two pieces of wood, one of which was pointed and the other provided in the end with a socket. This rod; being delicately held, was said to indicate the presence of the object sought for by a peculiar revolution of the point in the socket.

An inquiry into the uses of such rods leads us at once to the history of our subject, in the study of which it will appear that divining rods were first used in antiquity mainly or wholly for moral purposes; that in the Middle Ages their employment was for a long period confined to the discovery of material objects; that towards the end of the seventeenth century the moral use was again asserted, and that in the eighteenth century the divining rod was relegated to the material sphere, and assumed the comparatively modest functions in the discharge of which it still lingers among us.

It will be remembered that the Egyptian sorcerers confronted by Moses carried rods, as Moses and Aaron also did. The prophet Hosea denounces the uses of rods for divination by the Jews (Hosea 4:2). According to another prophet (Ezekiel 21:26) the King of Babylon consulted rods or arrows to decide his course. The Scythians, Persians, and Medes used them. Herodotus says that the Scythians detected perjurers by means of rods. The word *rhabdomancy*, originated by the Greeks, shows that they practiced this art; and the magic power of the rods of Minerva, Circe, and Hermes or Mercury is familiar to classical students. The *lituus* of the Romans, with which the augurs divined, was apparently an arched rod. Cicero, who had himself been an augur, says, in his treatise on divination, that he does not see how two augurs, meeting in the street, could look each other in the face without laughing. At the end of the first book of this treatise he quotes a couplet from the old Latin poet Ennius, representing a person from whom a diviner had demanded a fee as replying to this demand, "I will pay you out of the treasures which you enable me to find." This ancient joke, by the way, has been adopted in all seriousness by the "oil-smellers" of Pennsylvania, who, as I am informed, are accustomed to locate oil wells on precisely this condition, receiving nothing if the well proves unsuccessful and fifty dollars if oil is struck.

Marco Polo reports the use of rods or arrows for divination throughout the Orient, and a later traveler describes it among the Turks.

Tacitus says that the ancient Germans used for this purpose branches of fruit trees. One of their tribes, the Frisians, employed rods in church to detect murderers. Finally, if we may trust Gonsalez de Mendoza, the Chinese, who seem to have had everything before anybody else, used pieces of wood for divination.

Thus we perceive that the application of the divining rod in historical antiquity was mainly or wholly moral; that is, it was employed to detect guilt, decide future events, advise courses of action, etc. It is largely to the alchemists that we owe the development of its use for detecting material objects. In truth, the alchemists, relatively to their times, were scientific. They studied nature more, not less, than others. Their superstition was at least alloyed with science, while the general superstition was unalloyed. Hence they were likely to reject the supernatural or spiritual powers and uses of the divining rod, and to regard it as a mysterious but physical agent. Yet the first mention of it in this sphere found in any alchemistic book, namely, in the *Novum Testamentum* of Basil Valentin, supposed to have been written in the fifteenth century, though certainly not published or known to have existed before the sixteenth century, recognizes the practice of carrying the divining rod as common among German miners.

Whatever its antiquity, the use of the rod to discover hidden treasure or metallic ore became general in Germany, and was extended thence through Flanders, England, Sweden, France, Italy, and Spain before the end of the seventeenth century. It must be remembered that in those days the practice of burying money and plate was universal. A rod that would discover buried treasure only would at the present time be of comparatively little value. We know well enough where the large masses of gold and silver are piled. It is not ignorance, but bolts and bars, that prevent our getting at them; and a large class of the diviners of the Middle Ages would, if they lived to-day and practiced their professions, be obliged to become burglars or cashiers.

The scientific explanation of the divining rod at this period, like the scientific explanation of nearly all facts in chemistry and physics, was *affinity*, a word under which was concealed a little science together with a vast amount of ignorance and superstition. Philip Melancthon (1497–1560), the friend of Luther, adopted this theory to explain the effects of the divining rod. We must confess that in an age when the attraction of the magnet for iron and of electrified amber for light bodies was known, but not understood, there was no necessary absurdity in supposing that similar phenomena might be exhibited by other classes of substances. And this natural presumption, joined with the inherent credulity of ignorance and the tendency to generalize upon imperfect data, caused a very general acceptance of the alleged operations of the divining rod as true, and consequently the promulgation of crude quasi-scientific theories to account for it. On the other hand, it must be remembered that the belief in demonic agencies was still active and allpervading, so that when facts could not be scientifically explained they were at once referred to witchcraft or to the devil direct. So long as the discussion remained within the field of science it was conducted with courage and candor; but when it entered the demonic domain, the boldest philosopher, unless he were willing to sell his soul to Satan, became dumb. This may explain the attitude of the great Agricola (*De Re Metallica*, Basle, 1546, lib. ii.), a keen observer and wise reasoner, who, after saying that the alleged virtues of the divining rod are subject to much dispute, and stating both sides of the dispute with admirable clearness, demolishes in a few words the supposed analogies of magnetism and electricity, but declares that if the divining rod derives any power from spells and incantations, that is a matter neither permissible nor agreeable for him to discuss. He proceeds, moreover, to assert as the general result of experience in his time that the professors of the divining rod, though they sometimes succeed in discovering veins, quite as frequently fail, and have to dig like other people if they wish to find anything. Wherefore, he advises the respectable and sober miner to study the indications of nature, and then dig at once without further fooling. In the quaint wood-cut which accompanies this passage a miner is represented in the background as cutting his hazel twig, while another in the foreground is proceeding with it in due form for the discovery of the mine, and (whether in sarcasm or not, I do not undertake to say) at the very point to which the latter is steering, two of Agricola's "good and sober" miners have already found ore by the homely process of digging.

Paracelsus, the great hermeneutic philosopher of the first half of the sixteenth century, condemns in his writings as uncertain, illusory, and unlawful, the use of the divining rod. But his disciples did not uniformly agree with him in this view. Most of them accept as proved the efficacy of the rod, some ascribing it to a physical property and some to demonic agency; while a few discredit the alleged facts and pronounce the practice to be a superstition.

Still another view was advanced and greatly favored by the practitioners themselves, viz., that the performances of the rod are genuine and depend upon a physical property in part, their complete success requiring, however, a peculiar gift in the operator, conferred by divine favor. In pursuance of this idea, the practice was surrounded with highly pious ceremonies and formulas. It is true that some of the rules prescribed for the time and manner of cutting the hazel wand partook largely of heathen sorcery and astrology. Scandinavian and even Aryan mythology reappear in them. But this was atoned for when the rod, once cut, was duly Christianized by baptism, being laid for this purpose in the bed with a newly baptized child, by whose Christian name it was afterwards addressed. The following formula, cited by Gaetzschmann, may serve as an example: "In the name of the Father, and of the Son, and of the Holy Ghost, I adjure thee, Augusta Carolina, that thou tell me, so pure and true as Mary the Virgin was, who bore our Lord Jesus Christ, how many fathoms is it from here to the ore"? In this case, the rod was expected to reply by dipping a certain number of times corresponding to the number of fathoms.

Such devices, however, were not everywhere successful in diverting from the practitioners of this occult science the evil name of sorcery. A striking and pathetic instance is furnished in the seventeenth century by the history of the Baron and Baroness Beausoleil. The baron, born in Brabant, devoted himself to mineralogy and mining, and became, undoubtedly, one of the foremost mine engineers of his time. He visited and studied the mines of Germany, Hungary, Bohemia, Tyrol, Silesia, Moravia, Poland, Sweden, Italy, Spain, Scotland, England, and France. The Emperors Rudolph and Mathias appointed him counselor and commissary-general of the mines of Hungary. The Archduke Leopold made him director of the mines of Tyrol and Trent. The dukes of Bavaria, Neuburg, and Cleves gave him the same title. Finally, the Pope did the same for all the papal states. He appears to have amassed from these various employments a considerable fortune.

In 1600 he was engaged by the comptroller-general of the mines of France to open mines in Languedoc and some other provinces, and in 1626 this commission was still further extended. During this period he met and married his wife, who devoted herself with enthusiasm to his profession, studying and traveling extensively with him in Germany, Italy, Sweden, and perhaps Spain. They even made a voyage to the shores of the New World. In 1627 their house was robbed under legal forms of search on the charge of sorcery preferred by a local official. Their loss was estimated at one hundred thousand crowns. They easily obtained acquittal of the charge; but it is an instructive commentary on the justice of the times that they never were able to recover their property. They went to Hungary, but returned to France in 1632 under a new commission from Louis XIII. In this year the baroness, who was an accomplished author, published an account of one hundred and fifty mines already discovered in France, and of some medicinal springs. They expended, in further explorations, nearly the whole of their fortune, but were unable, in the face of their jealous rivals and enemies, to obtain from the Government the grants which had been promised them, and by means of which they expected to reimburse themselves. Finally, the baroness published a work, addressed to Richelieu, and entitled "The Restitution of Pluto" (reprinted at Paris in 1779), in which, with eloquent indignation, she declared the deserts of her husband and herself, and asserted their right to the rewards promised them, urging the cardinal-minister at the same time, by every consideration of the glory and greatness of France, to encourage the development of its mineral resources. Unfortunately, in this work she furnished new material for the slanderous accusation of sorcery. In magnifying the art of discovering mines and springs, and the skill required for this purpose, she gives a description of the means employed, showing that these hidden treasures are to be detected—

1. By digging, which is the least important way.
2. By the herbs and plants which grow above springs of water.
3. By the taste of the waters which flow from them.
4. By the vapors which arise from them at sunrise.
5. By the use of sixteen scientific instruments and of seven rods (the seven rods of Basil Valentin) connected with the seven planets, etc.

The first four means were undoubtedly real and really employed. Under the fifth head we have an illustration of what is so common in the alchemistic and other mediæval writers, namely, the covering of the facts of nature and the methods of investigation with assumed mystery, to hide them from the vulgar. So long as the baron and baroness were spending their own money for the good of the State, they were permitted to go on, and even received, from time to time, complimentary notices which, indeed, could not be withheld from persons of such eminent reputation. But when they became troublesome in their demands for more substantial favors, and came into collision with the rings which infested the kingdom, the charges of sorcery renewed against them furnished a convenient pretext for getting them out of the way. Richelieu may even have supposed that he was behaving in this case with lenity, since, instead of having them burned to death, as he did with another sorcerer of the same period, he only put the baron in the Bastile (1642) and his wife in Vincennes, where they soon (about 1645) died in destitution and misery, victims not so much of the superstition as of the corruption of the times.

It will be noted that the treatise of the baroness did not claim for the divining rod any moral virtue. What the Beausoleils appear to have done for this instrument was to bring forward its use in the discovery of springs as well as metals. (*a*)

For fifty years after their death the subject was discussed among *savans* and priests. Occasionally some one ventured to doubt the truth of all the stories told about the wonderful powers of the rod—as, for instance, when the celebrated Robert Boyle, in 1666, put the question, as member of the Royal Society of London, whether the divining rod is really moved by the proximity of metals. The learned Jesuit, Kircher, tested it by mounting such rods upon pivots, and concluded that they would not move except when in human hands. But this is almost the only careful experiment recorded of this period. Other observers seem to have taken the word of the operator, or accepted at second hand the tales of the wonder-stricken spectators.

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a The above account of the Beausoleils is abridged from Figuier's *Histoire du Merveilleux*, to which, together with Chevreul's *La Baguette Divinatoire*, Gaetzschmann's *Auf und Untersuchung der Lagerstätten*, and Agricola's *De Re Metallica*, I am indebted largely for the materials of this review. A full citation of authorities will be found in my more elaborate paper, already referred to.

Many pious dignitaries of the church took part in the discussion; and so long as only the detection of material objects was to be explained, they could take one or the other side freely. The earlier uses of the rod for general divination and moral discrimination seem to have been for a time forgotten. Some of the Jesuit writers do mention them towards the end of the century, only to condemn them as diabolic. Any attempt to justify them would have incurred at once the censure of the church, which would have settled the vexed question of agency by denouncing as unlawful this intrusion upon its spiritual prerogative. This is indeed what speedily happened, as we shall see. The lost doctrine of moral power reappeared, not among the learned, but out of the obscure mass of the people. In the province of Dauphiny, in the south of France, the practice of the divining rod, introduced perhaps by the Beausoleils, had become, fifty years after their death, an art followed by many experts, who were called *hommes à baguette.* They were employed to find springs of water, hidden treasure, mines, etc., and also to detect criminals, and even to settle disputes as to boundaries when the landmarks were gone. Two farmers, for instance, having a dispute as to the boundary between their farms, instead of going to a lawyer or judge, would send for a diviner; he, walking over the disputed ground, would indicate by the dipping of his rod the spot where the old landmark formerly stood; and this decision was accepted without appeal. Considering the expense of litigation in all times, and the peculiar character of the justice which at that time was sold so dear and worth so little, we may fairly say that whatever be the merits of the divining rod, the peasants of Dauphiny acted wisely in employing it!

In 1692 a mysterious murder was committed at Lyons, and the authorities were persuaded to accept as an assistant in tracing the unknown murderers a rich peasant of Dauphiny, already locally famous as a diviner. This man, Jacques Aymar by name, having gone through at the scene of the crime what he called an "impression" (consisting in shuddering, signs of pain and agitation, and accompanied by violent dipping of his rod), started on the trail, in the manner of a bloodhound, and after many days tracked down and discovered in the jail of another city one—the least important—of the three criminals. This was a hunchback, who had been an accomplice, and had kept watch at the door of the house while the murder was done in the cellar. The principals escaped, though Aymar professed to follow their traces beyond the borders of France. The hunchback was taken to Lyons, recognized by many persons as having been at the scene of the crime about the time of its perpetration, tried, and finally, upon his own full confession (and, as the judges took pains to declare, not upon the testimony of the rod), condemned and broken alive. A careful analysis of the numerous official and other records of this case shows it to be quite possible that Aymar was in possession of important clews at the outset; and that fact being granted (though the clews were no more than the fact that three strangers, one of whom was a hunchback, had been seen in the neighborhood), the rest is merely a piece of clever detective work.

Nevertheless the affair produced a wide-spread sensation in France; and Aymar was called to Paris, where both the court and the *savans* interested themselves greatly in his mysterious powers. To the present day his performances are often cited by those who think there is "something in it, after all." In respect of marvelous tales, the natural preference for belief is great; and it has apparently been forgotten that Aymar was really exposed as a failure and a cheat, while the alleged triumphs of his skill are eagerly recalled. His claims were absurd from the standpoint of any scientific theory. The rod was, as he said, merely an index and an intensifier of his feelings. He could do without it, but not as well. In his hands it was sensitive to the particular object which he was at the time seeking. When he sought a given murderer, the track of some other murderer or the neighborhood of subterranean water or hidden treasure would not disturb or divert him. If he felt these things in passing, the feeling was easily distinguishable from that connected with his intention, etc. But he was deceived over and over again, and the Prince de Condé at last publicly denounced him and warned the public against him. Yet many believed in him; and he grew sullen and audacious as he grew desperate. At last he undertook to divine character with his rod; and on one occasion demanded blackmail from a lady whose character he had been commissioned by her intended bridegroom to reveal. After leaving Paris he performed a similar trick in a village of France, where he maliciously designated a considerable number of the most respectable houses as the dwellings of bad women. His last appearance in history was the worst of all. In 1703 he was employed during the civil war to point out with his divining rod Protestants for massacre, on the pretext that they had been guilty of crimes, which his power could thus detect. I think the modern friends of the divining rod would do well to leave Aymar out of their list of experts.

The inquisition of Rome in 1701 denounced the divining rod and all works in its defense. But before that a number of books had appeared in which even the moral uses of the rod had been skillfully connected with the ruling Cartesian philosophy. The chief of these is the *Physique Occulte* of the Abbé Vallemont, which appeared in 1693, and in which the "corpuscles" of Descartes were made to do new duty. It declares that the holder of the divining rod receives corpuscular effluvia from various suitable substances or from other human bodies, and communicates them by transpiration through the pores of the skin to the divining rod. Differences of skin in different people result in various degrees of susceptibility to particular impressions; but Aymar was, according to the abbé, possessed of an epidermis which could receive all kinds of impressions without confounding them. The theory necessitated also differences among the corpuscles from springs, minerals, thieves, assassins, *missing boundary-stones* (!), etc. But the abbé bravely accepts the logical situation, and declares the existence of aqueous matter, larcenous matter, murderous matter, etc. Moreover, to explain how Aymar could track a crime, as he claimed, years after its commission, the abbé postulates an extraordinary levity of the corpuscles, by virtue of which they remain indefinitely suspended in the air, in spite of rain, wind, or even other corpuscles of later origin. The whole theory bristles with absurdities, which the science of that day, even, was able to detect. Lebrun and others demolished the corpuscular theory, as Kircher had demolished the theory of affinity. The demonic hypothesis remained. Several cases are reported at length in which persons possessed (through an unconscious compact with Satan) of the evil power of using the rod got rid of it by prayer and fasting. The anathema of the inquisition in 1701 had apparently this effect, that it stopped the worst abuses of the art. Certainly we hear little or nothing in the eighteenth century of the detection of criminals, the revelation of character, or the disclosure of the future by such means.

But Dauphiny still bred *sourciers*, *i. e.*, diviners of springs. In 1750 one of the most famous of these, Barthol̀émy Bleton, was born there. He matured just in time to suit the plans of a physician of Lorraine, Dr. Thouvenel, who was full of an electrical theory of the divining rod, and wanted, in 1780, an expert to experiment upon. The doctor, like his predecessors a hundred years before, tried credulous experiments, asked innumerable questions, believed the answers he got, and published forthwith a big book, with the scientific explanation. It is not worth while to analyze it, but two or three points are significant. Bleton did not profess to discover anything other than material objects, especially running water. He was what is called a hydroscopist. Again, he frankly declared that the rod was merely an index; that it was not necessary; that its form or substance was totally indifferent, having nothing to do with his power, which it manifested. Finally, he said (and Thouvenel proved it by "experiment"), that when he was insulated from the ground, the effect of water on him and, through him, the rod, was entirely cut off, to be restored again as soon as the insulation was removed.

Bleton went to Paris; and the story of Aymar was in some particulars repeated, except that Bleton was undoubtedly a skillful water-seeker, and not so bad a man as his famous predecessor. Yet he failed in many tests—as often, we may say, as he succeeded, apart from cases in which, with ample time and with the skill born of long experience, he located wells in the country. Even here his failures were numerous; but his recorded successes are also many. In one particular he may have shown bad faith, though the facts are not inconsistent with honest self-deception and the unconscious control of the imagination. I refer to the famous insulation experiment, which showed at Paris the same results as in Lorraine until the insulation, instead of being openly broken, was secretly destroyed by connecting with the ground, through a good conductor, the top of the glass-legged stool on which Bleton was standing. This being done without his knowledge, no results whatever followed. The alleged effects of insulation continued so long as Bleton thought the insulation still existed. The theory and this particular experiment of Thouvenel have been rediscovered by Mr. Charles Latimer, who, in his Cleveland lecture, claims them as new! They were exploded a good while before he was born.

Dr. Thouvenel was not discouraged by the failures of his *protegé*. Emigrating at the time of the Revolution, he took with him to Italy another Dauphinese hydroscopist named Pennet. After various experiences (on the whole unsatisfactory) in finding or failing to find water, hidden metals or ores, coal, etc., this expert came to grief finally at Florence, where he was caught at night in an inclosure which had been prepared for a careful test on the morrow by burying masses of metal here and there in it. Apparently intending to reconnoiter a little beforehand, he climbed over the wall into this inclosure. Somebody who was on the watch removed the ladder, and the wall being very high, Pennet was unable to divine any way out. This exposure caused him to leave Florence, and public life too, so far as I can learn. Yet the good doctor declares that "Pennet's moral defects had nothing to do with his physical faculty!" We are forcibly reminded of the way in which the votaries of modern "mediums" adhere to them after they have been exposed.

Affinity, corpuscles, electricity—each had its period of discussion. The beginning of this century, all excited as it was by the brilliant discoveries of Galvani, was very ready to find electricity anywhere—if not in the rod, then as "animal magnetism" in the man.

A vigorous discussion sprang up in Italy, and many hydroscopists appeared there. One of the most famous was Campetti, who in 1806 was called to Munich for scientific examination of his powers. He does not seem to have convinced the skeptical scientists. Another Italian, Amoretti, himself a member of a family which had produced many hydroscopists, published a very interesting critical essay on the subject, in which emphasis is laid upon the sensation experienced by the diviner in the presence of water. He says it is one of "heat or cold." This is a significant point to which I shall presently recur.

With regard to the evidence presented in our own country, it is safe to say that most of it, like most of the evidence of the past, is open to the suspicion of at least an alloy of deception. Men who make money out of their reputed skill with the divining rod, and who could not make as much money or advertise themselves as thoroughly if they claimed only a high degree of skill as prospectors, will almost inevitably ascribe to the rod what is due to other means of inquiry; will explain away failures, exaggerate successes, and not establish or execute or permit really thorough and sincere experiment. Nor are they easily discredited, any more than Aymar or Bleton was, or wonder-working "mediums" in our own day are, by failures or exposures, provided they continue to put a bold face upon the matter, and piously imitating the disciples of old, when persecuted in one city, flee to another. The most distinguished expert in this art on the Pacific coast has been repeatedly made ridiculous by the result of test experiments. On one occasion, as I learn from an eye-witness (who also reported the circumstances to the *Mining and Scientific Press*, of San Francisco), this diviner was invited to inspect a metallurgical laboratory containing a large amount of gold, in coin and bullion. After this inspection he was brought again, blindfolded, into the laboratory, and requested to point out the metal with his rod. But he could find nothing, though during his perambulation the point of his rod was frequently within an inch of thousands of dollars. When the bandage was removed from his eyes, and he was shown that all the coin had been put in its natural receptacle, the fireproof safe, while the bullion had been fastened by wire to the under side of a writing-table, he claimed that his rod had been diverted by the immense amount of treasure in a bank half a block distant!

There have also been in California operators professing to be "natural magnets," and not using the rod; but they have had no better success. One of these natural magnets was employed to trace the missing continuation of a vein for a mining company at Grass Valley, the mine of which had been at one time the most productive in California. Under his direction the company cut for many hundred feet, at an expense of $30 to $40 per foot, through tough greenstone, and found nothing. Not only are these greenstone belts at Grass Valley well known to be barren, but this particular belt was actually exposed in a cross-section, parallel with this expensive underground cross-cut, and only one-eighth of a mile away. The persons most familiar with the mining districts of the West declare that, though the divining rod, in one or another form, has made its appearance in many of them, it has discovered nothing of practical value.

The scientific explanation of the movement of the divining rod was given by M. Michel Eugène Chevreul, in a letter to M. Ampère, published in 1833 in the *Revue des Deux Mondes*. This letter, however, gave an account of experiments made by the writer in 1812, more than twenty years before. Finally, in 1853, M. Chevreul having been appointed by the Academy of Sciences upon a committee to examine a work on the divining rod, wrote a report on the subject, including the "exploring pendulum" and the then novel wonders of "table tipping." This report was published in 1844, under the title *De la Baguette Diviniatoire, du Pendule dit Explorateur, et des Tables Tournantes, au Point de Vue de l'Histoire, de la Critique et de la Méthode Expérimentale.* It is worthy of notice that this venerable *savant* is still active, at the age of ninety-seven. Only the other day he spoke before the Academy, referring to a paper he had presented to that body (if I remember correctly) seventy years ago.

Chevreul ascribes the movement of the rod, apart from cases of deliberate deception, to minute, unconscious, muscular movements, and these are caused, he thinks, by the imagination, or intention, or unconscious decision, or expectation of the operator. An impression that the rod will dip at a certain point, or a wish that it would, or even in some minds a fear that it may do so, are all effective causes of the peculiar muscular movement. Stories describing motions of the rod so violent as to strip the bark from it, in spite of the resistance of the holder, do not disprove the above theory. The position of arms, hands, and fingers usually prescribed for the holding of the rod, as explained in the beginning of this essay, is one in which it is not easy (though not impossible) to produce by conscious effort the peculiar movement referred to. But it is also one in which skillful effort, if employed, may be easily disguised; and, finally, it is one which invites muscular cramps and produces muscular torsions and involuntary movements, not to be resisted successfully *without a change of position.* Under these circumstances a man might easily twist the bark from a willow stick, and yet fancy he was trying not to do it.

In concluding this survey of the subject, I shall take a somewhat wider view than M. Chevreul, and my remarks, though based on his theory, should not be received as representing it.

From the mass of testimony, good, bad, and indifferent, the following propositions may be safely deduced:

1. The material, consecration, astrological relations, and ritual formalities of the rod are entirely irrelevant and indifferent to its efficacy. This disposes at a stroke of nine-tenths of the "science" which the Middle Ages so laboriously accumulated on the subject.

2. The rod itself is entirely inert, unless in the hands of a human operator; and, according to the declarations of the most famous experts, such as Aymar, Bleton, Amoretti, and many others, and a whole school of diviners who do not use the rod at all, the rod is merely an index, revealing and magnifying in visible results the peculiar inward sensations of the diviner.

3. The favorite and most convenient form of the rod (⅄) is one which promotes involuntary muscular movements, and also permits deception.

4. The involuntary minute muscular movements may proceed either from the causes enumerated by Chevreul, or from a truly and purely physical sensation. To this I will presently recur.

5. The uses of the rod for discovering moral qualities, relocating missing landmarks, tracing stolen property, prophesying the future, or even (as in the seventeenth century was the case) settling the orthodoxy of theological dogmas, will not now be seriously defended by any one. They belong to charlatanry and superstition.

6. The agency of demons we may also set aside, as a view outgrown if not disproved. The pious Jesuit Gaspard Schott (1662), who held this view, was shaken in his faith, though not convinced, by testimony showing how often the rod failed to act or gave unreliable indications.

He half admits that if Satan were at the bottom of it, it should work better! As an instrument of divination, it is unworthy of the Devil. But it might have been rejoined, that as a means of perplexing and misleading mankind that distinguished expert could scarcely have improved it.

7. The application of the rod to the discovery of metals, coal, buried treasure, etc., is shown abundantly to be chimerical. The rules and methods, as well as the asserted performances of its professors, contradict each other; and innumerable failures and exposures have justly covered with ridicule their pretensions.

8. The transparent humbug of locating oil-wells with the rod, to strike oil at depths of from a hundred to thousands of feet, needs no comment. In this case, there are positively no signs by which a given *spot* can be selected. The experience of neighbors may show a certain area to be probably productive; and within that area a certain line may be inferred, sometimes, to be the line of a productive channel. But if a keen observer, having gone so far, professes to select a point on that line, he is simply betting on his luck; and, as carried on in Pennsylvania, the bet is a safe one for the oil-smeller, who gets a handsome fee if he wins, and loses, in the opposite event, nothing but an hour or two of time.

9. The case is somewhat different with the discovery of springs, and (since ore deposits always have been, and often still are, the channels of springs) of ore deposits. Here we have much stronger and more abundant evidence in favor of the rod; and here, in my judgment, there is a residuum of scientific value, after making all necessary deductions for exaggeration, self-deception, and fraud. Keeping in mind that the rod is merely an index to the minute muscular movement, and that this movement may have a mental or a physical cause, let us consider (putting aside at once all cases of deliberate deception) the following facts:

There is undoubtedly a practical science of discovering mineral deposits and springs. The most skillful prospectors can scarcely explain how they decide upon the place where they dig; and yet, though they are by no means always successful, it is certain that they are more successful than the inexperienced. The books, from Agricola down, give rules and signs; but the practical explorer is unacquainted with the books. He has a science of his own, which affects his mind without conscious reasoning, by the principles of association and memory. He recognizes in a new locality the tokens that he has become accustomed to associate with a rich gulch or an abundance of pay-quartz elsewhere. Perhaps he never took conscious note of them; yet their recurrence affects his judgment. This practical skill is almost unerring within narrow limits. Under new conditions it breaks down. Some of the most absurdly foolish gold-mining enterprises I have ever known have been set on foot by old California miners, who, returning to their former homes east of the mountains, have said at once of some ravine or hillside that it was "just the place for gold." In like manner, certain omens and signs from Cornwall have been carried around the world by Cornish miners. But whatever the errors of practical prospectors, the noteworthy point is that in localities with which they are familiar (or in other localities where the conditions are the same) they come swiftly, surely, and without conscious reasoning to impressions and decisions. A decision of this kind would probably, in a man of suitable nervous organization, affect the muscles already constrained by holding a divining rod, and the minute muscular movement or inward sensation might be involuntary.

The case is still plainer with regard to the discovery of springs. Everybody knows that Indians in our desert West can find water where most white men cannot; and the experienced frontiersman has learned the art from the savages. The conformation of the surface, the tracks of animals, above all, the presence or absence of certain plants, are his guides. In regions where the finding of water within a few feet of the surface is a question of life or death, it becomes a science very rapidly. The location of artesian wells is a different matter. Science will do that in a general way; but science will not determine a difference between one spot and another, ten or twenty feet away, the geological and topographical conditions being alike in both; and the selection of one of two such points as better than the other for a deep well is purely a piece of imagination or deceit. It must be remembered, however, that the diviner has in such a case an easy task. If possessed of sufficient practical judgment to decide that a certain area or line would probably be suitable for boring, he is pretty sure to be safe in selecting any point of it. But this, it will be seen, is very different from the unconscious skill which points out in the dry *arroyo* the very spot where water will be found in half an hour's digging.

In abundantly watered regions, like New England, it is perfectly well known that the springs follow, under or through the soil and above the bed-rock, more or less defined channels. A well may be dug at one point without success; and a subsequent attempt, a few yards away, may be successful. The superficial signs of these water-courses are often subtle, and they are little studied by the inhabitants in general. It is not necessary that a farmer, who will want to locate a well once in a life-time, should know the signs of water as a ranchman or *vaquero* must know them. Hence this knowledge falls usually to a few, who being keen observers, and in many instances finding profit in the business, get impressions, amounting to a local science, of the "lay" of the rocks, the general courses of the springs, the differences in surface vegetation, the earlier or later greenness of grass, the presence of particular grasses and shrubs, the rise of vapors at sunrise, the behavior of frosts —in short, a hundred minute tokens which betray the presence, even at considerable depth, of a water-channel and the point at which it comes nearest to the surface. The unconscious judgment of such an expert may decide upon a given spot over which he walks; and while he could undoubtedly come to this conclusion without having a rod in his hand, I am willing to admit seriously that the rod may help him make up his mind. It should be remembered here that even Bleton, the greatest of all the hydroscopists, generally used to go (if permitted) many times over a piece of land before finally locating a well, and often disregarded the first intimations of the rod. In other words, unless he felt sure every time he crossed a given spot that it was a good place to dig, he did not rely upon his first sensation or impression. Moreover, neither he nor any other hydroscopist has ever accurately divined, except by an occasional lucky guess, either the distance from the surface or the quantity of a subterranean spring. Yet a very large spring or one very near the surface appears to have had, usually, a greater influence upon hydroscopes.

This brings me to the final inquiry, whether there may not be, apart from unconscious skill or judgment, a purely physical effect produced by a subterranean spring upon a person walking over it. Electrical theories on this point were only possible in the days when the laws of electricity were little understood. We know now that the earth is a vast conductor, and that the tension of its currents is consequently so low as to be reckoned as the zero of the electrician's scale; hence that no perceptible electrical current can leave a particular bit of the earth to pass through a human body and return. For this purpose, analogies between rock-contacts or fissure-veins and the voltaic pile are inapplicable.

But the effects of moisture and temperature upon the nerves are often very striking, and here, I think, is a matter which writers on the divining rod have overlooked. The distance at which animals will "scent water" is very great. Their faculty is supposed to consist in great sensitiveness to temperature and moisture. The quickness with which some people "catch cold" on the slightest exposure to dampness—particularly of the soles of the feet—is also a familiar phenomenon. Now it is curious that some of the most puzzling of the well-authenticated accounts of the divining rod have related instances in which women, unacquainted with its use, and not expecting it to work in their hands, have found it to dip without their conscious help, over spots previously or subsequently shown to contain springs.

Here I would recall the remark of Amoretti, that the sensation of the diviner is one of heat or cold. These two are not easily distinguishable when minute and transient. What we call a chill includes both. Is it not probable that a slight unconscious chill may be the physical result to certain sensitive persons of walking over a spring of water, or a belt of rock or soil kept by running water cooler than the adjacent rock or soil, or a spot of surface made by the same cause damper than the surrounding surface? That these causes exist is beyond doubt. Thermometrical measurements have not been made; but the way in which grass grows and snow lies and frost settles and vapors rise over springs is due to the temperature and moisture of the ground in such places. Goethe, in one of his novels (*Die Wahlverwandtschaften*, I believe) describes a lady as seized with a sudden chill upon a spot where subsequently the outcrop of a coal-bed is discovered. The incident is introduced without attempt at scientific explanation, and apparently to convey to the reader a vivid conception of the lady's extreme delicacy of temperament. I infer from it that such cases were known to the great philosopher; and that he believed such supersensitiveness to be in some way connected with the performances of diviners.

To this, then, the rod of Moses, of Jacob, of Mercury, of Circe, of Valentin, of Beausoleil, of Vallemont, of Aymar, of Bleton, of Pennet, of Campetti, has come at last! In itself it is nothing. Its claims to virtues derived from Deity, from Satan, from affinities, and sympathies, from corpuscular effluvia, from electrical currents, are hopelessly collapsed and discarded. A whole library of learned rubbish about it, which remains to us, furnishes jargon for charlatans, marvelous fables for fools, and amusement for antiquarians. Otherwise it is only fit to constitute a part of Mr. Caxton's "History of Human Error." And the sphere of the divining rod has shrunk with its authority. In one department after another it has been found useless. Even in the one application left to it with any show of reason, it is nothing unless held in skillful hands, and whoever has the skill may dispense with the rod. It belongs with "the magic pendulum and planchette," among the toys of children. Or if it be worthy the attention of scientific students, it is the students of psychology and biology, not of geology and hydroscopy and the science of ore deposits, who can profitably consider it. For us miners and prospectors the advice holds good which was given us three hundred years ago by the wise Agricola, the father of our profession, who says the believers in the rod find some veins with it by accident, *sed iidem multo sæpius perdunt operam, et ut venas invenire possint, nihilominus in fossis agendis defatigantur, quam adversæ partis metallici*—"but the same people much more frequently lose their pains, and in order to discover veins have to fatigue themselves with digging, not less than the miners of the opposite school."

As a piece of sorcery, he goes on to say, the virtuous and respectable miner will avoid it; as a piece of science it is inferior to the study of nature, following the indications of which the skillful and prudent miner selects a good place for exploration, and *ibi metallicus agit fossas*—"there the miner digs pits"—to which business, rod or no rod, he is bound to come at last.

ELECTROLYSIS IN THE METALLURGY OF COPPER, LEAD, ZINC, AND OTHER METALS.

By C. O. Mailloux.

THE GOVERNING PRINCIPLES.

Electricity, in the diversity of its practical applications, is fast invading every department of science and industry, and it was only to be expected that it would, at last, enter the domain of metallurgy. It seems rather strange, in fact, that the application of electricity to the separation and refining of metals should have been delayed until the present time, especially when the fact is considered that the power of electricity to produce electrolytic decomposition and deposition in metallic solutions has long since been turned to account successfully and profitably in electrotyping, or the art of depositing metal in molds to reproduce casts, works of art, etc., and in electroplating, or the art of protecting and embellishing various articles of manufacture by depositing a thin layer of more precious or more resisting metal on them.

The use of the electrical current in metallurgical processes depends on precisely the same principles as its use in these two valuable industries, and it may be said that the way has long been open to this new application. It is probably owing to the fact that electricians have given so little attention to the matter, in consequence of the absorbing interest produced by other questions, that the applications are so far behind in this direction. Not that the idea is recent, for it appears to have suggested itself to those engaged in electrotyping and electroplating at the very beginning of these two industries. The patent records both in England and in France are replete with ideas and schemes of various sorts, all tending to the application of electricity to the extraction of metals from their ores, and to the refining and purifying of metals. But scarcely one of these contains a valuable suggestion. The inventors were, for the most part, ignorant of the great fundamental principles which have become commonly known only of late years, and it was unreasonable to suppose that they could conceive anything of practical value in this connection. Many of their so-called inventions, duly patented and protected, are even absurd and chimerical in the light of the present knowledge of science.

Of recent years, however, the success of the Elkinton process of refining copper by electrolysis has brought the attention of chemists and electricians to the subject, and many improvements and new ideas are coming to the surface. The progress in physical science has disclosed some most interesting and important relations between electricity and chemical affinity, and it may be predicted that the coming few years will witness the development of a new art—electrometallurgy, and that we are even now on the threshold of important revelations and applications.

The encouraging results obtained with the Elkinton process have induced others to experiment with a view to extend the applicability of the electrical current, and there are to-day several places in Europe where the refining of copper and other metals by electricity is carried on with great success and with a measure of economy. In this country the attention of those engaged in metallurgical operations has not been called to investigate the claims of electricity as a refining agent, until lately, by an improvement of the Elkinton process for treating copper, introduced by Mr. Henry Cassel, and by an entirely new and original process for refining lead base bullion, invented by Prof. N. S. Keith. Electricity has also been lately applied with a measure of success in the extraction of zinc from its ores, as will be seen in the notice of the processes of M. Letrange and M. Lambotte, to be presently described.

General principles of electrolytic action.—In order that the actions which avail in producing the results obtained may be more easily understood, a brief consideration of the principles governing the electrical phenomena involved will be convenient. Electricity is the available agent, the power at hand, which it is the object to utilize in arriving at the results; and it is necessary to know, first, the place it occupies as a form of energy and its relations to other modes of force, for its presence is always brought about and followed by the appearance or development of other forces; and, second, it is necessary to know the peculiarities of action of electricity in the particular conditions of its use.

Electricity is of itself but a consequence, a result, a manifestation of a force in action. The force, which is the material, so to speak, from which electricity is evolved, is called energy. Energy may, therefore, be defined as a source of power, an assemblage of matter under certain conditions, such that it represents capacity to do work by evolving a force of some kind. When the energy remains pent up or confined by certain conditions preventing it from doing work, it is said to be "latent" or "potential" energy. Thus a weight raised contains latent energy; so does a coiled spring, or a head of water. There may not be any motion or any appearance of it, but there is nevertheless the potentiality of motion in each case, as becomes evident on making a way for the energy to act.

Energy in motion is called "active" or "kinetic" energy. Thus when the raised weight is allowed to run down, and is caused to run a clock, its energy is no longer latent but active, and it appears in the mechanical motion of the apparatus. The energy of gunpowder is latent also. It exists under the form of chemical affinity. When set free by burning, it becomes active and takes the form of heat and motion. It is now universally accepted as a belief that all of the so-called forces of nature, without exception, like heat, electricity, light, etc., are only different modes under which latent energy is set in motion. We suppose that the same energy when set in motion takes a different form with every change in the mode of motion. The law of the conservation of energy, now universally recognized as true, teaches that the forces are all modifications in form of energy, and that any form may be transformed into another by altering its mode of action; it teaches that in bringing new forms of energy into action we do not create energy, but simply derive it from some preëxisting form by transformation. Neither can we destroy energy; we can only transform it into another form. In every case the amount of energy present always remains the same. A part of the energy may remain in the condition of potential energy; another may become kinetic energy in several forms, like heat, light, electricity; but the sum total of the energy will not gain or lose by the successive changes. Whenever energy of one form is transformed into energy of another form, the amount appearing under the new form or forms is precisely equal to the amount disappearing from the old form. For instance, the energy of chemical affinity in coal is transformed into heat and light on burning the coal, and the combined energy of the heat and light produced is equal to that originally present in the coal. The energy of heat may be converted into that of motion, as in the steam-engine, or into chemical affinity, again, as in the smelting furnace; or into electricity, as in the thermoelectric battery; the electricity could then be transformed back again into heat, chemical affinity, or any desired form. But in any case all of these resultant forms, when added to each other, will represent an amount of energy precisely equal to that the heat has lost by transformation. Thus a given amount of any kind of force is equal to a given amount of another force, simply because it contains the same number of foot-pounds of energy. A certain quantity of heat is equivalent to a certain quantity of electricity, and *vice versâ*. Again, a certain amount of electricity can evolve a certain amount of chemical affinity, and *vice versâ*.

Now, chemical affinity is the form of energy with which the metallurgist has to deal the most. The ordinary means which he uses to control and direct chemical affinity in his operations is heat. It is the most convenient. Perhaps it may have seemed to be the only one. But there are others—light and electricity. These three forms of energy, heat, light, and electricity, are often called the "chemical agents," for this reason.

The application of heat to the blast furnace for determining chemical affinity is too well known to require consideration. The application of light as a power of inducing chemical affinity is of no interest in this connection. It is to the application of electricity as a means of producing chemical affinity that attention is to be turned, for it is precisely that important quality of directing chemical affinity which bids fair to make it a most valuable agent in metallurgy. When we pass a current from a battery through an electrolytic cell and cause the solution and the deposition of metals and compounds, we only reverse the action taking place in the battery which produced the current. In the battery chemical affinity produces an amount of electricity; in the electrolytic cell electricity produces chemical affinity. A few simple experimental details will make the question at once clear, and will also serve to emphasize the deep signification of this relation between the two. When two dissimilar metals are placed in contact in a solution of acid, which would ordinarily attack either separately, the action is found to be confined to one of the metals only—the most readily attackable of the two. Thus a piece of zinc or a piece of copper placed in nitric acid would each dissolve readily, whereas if we connect them together while in the solution by making them come in contact at one point or by connecting them with a wire, the action instantly ceases at the copper, and becomes entirely transferred to the zinc. A piece of iron placed in this solution with the copper would also dissolve and prevent the action on the copper, but if placed with a piece of zinc it would itself be protected at the expense of the zinc. The "galvanizing" of iron wire and other objects by a coat of zinc on their surface is intended to take advantage of this very fact, that the iron is protected from oxidation at the expense of the zinc. Now the cause of this result, whereby the destructive action becomes localized on the weaker of two metals brought in contact, is a current of electricity which is produced under these conditions. By suitable means in the above example a current of electricity could have been detected passing in the wire used to connect the two pieces of metal. In every case where a localized action takes place a current of electricity always results whose starting point is the surface of the oxidized metal itself, and which passes in the liquid toward the other metal to pass out through the connecting wire and return to the weaker metal again, thus completing the circuit which is necessary for the current to move through. When no current can circulate, each metal behaves as if it were alone. Since the weaker metal is always the starting point, it is always called the electropositive element, and the other is called the electronegative. These are only relative terms, of course, for, as just seen, iron is electropositive to copper, but electronegative to zinc. Ozone is supposed to be the most electronegative, and potassium the most electropositive, of the ordinary elements. The electrochemical order in which these elements stand is shown in the following table, the first named being more electronegative and less electropositive than those which follow them:

Electrochemical order of the elements.

Ozone.	Carbon (4).	Cobalt (4).
Oxygen (2).	Antimony (3).	Nickel (4).
Fluorine (1).	Silicon (4).	Iron (4).
Sulphur (2).	Hydrogen (1).	Zinc (2).
Nitrogen (3).	Gold (3).	Manganese (6).
Chlorine (1).	Platinum (4).	Aluminum (3).
Bromine (1).	Mercury (2).	Magnesium (2).

Iodine (1).	Silver (1).	Calcium (2).
Phosphorus (3).	Copper (2).	Barium (2).
Arsenic (3).	Bismuth (3).	Lithium (2).
Chromium (6).	Tin (4).	Sodium (1).
Boron (3).	Lead (4).	Potassium (1).

The order varies slightly, according to the acid solution used. The figures indicate the valency of the atoms of each element; thus 1 means monad; 2, dyad; 3, triad, etc.

From a glance at this table it is shown that all chemical compounds are the results of a combination of some electropositive element with some electronegative element. Thus oxide of manganese is composed of oxygen, electronegative, and manganese, electropositive; sulphide of lead is composed of sulphur, electronegative, and lead, electropositive. It seems that a combination between two elements cannot take place unless there exists this difference of electrical character. When the substances combining are closely allied in their properties, the combination is not so stable as when they are placed far apart in the scale.

It is also interesting to observe here that the electronegative elements are those which prove the most refractory to eliminate in metallurgical operations, and on the other hand the most electropositive substances are the ones which are most easily acted upon by the electronegative elements, and which give off the most energy on combining. So here is an evidence of relationship between electricity and chemical affinity.

A galvanic combination may be formed of any two of the substances mentioned in the table, but the further apart they are in the list the greater will be the energy or tension of the current of electricity to which they will give rise, because in that case the difference of affinity between them for the attacking element (usually oxygen) of the solution is greater than when the two substances are closely allied in electrochemical properties. It is seen that zinc is the most electropositive of the common metals, and that accounts for its universal use as the electropositive element in the galvanic batteries employed in telegraphy and in other various applications. Of the metals, gold is the most electronegative, but it is too costly. Copper is the one best adapted, on account of its cheapness. Carbon, however, is much better than copper because it stands higher as an electronegative element, and consequently it is used to a large extent for making batteries.

As just stated, the character of the current is affected by the electrochemical difference between them. This difference is called difference of potential. The pressure or "electromotive force" of the element is proportional to the difference of potential, and is expressed in arbitrary units called "volts." The electromotive force of one cell of the Daniell battery (copper, zinc, and sulphate of copper solution) is approximately one volt.

On inquiring into the nature of the reaction which takes place in the solution, during the time that the current is being evolved in a galvanic battery, other peculiar relations of electricity to affinity are disclosed. We might take the Daniell battery as a most convenient example, and analyze its reactions. The form of Daniell battery now most generally used is known as the gravity cell. A piece of copper attached to a wire is placed on the bottom of a vessel, and forms the electronegative plate or element. A piece of zinc is suspended near the top and forms the positive element. Sulphate of copper crystals are placed on the bottom of the vessel, which is then filled with water. These dissolve gradually and the sulphate difuses itself through the liquid, but not equally. Near the bottom the solution is very dense; near the top it is very weak. On closing the circuit, by connecting the zinc and the copper together, a current of electricity is evolved and a series of most interesting reactions take place in the solution. First, the zinc dissolves and forms sulphate of zinc. It has a higher affinity for sulphuric acid than copper, and so it displaces the latter from its combination. Now since the sulphate near the zinc is constantly losing its sulphuric acid, free metallic copper ought to appear there. Instead of that, however, it appears at the copper plate, where it is deposited as a layer. So, in course of time, all the sulphate of copper disappears, to be replaced by sulphate of zinc, and the copper held in solution is all deposited on the negative (copper) plate. The reason why the copper is not freed near the zinc and deposited in its vicinity is that a transfer of acid takes place from molecule to molecule, through a peculiar selective process. In this we have a very important law of electrolytic action and one which establishes still more the relation between affinity and electricity.

Chemical combinations, as stated above, result from the union of elements of different and opposite electrical character. Now under the influence of the current the electropositive element tends to move toward the electronegative plate of the battery and the electronegative element towards the electropositive plate. In other words the affinity which ordinarily makes these elements hold together in combination is influenced by the power of the current. In the above instance, sulphuric acid is the electronegative constituent of the solution, and copper the electropositive constituent. Now when a molecule of zinc appropriates a molecule of sulphuric acid to form sulphate of zinc, the molecule of copper set free tends to move toward the electronegative side (copper plate), and it combines for a time with the molecule of acid next in its way, leaving the next molecule of copper free. This molecule likewise "cheats" its neighboring molecule, and so finally the molecule of copper immediately near the copper plate becomes robbed of its acid, and as it cannot appropriate any acid anywhere it remains as a deposit on the surface of the copper. The next molecule of sulphuric acid taken up by the zinc will cause another series of changes likewise ending with the deposit of a molecule of copper at the copper plate, and so the process repeats itself until all the copper is deposited out of the solution.

Such is in essence the real theory of electrolysis. It is only a transfer by successive exchanges between molecules. We might say that the molecules in the path of the current are all "polarized" or turned in the line of direction of the current, some (electropositive) moving in the same direction as the current, and others (electronegative) moving in the contrary direction. It is indeed a fundamental law of electrolytic action that the ratio of electropositive elements acted upon always bears a true chemical relation to the electronegative elements. All compounds are formed of the union of two opposite electrical elements. It follows, therefore, that, no matter what the solution is, nor what mixture of compounds it contains, whenever some substances are electrolyzed (dissolved, or deposited, or set free) at one pole, a corresponding amount of an opposite electrical character, chemically equivalent thereto, must be electrolyzed at the other pole.

Now if in the above instance the dissolving of a molecule of zinc was accompanied by the deposit of a molecule of copper, then the weight of zinc dissolved should bear the same proportion to the weight of copper deposited that their atomic weights bear to each other, or 63 to 63.5. If the weights of each plate are taken before and after trying the experiment, the proportion will be found exactly as required by theory.

Hitherto we have been considering a case where chemical affinity is used as a source of electricity. It remains to be seen how perfectly and how accurately the same principles still apply in the opposite condition, or where electricity is used to produce chemical affinity, which is the valuable side of the question in the present connection. For this purpose let us reverse the experiment. Let us take a battery of two cells or of double the electromotive force, and connect it to the first cell, so that it will be in opposition. Now this cell tends as much as before to urge a current from zinc to copper through the solution with a pressure of one volt; but the opposing battery has a counter-pressure of two volts, and consequently it overbalances it and forces a current in the opposite direction. Practically the first cell is no longer a battery; it is an electrolyzing cell. In moving through the solution the current now passes from the copper plate and toward the zinc plate. The plate *from* which the current enters a solution in an electrolyzing cell is called the *anode*, and the plate *toward* which it moves is called the *cathode*. Again, the substances set free at the anode are called *anions;* those set free at the cathode, *cations*.

It is of practical convenience to note the fact here, that the metals when in solution are always the electropositive elements, because the acids, etc., are more electronegative than they are. The metals are therefore *cations*, and they move in the solutions *with* the current, while the acids are *anions* and move *against* the current in the solutions. This result is invariable.

Now in this case it is clear that if the current moves in that cell in the opposite direction from before, the sulphuric acid will move in the opposite direction. Let us see. The solution is supposed to be nearly all sulphate of zinc, the copper having been deposited from it and replaced by zinc. The copper plate is the anode. Sulphuric acid is an anion, consequently it is liberated near the copper and dissolves it. The zinc is a cation, and therefore it will be deposited at the cathode. The relative weights of copper and zinc acted upon will be the same as before.

Now suppose we take a new electrolyzing cell containing a solution of sulphate of copper and two copper plates, one as anode and the other as cathode. On passing the current, the copper dissolves from the anode and is deposited on the cathode, the amount of gain at the cathode being precisely equal to the amount lost at the anode. The operation goes on much faster, however, simply because there is no counter-electromotive force in this cell. By counter-electromotive force is meant that the reversed cell was constantly ready to send a current the other way, and that its own natural electromotive force constantly opposed the main current.

In this case both plates are of copper and consequently of the same potential, which is why no counter-electromotive force appears. However, in some kinds of solution some gases, especially hydrogen, are evolved under certain circumstances at the cathode and cover its whole surface. The gases given off under these conditions are very electropositive, and therefore they cause a difference of potential between the cathode and the anode, which produces a counter-electromotive force. In such cases it is said that the solution "polarizes."

Since there is no counter-electromotive force in the above instance, the available electromotive force of the battery has none to neutralize, and it is therefore twice as great (two volts) and the current passing is much stronger, for the current passing in a given circuit is (according to Ohm's law) equal to the (net) electromotive force divided by the resistance. If the resistance in this case were one ohm for the whole circuit, including the internal resistance of the battery, then the current would be two ampères. Now, the amount of action which takes place in a cell is exactly proportional to the quantity of electricity passing in the circuit. A current of one ampère will dissolve 1.19 grammes of copper per hour, and a current of two ampères will dissolve twice that quantity. Consequently when speed of action is required the conditions should be such as to permit a large quantity of current to pass.

It is proper to note that in this case, since the same current that circulated through the electrolyzing cell also circulated through the two battery cells in which it originated, the same equivalent amounts of zinc and copper were acted upon or electrolyzed in each cell. If the amount of copper deposited in the electrolyzing cell was 2.38 grammes per hour, assuming a two-ampère current, then the same amount of copper was also deposited in each gravity cell, and the proportional amount of zinc was also dissolved in each cell.

The well known process of electrotyping is nothing more than an application of the experiment just detailed. An impression of type casts is made in wax and covered with a coating of graphite so as to make it a better conductor of electricity, wax being a poor conductor. This mold is then attached to a conductor and placed in an electrolyzing cell so as to form the cathode, and soon it is covered with a coating of copper which fills every depression in the mold and reproduces the original to perfection. In large establishments, instead of batteries, dynamo-electric machines are used to supply the current, on account of the reduced expense. In the battery we burn zinc to produce the electricity; in the dynamo the power is derived from the consumption of coal. A pound of coal is not only cheaper but contains more foot pounds of energy than a pound of zinc. It is true that only a small proportion of the energy present in the coal is utilized by our best steam engines, but its great cheapness, as compared to zinc, gives it the preference. The dynamo-electric machine is indeed a source of current so much cheaper that by its use we can adapt electricity to applications where it would not have been profitable, were the power to have been derived from batteries.

Instead of a copper solution, other solutions can be used and other metals can be dissolved and deposited in the solutions by the agency of electricity. Thus silver-platers use a solution of cyanide of silver. The anode is a plate of silver; the cathode is the object to be plated. As the deposit takes place on the cathode, an exactly equal amount is dissolved; so the amount of silver in solution remains constant. Thus also with gold and other metals, the salt used being a matter of expediency and convenience. In every case the amount of metal acted upon by a current of one ampère will bear the same ratio to the amount of copper that its chemical combining weight does to copper, atom for atom, provided, of course, that they have both the same atomicity. Thus in a compound containing a monad with a dyad, two atoms of the monad are combined with one atom of the dyad. Now, on electrolyzing such a compound, two atoms of the monad would be evolved for each atom of the dyad. Take water, for instance (hydrogen 1, oxygen 2). For every atom of oxygen set free on passing the current through it two atoms of hydrogen are set free. In all cases the decompositions and recompositions take place according to the chemical formulæ of the substance. Thus, in electrolizing chloride of gold ($AuCl_3$), for instance, three atoms of chlorine would be set free for each atom of gold. If the copper sulphate were replaced by a salt of silver in the above experiments, then for each 65 grammes of zinc acted upon twice 108 (atomic weight of silver) grammes of silver would have been deposited, because silver is a monad, while zinc is a dyad.

Such are in brief the principles on which the applications of electricity to electrometallurgy depend. Once these properly are understood the practical details which follow will be clear and easy of comprehension.

PRACTICAL APPLICATION OF ELECTROLYSIS IN THE METALLURGY OF COPPER.

The Dechaud and Gaultier process.—Undoubtedly the first instance of the application of electrolysis in metallurgy was in the production of what is called "cement" copper in the wet process of treatment.

In certain mines the drainage water is often found charged with sulphate of copper, which is the result of the oxidation of the sulphide in the ore. It is from these solutions that the cementation copper is obtained. The wet process is particularly adapted to the treatment of the poorer oxidized ores, especially where fuel is scarce. These ores are treated with acid, either hydrochloric or sulphuric, or with a solution of ammonia, all three of which are good solvents of the oxides of copper. The precipitation is effected in the copper solution by placing iron in it. The action is the result of electrolysis.

When a piece of zinc or iron is plunged into a solution of copper its greater affinity causes it to combine with the acid holding the copper in solution, and the copper becomes deposited on the iron or zinc. When a portion of this piece of electropositive metal is covered with the electronegative copper, galvanic action begins, the current starting at the electropositive and going to the electronegative. The solution is electrolyzed; the iron is dissolved, and the copper is deposited. After this the action is entirely electrolytic, and it corresponds precisely with that taking place in the gravity cell, described in the preceding pages, where the copper is deposited from the solution, and zinc is dissolved by the acid, to replace it in the solution. The character of the deposited copper depends on the current, and the current depends on the strength of the solution.

In precipitating the copper from the solution pieces of iron are placed in the large vats containing it. The copper is, as a rule, deposited in a soft plastic form, whence the term "cementation copper."

The first patent having reference to electrolytic methods in metallurgy was for an improvement on this process. It was one granted in France, in 1846, to MM. Dechaud and Gaultier, for "Improvements in the extraction of copper from its ores, founded particularly on electro-chemical methods." M. Gaultier was professor of chemistry at the École Polytechnique in Paris, and M. Dechaud being likewise an able chemist and engineer, the details of the specification are interesting from their scientific precision.

In this specification these inventors introduce the idea of preparing the sulphate of copper from sulphide and oxide ores, by roasting them in the furnace, and then extracting the copper sulphate by lixiviation. Their method was doubtless excellent, and it seems strange that it should have become so little known. There was at that time a vein of copper oxide at Chessy, in France, but it soon became exhausted, and perhaps this was the reason why the process never found general application. Where fuel is scarce, as in the Waldeck mines in Europe, or where oxide ores are plenty, as in Chili and Australia, the process might perhaps be of use. The method of treating the ore in the roasting furnace was original with the inventors, and depended on a chemical reaction which they claimed to have been the first to observe. It is described thus: "If a mixture of oxide of copper and of sulphate of iron or zinc is subjected to the action of a suitable temperature and of an air current, the resulting product will be sulphate of copper and sesquioxide of iron or oxide of zinc." It is technically a double decomposition, taking place by the influence of a stronger base—the iron or zinc. The ore was first roasted and washed before being mixed with the sulphate of iron. The proportion of sulphate to the amount of ore was different for each kind of ore, and it was determined by experiment on a smaller scale.

MM. Dechaud and Gaultier found that carbonate ores of copper could also be reduced in the same manner. The suitable quantity of reducing sulphate having been well mixed with the dried, roasted ore, the mixture was roasted in a reverberatory furnace. It was then washed thoroughly to dissolve out the sulphate of copper formed. If the assay showed that the residue still contained copper, it was again mixed with sulphate and roasted as before. From the sulphate of copper solution obtained in the above manner the copper was deposited by the introduction of iron, though in an improved way. Instead of allowing the copper to be deposited on the iron, where it necessarily became mixed with the undissolved impurities of the iron, they provided separate cathodes, connected to the iron plates by wires, as will be shown presently.

The solution was concentrated and placed in wooden tanks lined with lead. These vats were made of large size, so as to have at least ten square metres of surface, though they were shallow, being scarcely one-fifth of a metre deep. On the bottom of each vat were placed a number of flat copper plates whose under surfaces were varnished with non-conducting material, so as to permit the deposition of copper on the upper side only. These plates presented a surface of nearly ten square metres. At the upper part of the solution plates of iron, cast with grooves and openings like a gridiron so as to present more surface and permit the escape of gases, were suspended in the solution of sulphate of copper by means of lugs which rested on the edges of the tanks. These plates weighed from 50 to 60 kilogrammes. All the copper plates were joined together electrically, and so were the iron plates. This was in fact a kind of gravity battery, with iron substituted for zinc at the positive plate. On connecting the two sides (that is, the combined copper plates with the combined iron plates) it is easy to see that deposition of the copper must go on at the cathode surface (copper), and that the iron must be dissolved at the anode surface (iron). But as the carbon and other impurities in the iron were liable to fall to the bottom and mix with the pure copper deposited, the inventors resorted to the expedient of placing a porous diaphragm between the two sets of plates, cotton cloth being mostly used for the purpose. Instead of copper cathodes they used lead in some cases, because the deposit was less adherent and could be detached more readily. The copper was not so soft as by the cementation method. Now, as the action proceeded, the copper solution would naturally grow weaker, while the amount of sulphate of iron present in the solution would increase. To prevent this they provided a means of automatic circulation by a system of lead pipes connecting with reservoirs whose valves were controlled by the rise and fall of hydrometers. One set of pipes delivered fresh copper solution at the bottom of the vat. This of course caused the solution to rise in the vat. But another tube placed at the upper part of the vat then drew off some sulphate of iron, and thus the solution remained always of the same density and contained the same amount of copper. The sulphate of iron was separated by evaporation and crystallization, and could then be sold as copperas, or else it was used as the reagent for reducing the next batch of ore.

The amount of copper which it was claimed could be reduced was 1,000 kilogrammes (about 2,200 pounds) per day, the weight of the original copper solution being 16,000 kilogrammes.

MM. Dechaud and Gaultier did not confine themselves to the first method of treating the ores. In a later addition to their patent they describe a method of utilizing the sulphurous acid gas produced by the roasting. The acid gases are passed through a second furnace supplied with air drafts and a small amount of aqueous vapor, and in this way sulphuric acid is produced, and then copper sulphate by its combination with the oxide. More than two furnaces could thus be joined in series. The sulphate of iron could also be roasted in a separate furnace and the sulphurous acid gas resulting could be passed over the ore, as just shown.

Many advantages were claimed for this process, foremost among which was that of economy. Next was the purity of the metals, which cannot be denied, for it is very well known that electrolytic copper as a rule is very pure. They also claimed that ores containing other intractable metals (antimony, for instance) gave no trouble in separation by this method. When arsenic was present it was condensed by passing the vapors through crooked chimneys. The copper was deposited in thin layers, and could be scaled off from the lead cathodes and passed under rollers to smooth the little inequalities, and thus make sheet copper with little trouble.

The process appears to have remained unknown outside of France, and it has indeed been rediscovered subsequently several times, as becomes evident on following the patent records.

Copper by electricity at the Oker mine.—In Germany, at the royal mines of Oker, the extraction of copper out of the solutions resulting from the washing of the copper mattes is done at present by the agency of electricity. However, instead of making the cell produce its own current, so to speak, as in the above case, dynamo-electric machines are used to furnish the current. Three Siemens machines are run day and night, the current being passed through 10 or 12 precipitating vats containing the solution. The anodes and cathodes used are of lead or other metal not soluble in the solution. The electromotive force of each machine is only three volts, a very low pressure, but the resistance is also extremely low, or only .0007 of one ohm. According to Ohm's law, then, the current passing in the circuit is $\frac{3}{.0007}$=427.6 ampères—a very large volume. This is, of course, provided there is no polarization. As a matter of fact the polarization is quite marked, because the lead of the anodes becomes peroxidized, just like the plates in a storage battery, by the oxygen set free; and as peroxide of lead is a very highly electronegative substance, there is a tendency to a return current in consequence of the counter-electromotive force developed.

The average product is 25 kilogrammes of metallic copper per vat per twenty-four hours, or between 250 and 300 kilogrammes for each machine, with an expenditure of 8 to 10 horse-power per machine. This method of working is not as economical as that of MM. Dechaud and Gaultier. By using iron plates as anodes the polarization would be diminished, because then the oxygen would attack the iron, and the result would be sulphate of iron. But we might then ask, "Why use the current from an external source at all, when there is a difference of affinity or potential between the two (iron and copper) that would of itself suffice to produce a current which would deposit the copper?" The dynamo-electric machine would undoubtedly push the action more rapidly, but not so economically. It would be better to use more vats and larger ones, and substitute the process of MM. Dechaud and Gaultier.

The Keith process for recovering copper.—In 1876, Prof. N. S. Keith came to the very same conclusion while engaged in studying a method of extracting the copper from the waste liquors of sulphate of copper manufactories. Without being aware of the process of MM. Dechaud and Gaultier, he arrived at a plan substantially the same in every particular.

The old liquors, charged with impurities, containing 3 or 4 per cent. of copper, are placed in vats. In the vats are porous vessels, somewhat like those used in galvanic batteries, only larger. In these vessels a dilute solution of sulphate of iron is placed with a piece of iron. A copper plate in the liquor is brought into electrical connection with this iron plate, and the action proceeds in the manner already understood from the details given above, until the copper is all precipitated out of the solution.

The Barratt process.—In England, about 1850, Mr. O. W. Barratt also conceived a crude application of the iron-copper galvanic battery to the precipitation of copper from drainage waters in a manner analogous to that of MM. Dechaud and Gaultier.

Crosse's method.—Mr. A. Crosse proposed about the same time to extract copper and other metals from their ores by calcining the ores and dissolving the powder in dilute sulphuric acid, and then passing a current through the solution. The probability is that he never reduced his idea to practice, but the patent is interesting from the fact that the principle will be found applied successfully in the case of some metals.

The Elkinton process.—Nothing of real importance in the metallurgy of copper appears to have been evolved until the year 1865, when Mr. James B. Elkinton brought out his method for refining and separating copper. In his process Mr. Elkinton has made, so to speak, a new departure so far as his aim was concerned. Hitherto all experimenters had looked forward to the total displacement of the blast furnace as a factor in metallurgy. They desired to do away with it, and use electricity instead. It occurred to Mr. Elkinton, however, that electricity could more readily and quickly solve the problem of applicability if its use was introduced as an accessory rather than as a usurper of the furnace, and therein may be found the secret of his success. Instead of attempting to treat ores, Mr. Elkinton thought it more logical, at least more practical, to treat the furnace products. He realized that the secondary operations and treatments to which the metals must be subjected in order to be separated from each other and to be rid of impurities, were still more laborious and costly than the first operation of smelting. He bent his energies in the study of methods for refining and separating copper from the smelting products as they came from the furnace, and known as matte, blister copper, pimple copper, regulus, etc. His process was successful from the start. The principle is so simple, moreover, that it seems strange it was not applied sooner.

His patent, granted in England, and dated November 3, 1865, was for "improvements in the manufacture of copper from copper ores." The idea of this process is to take the copper after it has come from the smelting furnace, in the shape of matte, pimple, blister, or regulus, and to refine it by electrolysis. The impure copper is cast into plates of any convenient size, say 18 by 18 inches, and three-fourths of an inch thick. Each plate is provided with lugs at one end, by means of which it may be suspended in the solution. These plates are placed in suitable vats or troughs containing a strong solution of sulphate of copper. In a trough several such plates may be suspended at equal distances from each other. If we suppose that the lugs rest on copper bars placed along the edge of the vats, then it will be understood that all these plates are electrically joined. Now between these plates thin sheets of copper of the same size are placed, and they are kept insulated from the impure copper plates, but are all similarly connected to each other by a common conductor. The impure copper plates are joined with the positive pole of the source of current, preferably a dynamo-electric machine, and they consequently form the anodes. The current passes from each surface of the anodes through the solution and enters the cathodes suspended between them. Each vat is therefore a true electrolyzing cell. The current causes the copper to be dissolved out of the matte plates, and at the same time it is deposited at the cathodes in equal amount. Almost all the impurities ordinarily present in the anode are insoluble in the solution except iron, and as the anode becomes eaten up they fall to the bottom and settle as a sediment. The iron usually present becomes dissolved, but it remains in solution; because, when several metals exist in solution, the least electropositive (the copper in this case) is deposited first, and as long as there is enough of this latter present in the solution to satisfy the depositing power of the current, it alone will continue to be deposited. If, however, the strength of the current is increased inordinately, then the metal which is next in order as an electronegative will be deposited also. The character of the solution has also some influence on this result. As a rule a copper solution is more likely to electrolyze copper only, and so with solutions of other metals. Different metals from the one acted upon, when present at the anode or in solution, are apt to fall down as impurities.

When the plates of impure copper are all dissolved the scraps are taken out to be remelted into other plates. The cathodes may be kept in until they are quite thickly covered, and then the pure copper may be scaled off from their surface. The solution eventually becomes charged with sulphate of iron to such an extent that its further use is inconvenient. In that case the copper may be recovered from it by precipitation, and then a new solution is used.

In his patent Mr. Elkinton states that other solutions of copper may be used also, but "not so conveniently." The residue is collected from the bottom of the tank and treated by a special refining process, because it almost always contains gold and silver, besides tin and antimony.

In practice, instead of one tank, a large number are used, the power of the current being the only limit to the number. The manner in which they are connected also varies with the construction of the machine. Sometimes the line from the positive pole of the machine divides into branches, one of which goes to each anode, while branches from each cathode go to unite at the negative pole. In this case we might consider that the current divides through so many parallel paths, as a river divides into branches to pass around several islands. Now, in this case each branch must evidently diminish the resistance, because it literally widens the path of passage for the current. This is called connecting in "multiple" or "parallel" circuit.

In other instances the current passes through all the tanks in a line from the cathode of the first to the anode of the next, and so on, or in "series." In this case each one added increases the resistance by so much. The importance of bearing in mind these facts cannot be overestimated, because the whole question of economy in using electricity depends on them. It may seem a most extraordinary circumstance, but nevertheless it is literally true that the same current which will refine one ton of copper in a given time may be made if desired to refine two tons, ten tons, a hundred tons, in the same time. This sounds paradoxical; yet it is easy to explain. As long as no polarization occurs in a liquid the electrolytic actions taking place in it consume no energy. With a solution which is a perfect electrolyte (that is to say, in which the energy absorbed as chemical affinity at the anode is exactly equivalent to the energy of chemical affinity converted into current at the cathode) there is no polarization. The sulphate of copper solution of the Elkinton process is practically a perfect electrolyte, and does not give rise to polarization with the proper rate of working. Now, the current, in passing through such a liquid, loses energy only in overcoming its electrical resistance, just as it does in overcoming that of the conducting wires in the other parts of the circuit. Therefore, if the resistance of the liquid were diminished to zero, then the current would lose no energy in passing through the solution. The advantage of reducing the resistance is therefore evident. Practically it may be reduced to a very small fraction. The resistance of a liquid depends, of course, on the nature of the substance it contains. It varies as the resistance of metals. But just as a larger wire presents less resistance to the passage of a given current, so the volume of liquid through which the current passes affects the resistance. Accordingly, by making the plates twice as large, so that the current can spread over a larger surface to pass through the solution, it will have a path of passage twice more free. In other words, the resistance will be twice as small. So the more we increase the anodes and cathodes the less will be the resistance. By putting several plates in each vat and connecting all the anodes together and all the cathodes together, we have substantially the same thing as one large plate equal in surface to all the plates thus joined. If we connect three vats in multiple circuit then we are literally making them all one tank having a plate surface equal to the combined plate surface of all three. The resistance is only one-third of what it would be through each tank alone. With four vats in multiple circuit the resistance would be one-fourth, and so on. On the other hand, if we connect three vats in series, the resistance is three times the resistance of one vat. With four vats in series the resistance is four times, and so on.

Let us now consider two cases, one with four vats in simple series, another with a number of vats arranged in multiple and series both, but in such a way that the resistance through both circuits is the same. With the four vats in single series, all the current passes through each vat. The deposit of metal is therefore four times that in one vat. Now, we make each vat twice as large by connecting another vat to it in multiple circuit. The resistance of each double vat is then one-half as much as before. Consequently, to make the total resistance equal to what it was before, we must add four more double vats to these, making sixteen vats. The resistance is then the same and the energy expended by the current is also the same. But let us see the result. The same current now divides through two tanks at a time, therefore each tank only deposits half as rapidly as before. But we have sixteen vats; therefore we have a total of eight times the efficiency of one vat with the same expenditure of energy as before, which gave us only four times one vat. Thus the result is doubled. Now, let us take ten vats abreast, or connected in multiple circuit. Their combined resistance is one-tenth of one vat because the current divides through the whole ten, and they are equivalent to one vat having ten times the surface. Now, to make the total resistance in circuit equal to the single series of four vats, we must add ten times four such multiple vats, or forty, and the total number of vats will then be four hundred. The current will expend the same energy in passing through this circuit. Each vat will work at one-tenth the rate of each vat in the simple series, because the current divides through the ten abreast. Each ten will therefore be equal to one of the four, or the total efficiency will be ten times greater in this case.

It is not expedient, however, to carry this idea too far in practice, for another important question arises. In the last example, while we raised the efficiency of the given current ten times more than in the case of eight vats, we also increased the size (and cost) of the plant one hundred times. Not only this, but as the rate is ten times slower in each vat in the last instance, it will take ten times longer for each plate to be refined; hence the amount of metal which would need to be carried in stock is ten times greater. It would be better to use a stronger current and work less vats at a more rapid rate. The above consideration, which is merely a consequence of Ohm's law, shows plainly, however, that the amount of current required in metallurgical operations of this nature need not be great. It would depend largely on the circumstances of operation of the plan.

The Elkinton process has long since passed into practice in Europe. There is a firm in the neighborhood of Swansea which has been using this process in competition with the furnace methods for five or six years. It is also used in competition with the wet processes of separating and refining copper, gold, and silver. In this place there are over 1,500 depositing vats, arranged in various ways. In some cases there are a hundred or more in series, and there are four in multiple circuit, thus making four to five hundred vats in a circuit. Copper mattes containing silver and gold in too minute quantities for profitable separation by the fire process may be economically treated. Thousands of tons of Chilian copper mattes, containing traces of gold and silver, find their way to Swansea, and the greatest portion of them is refined by electrolysis. The production amounts to several tons of pure copper a day in each place. It is extremely difficult to secure definite and exact data as to the cost of working, but there is no doubt as to the economy of the process. Only a little labor is required for attention in such accessory operations as casting the plates, emptying and filling vats, etc. The power required need not be very great. An expenditure of 20 horse-power would no doubt suffice to produce enough current by means of dynamo-electric machines to refine as many tons of copper a day, without necessitating a plant of undue or undesirable size. The solution, it is seen, is not costly; moreover, it is durable. It undergoes no changes by use, except that it becomes charged with iron and other impurities derived from the crude copper. Iron is the most frequent impurity. In some cases it may be crystallized out of the solution; in other cases the solution has to receive the addition of fresh acid at periodic intervals. Again, in other instances the copper is precipitated out of the solution and a new solution is used, this being repeated at regular intervals.

In Germany the Elkinton process has met with great favor, and is now used in several smelting establishments to the exclusion of all other refining processes. The Norddeutsche Affinerie refines as much as 500 tons of copper per annum by electrolytic methods. There are six Gramme dynamo-electric machines used, and the power is derived from a 40 horse-power engine. By using more vats to do the same work, it will be understood from what has been said that less power would be needed, though the rate is much slower in each vat. It is probable that in this case each vat is worked at its most rapid rate, so that the amount under treatment need not be so large, and for this reason more power is used than would otherwise be the case. At these works the separation and purification of gold and silver by electrolysis is also practiced, as will be mentioned further on. At the works of the Königlich Preussiches und Herzoglich Braunschweigisches Communion Hütternaut, a process substantially like that of Elkinton is also used on a large scale. No detailed information is obtainable concerning the plant, however.

It is said that the Elkinton process has been tried at various times and places in this country, but it does not appear that the experiments have proved sufficiently successful to warrant its adoption on a large scale. However, the fact that this method of refining has been uniformly successful in Europe would seem to indicate that the difficulties met with in America have arisen from lack of skill and precision in applying the process. The details of such a process should undoubtedly be supervised and carried out by persons having an adequate knowledge of electricity.

Postal Telegraph Company.—The works of the Postal Telegraph Company, at Ansonia, Connecticut, are interesting in connection with electrolytic methods, depending on the same principles as Elkinton's. At these works, where the copper wire used by the company is manufactured, the operation of refining is carried on as incidental to the work. The copper covering is deposited by electrolysis on a steel or iron wire, which forms the core of the compound wire. There are 350 depositing vats, and these are supplied by 50 Wallace-Farmer dynamo-electric machines, making seven vats to each machine. The vats are connected in series. The solution used is sulphate of copper, with sulphuric acid added, so as to give it a distinctly acid reaction. As anodes, ordinary Lake Superior copper is used, cast in the form of plates, which are placed on each side in the vats. A cylinder revolving on a shaft placed lengthwise near the top of the tank is driven by machinery, and the wire winds around this cylinder and passes continuously through the solution from one end of the vat to the other in a worm-like manner. The wire is included in the circuit, so as to form the cathode in every case. It therefore receives a deposit on its way through the solution. The copper used in the anodes is almost pure. It contains no gold, but it has on an average about 16 ounces of silver per ton. Only copper is deposited on the wire. Whatever impurities are present in small proportion in the anodes, as sulphur, arsenic, etc., together with the silver, fall to the bottom of the vat. The silver is recovered in the form of a fine metallic powder, which may be separated from the impurities in many cases by simple decantation after being washed with water. Each dynamo consumes about nine horse-power. Its electromotive force is between three and four volts, and its internal resistance is about .001 ohm. The amount of copper deposited by each machine in the seven vats averages about 100 pounds per day, and accordingly the total depositing capacity of the plant amounts to 5,000 pounds per day. The power is supplied by a large 500 horse-power engine.

Thus the operation of separating metals is conducted in combination with that of depositing copper for an industrial purpose. The arrangement of the vats with respect to the machines is not so favorable to economy of power as it might be made, because there are other considerations involved, such as the quality of the deposit, which is the main factor to be considered. Were the operation conducted merely for refining purposes, it would be possible to deposit considerably more copper in the same time with a fraction of the power that is consumed; and we have already seen that by arranging the vats properly and having a sufficient number of them, so as to keep a large amount of metal under way, the power required could be reduced to any desired degree. Where the quantity of metal used is so large as in this case, it would doubtless be greater economy if a cheaper form of copper could be used, like matte or regulus. But as the quality of the deposit is an important desideratum, and as it is important for this that the solution should remain comparatively uniform in character and purity, the use of anodes of this kind is inadmissible. The presence of iron and zinc and other electropositive metals would be very objectionable.

Difficulties connected with Elkinton's process.—The process of Elkinton undoubtedly attains the end for which it was conceived, namely, the purification of copper. However, it is often the case that the noble metals, gold and silver, exist in the metal to be treated in such quantities that their extraction and separation in a pure state is a matter of greater consequence even than the purification of the copper. In this respect the Elkinton process is at a great disadvantage, because none of the separated metals except the copper are obtained so pure as to require no further refining. It is true that the silver and gold fall to the bottom, but not alone. Various other impurities, as the metalloids, sulphur, phosphorus, carbon, silicon, etc., also go to the bottom. Lead is converted into peroxide and to some extent into sulphate, both of which are insoluble in the solution, and therefore go to the bottom. Carbides, sulphides, arsenides, etc., also fall as an insoluble powder. Tin also would go the bottom, with several other metals present in minute quantities and not soluble in the solution.

Various attempts have been made to improve on Elkinton's process so as to render it applicable to the treatment of alloys rich in silver or gold. The object of these improvements is to separate the silver and the gold, each in a pure state, so that they may not require any subsequent refining.

Cassel's process.—About January, 1882, Messrs. Mathey & Riotte, metallurgists, of New York City, began a series of experiments on a large scale with a process for refining gold and silver bullion by electrolysis. The plan of the process was said to have been brought to this country from Germany, where it had met with some success. However, it did not prove successful in their hands and was soon abandoned. Mr. Henry R. Cassel, of New York, appears to have become interested in this process, and he set about improving it. On the 26th of September, 1882, he obtained two patents on his improvements. In these patents Mr. Cassel proposed the use of linen or felt bags around the cathodes, which bags were supposed to permit the passage of the copper only, and to deposit the silver in their meshes, a tray being placed below each cathode into which it fell. Mr. Cassel proposed also to suspend screens of copper wire between the anodes and cathodes, their function being to deposit the silver as it passed in the solution on its way to the cathode. In both cases the solution proposed was the same as Elkinton's. These ideas did not possess very much practical value in the manner in which they were applied. There may be some suggestion in the second idea, but it had been adopted previously by M. André, and to much better advantage.

A company known as the United States Bullion Refining Company was organized for the purpose of working the process patented by Mr. Cassel. A plant was erected at 69 Cortlandt street, New York, with a projected refining capacity of 25,000 ounces of bullion per day. It was completed sometime in January of the present year and was worked at irregular intervals; but it never proved successful, as might have been anticipated. Efforts were then made to introduce modifications in several important respects, so as to make the process successful, but with little avail. The process never passed beyond the experimental stage, and financially the enterprise proved a total failure. The project was abandoned about May 1, 1883.

In this plant the bullion plates (about 7 by 15 inches and about an inch thick at the top, $\frac{3}{4}$ inch at the bottom, and weighing about 20 pounds each) were suspended by hooks passing through eyes at their upper portion, where ear pieces were provided for the purpose. They were placed in 20 vats made of sawed casks and lead-lined, each having a capacity of about 30 gallons. There were six such plates in each vat, all connected to the positive pole, and consequently forming a multiple anode. They were placed in pairs in the vats, and between the three pairs there were two pairs of copper sheets, forming a multiple cathode. Each pair of cathode plates was inclosed in a narrow rectangular box of leather called a "dialyzer." This dialyzer evidently corresponded to the porous covering mentioned in Mr. Cassel's patent. It was claimed that this dialyzer had a selective influence over the metals and allowed only the impurities, such as the arsenic, antimony, phosphorus, etc., to pass, leaving the solution outside comparatively free from them, while preventing the copper from passing through. But this was undoubtedly a delusion. It was not a dialyzer at all. A wooden box or a box made of porous clay would have answered as well. The only purpose which this box filled was that which the porous cup fills in the Grove and the Bunsen batteries, namely, to permit the passage of the current, while yet preventing the diffusion of the liquids. It was simply a partition which prevented the saturated copper solution from passing through to come near the cathode. Eventually such diffusion did take place in all cases, and then the copper and whatever other metals were present in solution became deposited, instead of hydrogen. The evolution of hydrogen was very copious during the passage of the current. This is easily explained. Hydrogen is the electropositive element of the ordinary acids, and it is that part of the acid which is replaced when metals are dissolved in these acids. Thus when copper dissolves in sulphuric acid each atom of copper (dyad) replaces two atoms of hydrogen (monad), and sulphuric acid (H_2SO_4) becomes sulphate of copper ($CuSO_4$). Now when a solution is electrolyzed, if there is no metal present in solution, hydrogen itself is separated from the acid and is evolved at the cathode. In this case the porous box prevented the copper sulphate from passing into the neighborhood of the cathode, or at least retarded it, since it ultimately appeared in sufficient quantities to be deposited on the cathode. Hydrogen is very electropositive to copper, hence a counter-electromotive force of polarization was apparent. This was one of the great disadvantages of the process, for it meant additional consumption of power to produce a current powerful enough to overcome this back current. Moreover the porous partition added considerably to the resistance of each vat, and this made the power required greater also.

Mr. Cassel claimed that the solution used in these vats was only ordinary sulphuric acid and water at 10° Baumé, but it has transpired since that a certain quantity of nitric acid had been added by him to the sulphuric-acid solution. Under the influence of the current passing through the 20 vats in series, every metal except gold was supposed to be dissolved. The solution was not allowed to become saturated with the metals dissolved, but was constantly drawn off through leaden pipes and conveyed to a series of nine tanks arranged "in cascade," or in such a manner that the liquid was siphoned successively from the highest to the lowest. In these vats the silver was precipitated by means of ten copper plates suspended in the solution, the copper from the plates dissolving gradually, while the silver fell to the bottom as a fine crystalline coherent white mass. It was evidently very pure, since metals assume the crystalline condition only when chemically pure. The silver is said to have assayed .999 fine.

The solution was taken at the last of these precipitating vats, and if not too saturated with copper it was returned to the electrolyzing vats for another round; if it contained too much copper, it was drawn into another series of six tanks containing lead anodes and cathodes, and on passing the current from a special dynamo-electric machine the copper was deposited out of it, on the cathodes. The anodes at the same time became peroxidized like the negative plates of a storage cell, and a strong polarization was the result. Being freed of its copper the solution was returned to the depositing vats once more. The copper deposited was pure; the impurities, including the iron, remaining in solution. The gold had the appearance of a soot-like sediment in the bottom of the vats. This was not pure, however, because several metalloids were also thrown down with it.

The most important cause of the failure of this process was the presence of iron in the solution. Iron is inevitably contained in the crude bullion, and it dissolves and remains in solution. Were it inert there, it would not be objectionable. But it has the property of precipitating the silver in the depositing vat and thus causing it to become mixed with the gold. In a word, the silver could not be depended upon to be deposited by itself when iron is present, and the gold would have to be separated from the silver by another process of refining. This solution would become charged with iron to such an extent that it would need to be replaced or "doctored."

It is perhaps well to observe here that this process was not intended to treat lead base bullion, because lead is not soluble in the liquor.

The amount of power consumed in producing the currents necessary was also a great objection. The definite quantity could not be ascertained, but the engine used was capable of developing 50 horse-powers, and it is safe to say that at least 25 horse-powers were in requisition for the work of refining and for precipitating the copper from the saturated solution. The largest portion of this energy was probably wasted so far as useful result was concerned, for it served only to overcome the polarization present in the vats and tanks. It would have been a great improvement to have connected the vats in multiple circuit, instead of in series. In that case the counter-electromotive force would have been equal to that of one vat only, instead of being twenty times one. Another great improvement would have been to permit the deposition of the copper (or some other metal) in the electrolyzing vats, which would have eliminated the counter-electromotive force almost entirely; and the amount of power required would have been reduced materially in consequence, and also from the fact that the separate deposition of the copper in special tanks required an expenditure of energy equal to that consumed in dissolving it, while it was in the anode in the electrolyzing vats. The current for electrolyzing the bullion was supplied by a Hochausen 50-volt dynamo-electric machine of extremely low resistance. The extraction of the copper from the solution was done by the current from a Siemens 3-volt dynamo of low resistance, the tanks being connected in multiple circuit. The actual cost of the plant cannot be determined definitely.

The plan originally included the buying and refining of bullion on speculation, and also the refining at regular mint rates for outside parties. It was believed that returns could be made in less than a week. This is not improbable, for with this plant each bullion plate could probably be electrolyzed inside of three days. With a proper disposition of vats and with a suitable current the operation could be materially shortened.

Norddeutsche Affinerie.—The refining of bullion is carried on successfully at this establishment, which, as previously stated, refines copper by electrolysis. The bullion is cast into plates and electrolyzed, but the composition of the solutions which are used as electrolytes is kept a secret, and the exact mode of procedure is also wrapt in mystery. The refining of gold is also practiced, the gold being used as an anode in a solution doubtless a cyanide, as used in electroplating. Some gold refined in this way assayed 1000 fine at the Paris mint.

The refining of bullion is also carried on with good results at other places, but unfortunately no details can be obtained from which the manner of overcoming the defects seen in Cassel's process may be determined.

M. André.—This gentleman has experimented with copper mattes containing nickel with impurities, for the purpose of separating the nickel. In a solution of sulphuric acid both copper and nickel are dissolved by the current, but the nickel is not deposited so long as the solution remains acid. When the copper of the matte is all electrolyzed a carbon anode is used and the action is kept up until the copper is all deposited. The solution is neutralized with ammonia, and is evaporated in the presence of air to precipitate the iron. The filtered solution is then electrolyzed with a zinc anode separated from the cathode to prevent admixture of the solutions; and on passing the current the zinc dissolves, while the nickel is deposited in the metallic form.

M. André has also invented a process for refining gold and silver alloys which is in fact a bullion refining process. The alloys are made the anode in dilute sulphuric acid; and between the anode and cathode a diaphragm of peculiar construction is interposed. This is made of two sheets of cotton fabric so held in a frame as to leave a slight distance between them, which is filled with granulated or scrap copper. This arrangement precedes the screen of Mr. Cassel by at least two years, since it was described in *La Revue Industrielle* early in 1880. When the anode contains copper, silver, and gold, the first two only are dissolved, and the silver is precipitated on the copper contained in the partition; while pure copper only is deposited at the cathode. The precipitated silver may be readily separated from the copper, and in a state sufficiently pure to need no further refining.

ELECTROLYTIC TREATMENT OF LEAD BULLION.

Keith's process for desilvering and purifying base bullion.—In 1878 Prof. N. S. Keith, of New York, invented a process for the adaptation of electrolysis to lead base bullion or argentiferous lead, with the object of extracting the silver and at the same time separating the lead in a pure metallic state. This process represents a new departure in electrometallurgy, and one which is destined to be of great importance if the application of the process on a large scale proves as successful as it already has on a small scale. The sphere of usefulness and the field of applicability are much more extensive in this case than in that of processes intended for the treatment of copper bullion; because while the improvements in the ordinary methods for treating the latter leave scarcely any margin for greater perfection, the methods of treating lead base bullion, Pattinson's and Park's processes, are at best quite costly from the multifarious stages of treatment, and the losses by volatilization, which they involve. It was from these considerations that Professor Keith was led to devote himself to the search of a method for accomplishing the work by electricity with a view to greater economy.

Lead is by far the main constituent of base bullion; it forms on the average over 90 per cent. of the mass. So in treating base bullion by electricity the most rational way is to remove the lead in merchantable form, just as it is the most rational to remove the copper in treating copper bullion. This is what Professor Keith sought to do; though it required much study and experimenting to arrive at a practical method of doing it. Nothing was known of the electrolysis of lead beyond the fact that the "lead tree" is formed when a piece of zinc is placed in a solution of acetate of lead, the lead being deposited on the zinc in a crystalline state. Lead could doubtless be electrolyzed in a solution of acetate of lead, but it was found that the deposit on the cathode was liable to build out towards the anode and that it soon bridged across completely. This bridge of crystalline lead provided a free conducting path for the current, and no more electrolytic action occurred between the two plates—they were provided with a short circuit or less resistant connection. Nitrate of lead was a good electrolyte for lead, but the nitric acid could also dissolve the silver from the bullion anodes, which was not desirable. Sulphuric acid dissolves lead in small quantity, but the sulphate of lead becomes precipitated in the solution, and none appears at the cathode to be decomposed and to deposit metallic lead again. After an extended trial of all the known salts of lead, in various combinations, Professor Keith finally produced several solutions which could serve as more or less perfect electrolytes for lead; and it is in the discovery of these solutions that the merits of his process find their explanation. Once a good electrolyte found, the rest was a mere matter of electrical and chemical details and of practical adaptation.

Professor Keith has obtained two patents on his process. The first is No. 209,056, dated October 15, 1878, for "Improvements in processes for refining impure lead"; and the second is No. 215,463, dated May 20, 1879, "For improvements in solutions for electrolysis of lead." It is believed that Professor Keith's patents cover the use of practical lead electrolytes of all known composition, but in practice he has limited himself to a few only, which were found most suitable for the purpose. The solution which he has definitely settled upon consists of acetate of sodium, about 1½ pounds to the gallon, in which 2½ to 3 ounces of sulphate of lead is dissolved. It might be supposed at first sight that a double decomposition would result between these two salts, yet such is not the case. The acetate of soda appears to act merely as a solvent for the sulphate of lead.

This process is essentially the same in its appointments as the Elkinton process. Bullion plates are placed equidistant in a vat and form a multiple anode, while metallic plates placed between them form a multiple cathode. The bullion plates are very much thinner, however, being only from one-eighth to three-sixteenths of an inch in thickness. A plate of bullion 15 by 24 inches of this thickness weighs about 20 pounds. Before being put into the vats a muslin bag is drawn over each bullion plate. The function of this bag is to hold the residues, instead of allowing them to fall at the bottom of the vat, as in Elkinton's process. The lead is intended to accumulate on the bottom of the vats, and by this means prevent its contamination by the impurities from which it has been separated. The mesh of the bag is fine enough to prevent the fine powder from being washed through by agitation of the solution, for these fine particles would eventually settle to the bottom and mix with the lead. At the same time the diffusion of the liquid is quite free between the inside and the outside of the bag, while the electrical resistance is not increased perceptibly by the bag. The diffusion is quite necessary, for the lead becomes dissolved as sulphate by electrolysis, and this sulphate must diffuse itself in the solution to take the place of the sulphate which has been decomposed at the cathode to deposit metallic lead. If the diffusion were to take place too slowly it is easy to see that in a short time the amount of lead present in solution outside the bags would be too little to satisfy the depositing power of the current, and hydrogen would begin to be evolved, with the consequent occurrence of polarization. If the solution is constantly stirred, therefore, the current may be much stronger without fear of polarization. It is found that by heating the solution the diffusion takes place more readily. Another great advantage of heating the solution is that its resistance is thereby materially reduced. In practice the solution is therefore heated to about 100° Fahr. The solution is maintained neutral; for when its reaction becomes alkaline, the alkali (in this case soda) becomes decomposed, furnishing oxygen to the anode and peroxidizing the lead therein, while hydrogen is evolved at the cathode and produces polarization, this result being irrespective of the state of diffusion.

When the action is normal there is no polarization in this solution. In this condition the lead is dissolved from the anodes, and an exactly equivalent amount is deposited on the cathodes and collects as a crystalline coherent layer. In some cases, after the layer becomes sufficiently thick, it rolls off the surface of the cathodes, and falls to the bottom of the vats. In other cases the cathodes have to be gently scraped by a special contrivance to divest them of their leaden coat.

After the lead is all electrolyzed from the bullion plates (anodes) nothing but the impurities remain in the bag. These constitute about 5 per cent. of the whole mass. If care is taken in removing the bag it will be found that the anode has scarcely changed in appearance. It has a bright metallic aspect, with a display of iridescent color; it seems at first as if no action had taken place. On touching the plate, however, it is found to yield under the finger, just like so much blue clay, which it resembles in appearance. This is the residuum. Here and there remains a small scrap of lead which became detached from the plate as it grew thinner, and then failed to receive any more current. The residuum is placed in water, and these scraps are easily washed from the "mud," which afterwards settles as a clayey layer, leaving the water perfectly clear again. The scraps are remelted and recast into plates. The lead is drawn out from the vats at convenient intervals, and is then washed in water to clear it of "solution," after which it is dried rapidly, and is either pressed into slugs, cohering readily, or else it is melted at a low heat and cast into pigs.

The residue which contains the silver and the gold, with the impurities (such as arsenic and antimony), is subjected to a special process of refining by which the metals are separated and utilized. Professor Keith reviews the treatment of this residue in the following manner:

"In laying out our plan of procedure we must first consider the conditions and liabilities. These may be formulated thus:

"1. It is a wet powder, and must be dried.

"2. The oxidizable constituents must be oxidized.

"3. It must be mixed with fluxes and fused.

"4. Antimony and arsenic are volatile, and carry off in vaporizing, mechanically or otherwise, silver, and perhaps gold.

"5. It is absolutely necessary to get *all* the gold and silver, and as pure as possible, though they may be alloyed together.

"6. It is obvious that drying the powder and roasting it in a reverberatory furnace will cause a great loss in silver from volatilization with arsenic and antimony, besides loss of powder carried off by the draught. Its roasting needs most careful treatment, as from the easy fusibility of antimony masses of alloy may be formed which cannot be practically oxidized. Recognizing these conditions and difficulties, the plan of proceeding is this: After having removed the powder from the filters while it is still wet it is mixed with a proper quantity of nitrate of soda, when it may be dried without loss of dust, as the nitrate cements the whole together. When sufficiently dry it is placed in crucibles for fusion. These are cautiously heated; the nitrate decomposing gives oxygen to the antimony, arsenic, copper, iron, etc., thus forming teroxide of antimony, arsenious acid, and oxides of copper, iron, etc. The soda combines with the teroxide of antimony and the arsenious acids, forming antimoniate of soda and arsenite of soda, which are fusible. A little borax added makes the slag more liquid when the oxides of iron and copper are present. A button of pure gold and silver collects in the bottom of the crucible.

"Now, though antimony, arsenic, and arsenious acid are volatile, antimoniate of soda and arsenite of soda are not, so there can be no loss from their volatilization. Nitrate of potash may be substituted for the soda salt, with the same effect. This slag of antimoniates and arsenites can be utilized in the following manner: When treated with hot water the arsenite of soda or potash is dissolved and the antimoniate remains undissolved, together with the oxides of copper and iron. The arsenite of soda or potash is obtained by crystallization, and finds its use in dyeing, color-making, etc., or metallic arsenic may be obtained from it by sublimation. Antimony may be obtained from the residue by mixing it with charcoal and melting in a crucible. No copper or iron need be reduced with the antimony, with proper care. But if they are they may be removed by a subsequent fusion with some teroxide of antimony. Perhaps it will not be found profitable to carry the utilization further than to save the antimony and arsenic."

The reason why the plates are cast thin is that the speed at which the electrolysis can be pushed is limited by the rate of diffusion of the sulphate of lead through the bags, as explained above. It was found in practice that with plates 15 by 24 inches the rate of electrolytic transfer of lead was from 1½ to 2 ounces per hour, and a plate of this size, weighing 20 pounds, would therefore require from six to eight days. If made twice as thick, or ¼ inch, it would last twice as long, and to make a given return per day the amount under treatment would require to be greater. If cast thinner and larger, so as to expose more surface, then they will be electrolyzed at a more rapid rate. The solution does not become altered by continued use. Iron and zinc, if present in the bullion, become dissolved and remain in solution, but this does not impair its efficiency. The addition of a small quantity of sulphate of lead will correct any defect from this cause. Moreover, the sulphate of iron becomes gradually oxidized, and sesquioxide of iron eventually comes to the surface as a scum which may be skimmed off if desired.

The main object to be accomplished in the treatment of lead base bullion is evidently the separation of the silver from the lead. It is to attain this result that the expensive and laborious stages of the old processes, culminating in cupellation, are followed. Moreover the presence of impurities, especially antimony, has a great influence on the facility of such treatment. Some varieties of bullion containing antimony in large proportions are so troublesome and refractory that in many cases they cannot be profitably separated.

Bearing in mind the above difficulties connected with the fire processes, the Keith process presents interesting advantages. The silver and lead are directly separated, and that separation takes place as readily whether the bullion contains a large or a small percentage of antimony. Not only this, but the antimony itself is saved and can be sold at the market price. None of the lead is lost, or at most but a very light amount by vaporization, oxidation, etc., because the bullion is only heated sufficiently to be melted and cast into plates, instead of being repeatedly heated. All of the gold and the silver is saved. The purity of the lead obtained is another advantage. A sample of electrolytic lead produced by Keith's process was found by analysis to contain only .000068 per cent. of silver (.02 oz. per ton); and although a large quantity was used for analysis, only traces of arsenic and antimony could be detected, and there was no copper, though the bullion contained some. There is reason to believe that even this small amount of silver was due to insufficient care in handling the anodes, so that some of the residue was washed into the solution and settled upon the lead at the bottom of the vat. The bullion from which this lead was electrolyzed was also analyzed, with the following result:

Lead	96.36
Silver (161.7 ounces per ton)	.5544
Copper	.315
Antimony	1.07
Arsenic	1.22
Traces of zinc and iron, undetermined matter and loss	.4806
	100.0000

Among the other advantages of Keith's process may be mentioned simplicity of working, which does not require many hands. The power consumed is very low, and inasmuch as there is no polarization in the solution, the amount of power can be controlled absolutely by the size of plant.

The patents of Professor Keith are now owned by a company—the Electro-Metal Refining Company, of Rome, New York—formed for the purpose of developing the process. This company has had in operation two small experimental plants, the second of which was located at No. 97 Liberty street, New York, and maintained during the greater part of the year 1882. In this plant there were four vats 10 feet long, 2 feet wide, and 3 feet 6 inches deep, made of wood and covered with pitch without and within to make them waterproof. Copper rods one inch square resting on the edge of each tank served as conductors for the current. The anodes and cathodes rested on these conductors by means of hooks projecting from their upper margin. A piece of paper was placed between the hook of each anode and the conductor, on one side, so as to prevent contact; while the cathodes were also insulated in like manner from the other conductor. There were about forty anodes and as many cathodes in each tank. The tanks were connected in series to a Weston dynamo-electric machine for electro-deposition, having an electromotive force of about one volt and a very low resistance. A circulating and heating apparatus was also provided as follows: The solution was allowed to run off from a gutter at one end of each tank, and was thence conveyed to a tub, from which it was pumped up into a cask placed higher than the tanks. From the bottom of this cask was a delivery pipe which subdivided into four smaller pipes, one extending along the bottom of each tank. These small pipes were perforated with numerous holes, through which the solution entered the tank. In the cask a copper still-worm was placed which was heated by steam. Thus the solution was agitated and heated at the same time. The weight of each plate (15 by 24 by $\frac{1}{8}$ inches) being about 20 pounds, the amount under treatment was consequenty 160 (plates) $\times$ 20=3,200 pounds. At the rate of $1\frac{1}{2}$ ounces per plate per hour, which was the average of working, the deposit was 360 pounds per day of 24 hours. It will readily be understood that the machine can be worked by night as well as by day. At this rate a plate would be exhausted in somewhat less than nine days. In practice the plates are not all exhausted however; there always remain small pieces which become detached from the rest of the plate. The weight of these scraps would average about one pound, though in this case many of the plates were cracked to begin with, and did not hold out so well for this reason.

The company is now engaged in erecting a plant at Rome, New York, on a larger scale. The works are in a one-story building 150 by 50 feet, of which the present working capacity (three tons per day) will require only one-third the space. The design of the works is by Mr. C. O. Yale, mechanical engineer in charge of their construction, and reflects great credit on his ability. The casting of the bullion plates will be done by means of a casting machine, or system of mechanical molds rotating around a center and passing successively under the spout of the melting furnace. There will be 12 molds. Each mold holds at its upper part two thin strips of copper perforated with holes. When the lead is poured into the mold it fills these holes, and the strips form suspension lugs and connections at the same time. At the side of the revolving system opposite from the furnace the plates are taken away by a boy who replaces other copper strips and closes the mold again for another round. A man and a boy will make 180 plates per hour. Each plate is 24 by 6 by $\frac{1}{8}$ inches, and weighs about 8 pounds. The plates are hung from a frame and carried by an overhead railway to the vats. There will be thirty circular vats, made of a kind of concrete mixture. Each vat is 6 feet in diameter, 40 inches high, and has a central core or pillar 2 feet in diameter and equal in height to the height of the vat.

The cathodes consist of 13 circular hoops or bands of sheet brass two feet high and arranged concentrically two inches apart. The plates of bullion are lowered between these circular cathodes. The anode frame or bullion-carrier has 12 consecutive rings of brass, two inches wide and one-eighth of an inch thick, also arranged two inches apart. Rivet heads of copper project from these rings, and the bullion plates are suspended to these by the eye-holes in the suspension lugs. Each frame will receive 270 bullion plates, making the total weight of bullion about 2,160 pounds per vat, or slightly over one ton. The carrying power of the overhead railway will be 3,000 pounds. The solution is allowed to overflow from the vats by a small gutter to the floor, which is of concrete and grooved with gutters that lead to cisterns at the end of the building which have a capacity of 3,000 gallons; whence it is pumped by a centrifugal pump to an overhead tank, where it is heated by a system of steam pipes to 100° Fah., automatic electrical regulation of the temperature being secured by a special device. From this tank the solution is distributed to the vats by a system of pipes. An Edison dynamo-electric machine, constructed specially for this purpose, will be used to furnish the current. This machine will have an electromotive force of ten volts and an internal resistance of .005 ohm, and will, therefore, produce the enormous volume of current of 2,000 ampères. This current will nevertheless be entirely safe to the employés, on account of its very low electromotive force.

The vats will be connected in series, and two other series of 30 each will be added later in parallel circuit, if the enterprise prove successful. The speed of the dynamo will be adjusted so that the current produced will dissolve each plate in ten days. The power used by the machine will not exceed 10 horse-power for thirty vats. The vats will be charged in rotation, three per day, and on the tenth day the first three will be renewed, and after that the renewal will follow in the same order. In this way there will be three tons put under treatment every day and three tons refined and returned. The anode carriers can be rotated around the core of the vat as a center; and they carry mechanical fingers which will scrape the surface of the cathodes by the motion.

By removing a plug each vat may be emptied rapidly, and the crystalline lead shoveled out. This lead is washed in water and placed in a centrifugal dryer, after which it is melted under oil or other reducing material to expel the remaining traces of moisture without oxidation, and it is then ready for the market. There will be ovens and muffles, etc., for assay purposes and for reducing the residues. These residues will be washed in water and the water run through a sieve to take out the scraps of bullion, and then they will be allowed to settle, after which they will be decanted and dried. It is expected that all the arrangements will be completed by July 15, 1883.

THE ELECTROLYTIC SEPARATION OF ZINC FROM ITS ORES.

The Lambotte-Doucet method.—These gentlemen have lately been experimenting with a method of extracting zinc from its ores, in which electricity plays a part. The ore is first roasted as usual, and is then dissolved in hydrochloric acid. A concentrated neutral solution of zinc chloride, free from iron, the latter having been precipitated in the form of oxide, is thus formed. The solution is then submitted to the action of a current of electricity, between carbon anodes and zinc cathodes, and the zinc is deposited out of the solution in the metallic state.

The Letrange method.—This method of M. Letrange is applicable to all zinc ores; but it is specially designed for treating blende (sphalerite, sulphide of zinc), which is a common form of ore often neglected on account of its rebelliousness. M. Letrange takes advantage of the presence of sulphur in the blende. He transforms zinc into sulphate by the oxidation of the sulphur, so as to furnish sulphuric acid. The operation is not so protracted as when the ordinary fire process is followed. The galena present need not be separated, since it is not soluble in sulphuric acid, and remains in the residues. The calamine does not require to be calcined. The blende itself need be roasted only moderately, because a low temperature is more favorable to the formation of sulphate than a too high temperature. The roasting is done either in a reverberatory or in a puddling furnace.

After the ore is transformed into sulphate it is placed in large vats in which a current of water circulates. The liquid sulphate is then passed very slowly through a series of basins, and there undergoes electrolysis. The anodes are of lead and the cathodes of zinc. The baths are so arranged as to diminish as much as possible the distance between the anodes and cathodes, and so as to present a largely increased surface, whereby the resistance is reduced to its lowest amount. A part of the zinc contained in the solution is deposited on the cathodes. The solution is then poured over heaps of ores and dissolves the oxides of zinc, and is again saturated with sulphate. The motion of the solution in the basins is nicely regulated by a slight difference of level between the ends of the system. The solution is thus passed repeatedly through the precipitating basins and deprived of its zinc after each round through a heap of ore. So the same acid is used over and over. The amount present in the wasted ore need be only sufficient to provide for losses from the combination of acid with foreign metals. The silver, lead, and other insoluble substances are left in the ore, and may afterwards be recovered by suitable methods.

There is only one fault to be found with these two methods from an electrical point of view; it is that the amount of power required for the deposition must be quite high. If the anode were soluble the counter-electromotive force would be much reduced. As it is, the counter-electromotive force between the peroxidized surface of the lead anodes and the zinc cathodes must be very high, and this means of course an opposition to the depositing current which is to be overcome only by the expenditure of power. So far the experiments of M. Letrange have not shown a better return than 50 pounds deposited per horse-power per day. This expenditure may be economical as compared to the amount of fuel, etc., required in treating the ores in the ordinary way, but still it leaves much room for improvement.

ELECTROLYTIC ASSAYING.

It may not be improper to mention briefly here that among the subjects occupying the attention of electricians and chemists the estimation of metals by electrolytic assaying is receiving some attention. A French chemist, M. Alfred Riche, has applied the idea successfully to the assay of copper, lead, zinc, manganese, etc. The principle is simply to make a solution of the metal and to deposit this metal by electrolysis. This method presents great advantages sometimes, as in some cases it is difficult to separate the metal entirely by means of chemical reagents.

THE MINOR MINERALS OF NORTH CAROLINA.

By W. C. Kerr.

Omitting the leading mining industries of coal and of gold, iron, copper, and silver ores (and incidentally of lead and zinc), there remain about a dozen other minerals which are the subjects of mining operations. These are mica, corundum, pyrophyllite (soapstone), talc (soapstone), barytes, garnet, asbestus, black oxide of manganese, zircon, kaolin (and potter's clay), gems, and pyrite.

Pyrite and pyrrhotine.—These are commonly found associated with gold and copper in the veins of those metals, and are distributed very widely throughout the Archæan formations of the State, often in large bodies. Many of the largest veins, however, show but a trace of these minerals. Pyrite has been mined for the production of sulphur on one occasion only, during the late war. Nothing but the lack of cheap transportation has prevented its use in the manufacture of sulphuric acid at Charleston, Atlanta, and Nashville for producing superphosphates. Arrangements are making to overcome this difficulty, so that in a short time those establishments will be able to substitute the native pyrite for the imported Spanish article.

Kaolin was mined by the Indians before the settlement of the country, and sold to European traders. It is now mined only incidentally with mica, and goes into the dump. But it is of the finest quality, and is found in very large bodies, and will become valuable when the region (the mountains) shall be rendered accessible by railroads.

Potter's clay has been mined and manufactured into stone and earthen ware throughout the middle region of the State, since the first settlement of the country.

Zircon has been mined only at one place, and merely for cabinet specimens, and only on one occasion on any considerable scale. One thousand pounds of zircon crystals were mined by General Clingman a few years ago. They were washed out with rockers, after the manner of placer gold mining. This locality is in Henderson county on the Blue Ridge. The mineral is found in many other places, notably in most of the gold deposits, but in small quantities of minute transparent crystals.

Black oxide of manganese is found in the form of psilomilane and pyrolusite, in a number of localities in small veins, but has been mined for market only at one point, and in a tentative way, a ton or two having been sent from Caldwell county to New York.

Asbestus is a very common mineral in the State, but has been mined for market only in three counties. From Mitchell two carloads were hauled in wagons 40 miles, over the Smoky mountains, to a railroad and transported to New York. Of course the enterprise was not profitable under those conditions. About 40 tons were also mined and sent to New York from Caldwell and Burke counties five or six years ago. Cheap transportation will revive this industry, and in many new localities, as the mineral is found in nearly every section of the State except near the coast.

Barytes has been mined at but one point on a large scale, although explorations have been made and a few tons mined at other localities. Several hundred tons were mined in Gaston county, near King's mountain, a few years ago, and transported to Boston. There are large veins of it in this and several other counties.

Garnet, red, massive, granular, and crystalline, is now and has been for a year past mined in Burke county, near Morganton, on a considerable scale. It is stamped to a coarse gravel and shipped in bags, for replacing corundum and emery in the manufacture of polishing or abrasive powders and papers. From the best information obtainable, it is probable that several hundred tons have been shipped. The results were not, however, satisfactory, as the garnet is too brittle to form a substitute for corundum, and cannot compete in price with quartz, glass, etc. This mineral is found in large veins in many localities, and in crystals, often very large, in the mica and chlorite schists in various parts of the State.

Talc, under the common name soapstone, is mined on a large scale in Cherokee and Swain counties, where it is found in large bodies and of great purity and fineness of texture. Although it must undergo the expense of being hauled in wagons 50 or 60 miles, over mountain roads (which are no roads at all), yet not less than 200 or 300 tons are shipped in a year. This mineral is found nowhere else in North Carolina of so high a quality, but beds of it of inferior grade are of common occurrence throughout the region of the older rocks.

Pyrophyllite, under the name of soapstone, has been mined in large quantities in Moore and Chatham counties, near Deep river. It is ground and bolted like flour, and transported in barrels. One firm in Fayetteville has handled 10,000 barrels, of 300 pounds each. The mineral is found in large slaty or schistose beds associated with the later Archæan rocks; and it occurs in many places. There have been no shipments for a number of years; but the completion of the Fayetteville and Greensborough railroad within a few months will furnish such facilities for transportation that the business can be resumed under better conditions than formerly.

Corundum is a mineral of very common occurrence in the State. It is found both in crystals and in tabular masses, and is also found distributed in a granular form in veins of chlorite associated with the dunyte so common in the western part of the State. It has been mined to the extent of a few tons in Madison, Buncombe, and Clay counties, and on a large scale near Franklin, in Macon county, at the Cullasaja or Corundum Hill mine. It is obtained here both from chlorite veins and by washing the gravel and earthy deposits on the hillsides; and several hundred tons are annually shipped. The supply seems to be abundant and permanent.

Mica is the subject of the most important of these secondary mining industries in the State. There are scores of mica mines in the mountain section, mostly beyond the Blue Ridge. The most important of these occur in Mitchell, Yancey, and Macon counties; several of them under favorable conditions yield 1,000 to 2,500 pounds of marketable mica per month. The mineral occurs in very coarse granite dikes or veins which penetrate the old gneisses and schists. These dikes are very numerous and often many yards or even rods in thickness, and may sometimes be traced a mile or more. The total product of these mines since 1868, when the first were opened, is about 400,000 pounds. The average value has not been less than $2 per pound, probably nearer $2.50; so that the aggregate commercial result has been about $1,000,000.

From what has been stated of the mode of occurrence of mica, it is apparent that the industry is a permanent one. In fact it is continually enlarging in area and product, and improving in mining methods.

Gems have been systematically mined in only two instances. General Clingman made the first experiment of the sort, in the search for rubies and sapphires, in the vicinity of the corundum mine, above referred to, which has been since developed. He found a number of both varieties of gems, but none of much purity or value. Other and better specimens have since been obtained incidentally in the ordinary mining processes. Mr. Hidden has inaugurated in Alexander county the most important enterprise of this sort that has been undertaken in the State. The objects of his search are beryls and the new mineral hiddenite.(*a*)

Six or eight diamonds have been obtained from the gold gravels of the State, some of them of high quality, but only a few karats in weight. Garnets are often found of sufficient depth of color and clearness to serve as gems, and some rather deeply-colored spinel rubies have been found in Jackson county. Amethysts and rose quartz and sagenites of great beauty have been obtained in many places. Professor Humphreys, of Greensborough, made a business of searching and mining for these stones, in which he was remarkably successful. Mr. Stevenson, of Statesville, has also been quite successful as a collector in the same line, and also in obtaining rutiles, some of which have made very pretty gems. And in the mica mines some very fine aquamarines have been found. These are the principal minerals which have yielded gems heretofore, but the number has increased very considerably within the last decade.

All the above-described secondary mining interests, being dependent mainly on the facilities for transportation, are sure to revive and multiply with the improvements now making in this respect; the number of miles of railroad having been doubled since the war, and the lines penetrating regions hitherto quite inaccessible.

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a See pp. 500 and 502, this report.

MINOR MINERALS OF THE PACIFIC COAST.

By C. G. Yale.

Notwithstanding the fact that the business of mining for the precious metals on the Pacific coast has heretofore engrossed attention to the exclusion of nearly all other metals and minerals, these latter occur in great variety and generally in great abundance. Indeed, there is hardly a mineral product of use in the manufacturing or mechanic arts or of interest to science but has been found somewhere in this region, though not always under conditions which impart to it any large or present commercial value. Thus, while it has been possible to profitably work deposits of coal, copper, cinnabar, sulphur, borax, and a few others, there are a variety of substances, such as mica, zinc, nickel, niter, antimony, diamonds and other precious stones, plumbago, manganese, platinum, etc., which, though justly entitled to a place among the mineral resources of the region, have as yet proved to be of little or no economic value, because of their limited quantity, imperfect quality, difficulty of access, or other unfavorable conditions.

In addition to those above mentioned, the metals and minerals found in the Pacific States and Territories under conditions which give them some, and in most cases a large present or prospective value, may be enumerated as follows: Iron, lead, salt, soda, petroleum, asphaltum, gypsum, marls, asbestus, tin, chromic iron, hydraulic cement, marble, chalk, lime, fissile slates, mineral pigments, infusorial earth, kaolin, fire and other valuable clays, alabaster, magnesia, steatite, mineral soap, alum, arsenic, emery, ocher, bismuth, tellurium, cobalt, molybdenum, etc.

Besides the deposits named elsewhere in this volume which have been worked continuously and with profit, there are some others the working of which, after a trial, had to be abandoned, labor and the other factors of production having been too dear or the home demand too limited to warrant a continuance of operations. Thus attempts to utilize the deposits of plumbago, chromic iron, fire and other clays, manganese, antimony, etc., have either wholly failed or have been continued in only a feeble and spasmodic way.

Some of these industries, after languishing or being wholy extinguished during earlier struggles for existence, having at a later period been resuscitated, have since prospered and grown into large proportions, the production of copper, borax, and petroleum furnishing notable examples of this kind. It is the case, in fact, that nearly every industry belonging to this class has at one time or another experienced seasons of great depression, owing to the prevalence of low prices for the particular product; or, as in the case of quicksilver and borax, because of a real or apprehended overproduction. Never, however, have any of these pursuits failed by reason of the inferior quality or any lack of the raw material.

But for the greater allurements presented by gold and silver mining the other mineral resources would no doubt have met with much greater development than they have done, the high prices and the instability of labor in connection with the excitements incident to gold mining having for a long time tended to prevent such development. Since the exhaustion of the more accessible surface deposits, placer operations have been on the decline, reducing in like ratio the wages of unskilled labor, and causing that class of miners to seek employment in other occupations. With this altered state of affairs mining pursuits have become more diversified, men of enterprise and means having been encouraged to experiment with a variety of the more common minerals and metals, the most of which had before been neglected or had been worked at a loss. There is reason now to believe that these efforts will meet with better results and ultimately be so extended that most of the local requirements will be supplied from home sources, with a surplus of some commodities for exportation. In the past the Pacific coast has numbered among its exports quicksilver, lead, borax, copper, and several other important substances, and the list is gradually increasing. Moreover, there is a corresponding increase in amount making itself apparent. As the country grows in population and railroad facilities are extended, mineral deposits become available which, though they have long been known to exist, have not been before utilized.

THE USEFUL MINERALS OF THE UNITED STATES.

Some explanation seems appropriate in presenting the following lists. The design is to simplify a very intricate subject, and to show in as compact and concise a form as possible the principal occurrences of the ores, minerals, and mineral substances of industrial importance of the several States and Territories, and to indicate whether these resources are or are not at present being utilized.

From the point of view of the mineralogist, to cite a "locality" is useless unless the reference is very specific and most carefully verified. The general reader, and the statist as well, are far more interested in the economic features of the topic. To quote all the mineral localities which are known and have already been reported would occupy quite as many pages as this volume contains; while the vast preponderance of occurrences which have no economic importance, however interesting they may be to the scientific observer, would at once defeat the whole object of the work by obscuring the main features which it is desired to develop. On the other hand a certain amount of detail is required, both as a means of verification and to give a closer insight into the conditions than is afforded by a division based upon the unit of a State or Territory. The endeavor has therefore been to avoid unnecessary minuteness on the one side and barrenness on the other.

Much confusion exists as to a classification which shall include substances of a real value, and omit those which for all practical purposes may be considered merely in the light of mineralogical curiosities. Indeed it is impossible to draw a hard and fast line of demarcation in the matter. For example, iron pyrites is certainly a mineral of industrial importance in some of the Atlantic States, but in the Far West it is worthless unless containing workable gold contents. So the greater number of mineral species mined in the latter region are sought and treated only because of their auriferous or argentiferous character, the gold or silver being in fact usually accidental impurities in minerals which would otherwise possess no practical interest. In the outlying Territories, many occurrences, such as of fire clay, potter's clay, gypsum, barytes, etc., may be at present useless; but the existing condition of things is not to continue indefinitely. As the newer country becomes settled, local demands steadily bring into play mineral resources which formerly were hardly given a thought. So, as regards the definition of "industrial importance," it was deemed best to allow a certain latitude as to class in places now undeveloped, while drawing the line somewhat closer as to quantity.

This leads to another perplexing question: What is a workable quantity of any given mineral? Muscovite mica may be found almost anywhere; but how large must the sheets be, and how concentrated the occurrence, to make it valuable? Small local segregations of asbestus are common; but how much is required to pay for the trouble of mining it? On this head many discrepancies will be noticed in different parts of the lists.

A graver difficulty is the question of authenticity; a troublesome matter indeed in a compilation of the present extent. In this respect the several gentlemen who have contributed to these lists vary somewhat in the strictness of their scrutiny, both as to the correct determination of species and as to geographical position; but, as a whole, the work has been done so conscientiously that the references may be relied on, so far as they go.

Exhaustiveness is not to be expected in work of this kind, and no pretense is made that even an approximation to completeness has been reached. The lists should be regarded as *cadres*, to be filled out in future work, by further additions from time to time; but, even if revised again and again, to still require many additions after the last revision. It is only by bearing the acknowledged deficiencies in mind, and remembering the design of the compilation, that the lists can be studied to advantage.

EASTERN DIVISION.

The term "Eastern Division," as used in this connection, includes, roughly speaking, the area lying east of the 100th meridian; the westernmost political subdivisions being Minnesota, Nebraska, Kansas, Indian Territory, and Texas. Prof. John C. Smock, of the Geological Survey of New Jersey, who was charged with the preparation of the lists of occurrences of the ores, minerals, and mineral substances of industrial importance in this region, explains in the accompanying letter certain points regarding the method of compilation:

NEW BRUNSWICK, NEW JERSEY,
May 28, 1883.

MR. ALBERT WILLIAMS, JR.,
United States Geologist, Washington, D. C.

SIR: Having forwarded the manuscript lists for the several States and Indian Territory embraced within the limits of the country assigned to me, I would respectfully submit the following points as pertinent to the work, and perchance of interest and importance in making up your report upon the minerals of the country:

1. The original notes (with the exception of New Jersey, New York, Pennsylvania, and North Carolina, in part) were made in index note-books, with references to the authorities whence notes of localities, etc., were taken.

2. The authorities consist, first (and very largely), of the various State geological and agricultural reports; second, articles in the several volumes of the Transactions of the American Institute of Mining Engineers, the *American Journal of Science*, Bulletins of the American Iron and Steel Association, *Engineering and Mining Journal*,

and *Mining Record;* besides the United States census reports and the various hand-books on coal, petroleum, iron, minerals, etc. Dana's Mineralogy, fifth edition, has been followed closely in the nomenclature, both mineralogical and common.

3. Valuable assistance has been given in the way of reports, and in answer to special inquiries, by the several State geologists (in States where geological surveys are in progress); also by the commissioners of agriculture in a few States, and by mining engineers and geologists in still others. In two cases, referred to elsewhere (as foot-notes), the manuscript lists have been revised by the State geologists. The thanks of the compiler are tendered through you to all these gentlemen.

4. The plan has been, so far as possible, to give both the town and county in the localities enumerated. In some of the New England States the county has been omitted, as there the autónomy of the town is so prominent.

5. Where any given ore or mineral of economic importance is quarried or mined at very many points in a region or territory (for example, coal in wide fields or iron ore in certain districts), the individual localities have been generally neglected, and a few mining centers or exceptionally large mines have been mentioned, to the exclusion of all others.

6. Occurrences of unimportant minerals—from an economic point of view—have been in nearly all cases neglected; also the occurrences of many useful minerals or ores where they occur not in mass but sparsely disseminated through rock as rock or vein constituents. At present such occurrences do not belong to the category of ores.

7. Statistics, with few exceptions, have not been included in the remarks upon localities.

8. The geological horizon has, whenever known, been stated, either in general descriptions or in very brief notes.

9. The State has served as the basis of occurrence and division. Hence in nearly all States there are localities now no longer worked or undeveloped included in the schedule of minerals "at present mined."

10. On account of the short time allowed for compilation, the lists are of necessity incomplete.

Very respectfully, your obedient servant,

J. C. SMOCK.

ALABAMA. (a)

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Mineralogical name.	Common name.	Remarks.
Cassiterite	Tin ore, tinstone	Two miles southeast of Ashland, Clay county; works erected here and tin extracted; now working.
Coal, var. bituminous.	Coal, bituminous coal.	Three distinct coal fields: 1. Coosa, 100 square miles; 2. Cahaba, 230 square miles; 3. Warrior, 5,000 square miles. General section between Locust fork and Jones's valley includes 2,600 feet of Coal Measures and thirty-five seams of coal, of which twelve are from 2½ to 7 feet thick, and with an aggregate of 50 feet. Mines on line of South and North Alabama Railroad at Warrior, Jefferson, and Newcastle stations, and at Pratt mines, west of Birmingham. Several localities worked in Madison and Jackson counties, on line of Memphis and Charleston railroad and on Alabama Great Southern railroad, in De Kalb county, also in Walker and Fayette counties. These are in the plateau region and are in the Warrior field. Mines worked in Tuscaloosa and vicinity, at Coaling and Dudley, and on small scale on Monte Sano, Huntsville, T. 3, R. 1 E., Madison county; near Larkinsville, on Memphis and Charleston railroad, Jackson county. Cahaba field: Mines now in operation at Helena and at Montevallo, in Shelby county. No mining done in Coosa field, as it is at distance from railroads and Coosa river is not navigable. One locality worked during the war.
	Fire clay	Common in Coal Measures. Firebrick works at Bibbville use such clays.
	Flagging stone	In the yellow sandstone of Red Mountain group, valley from Bricksville to Saint Clair Springs, and at Pratt's ferry on Cahaba river. Sandstone flags of Coal Measures, Plank Shoals, on North river, Tuscaloosa county. Thin-bedded limestones in Lower Silurian and in sub-Carboniferous group. Also gneisses and mica schists of metamorphic region. Fine quarries at Tallahassee falls on Tallapoosa river, in siliceous slates (itacolumite). Same rock quarried at Farrell's mill and other localities in Lee county. Many localities opened for local supply.
Gold	Gold	Arbacoochee, Cleburne county; Randall mine, Hillibee, Talladega county; Riddle mine, same county; Stewart's mine and localities on Wesgriffin and Hatchet creeks, Coosa county; Pinetucky mine and other openings in Randolph county; Haral's mine, Clay county; Goldville, Tallapoosa county; near court house, Fayette county; Marion county; Chilton county. Gold occurs mostly in quartz veins; some localities in drift and soils.
	Granite	Localities in the metamorphic region. Worked for local supply mainly. Near Bradford and also Rockford, Coosa county; Notasulga, Macon county; Auburn and Chewacla, Lee county; Tallahassee, in Tallapoosa county; Milltown, Chambers county. Not properly granites, but thick-bedded gneisses.
Graphite	Plumbago, black lead.	Localities in Chilton, Clary, Coosa, Chambers, Randolph, and Tallapoosa counties. Dug near Millville, Clay county; north of Milltown, Chambers county; and between Wedowee and Louina, in Randolph county, for use as a lubricating agent. Occurs in black, graphitic schists; also in argillaceous, schistose rocks.
Halloysite		Near Sulphur Springs station, De Kalb county. Mined extensively for manufacture of fine ware. Also found southeast of Stevenson, in Jackson county. Both occurrences in cherty strata of lower sub-Carboniferous.
Hematite	Fossil ore, dyestone ore, red iron ore.	Interstratified with shales and sandstones of Clinton group, in Brown's valley, Roup's or Jones's valley; from Pratt's Ferry, in Bibb county, to Jefferson county; Coosa valley, thence to Coosa river, near Gadsden; Wills's valley from

a Revised and enlarged by Prof. Eugene A. Smith, of Tuscaloosa, State Geologist.

ALABAMA—Continued.

Mineralogical name.	Common name.	Remarks.
Hematite—Continued.	Fossil ore, dyestone ore, red iron ore.	Attala, in Etowah county, to Georgia line; eastern side of Cahaba valley; from Gadsden on eastern foot of Lookout mountain to the Georgia line; above Gaylesville, Cherokee county, on both sides of the Coosa valley. Ore ridges traverse Blount, Marshall, Jackson, Tuscaloosa, Bibb, Shelby, Jefferson, Saint Clair, Etowah, Cherokee, and De Kalb counties; mines at Jonesborough, Hillman, near Birmingham, in Roup and Jones' valleys; west of Springville, at bifurcation of Jones' valley; northeast of Springville, at Gadsden, Round mountain, and Gaylesville, in Coosa valley; at Attala, Portersville, and one or two other places in Wills's valley; also on eastern side of Jones's valley, at several places between Jonesborough and Birmingham, besides other localities in Saint Clair and Cherokee counties. Another horizon of oölitic red ore is just below the Trenton limestones, only a few feet thick, and is traced up valley from Pratt's ferry, Bibb county, nearly to Birmingham. Hematite occurs in thin scales impregnating metamorphic schists of Coosa, Clay, and Tallapoosa counties.
Kaolinite	Kaolin, clay	Near Jacksonville, Calhoun county, extensive beds; near Louina, Randolph county. [See, also, under Halloysite.]
Limonite	Brown hematite	Occurs as "gossans" at outcrops of pyritous ores—copper mines in Cleburne, Clay, and Coosa counties. In concretionary masses associated with hornblendic rock and worked formerly at localities in Clay and Chilton counties. Ore banks at top of the dolomitic limestone (calciferous) in the Coosa valley. These are opened at intervals from near Columbiana in Shelby county northeast to Georgia line; Alabama furnace, Talladega county; Woodstock furnace, at Anniston, Calhoun county; Stonewall, Rock Run, and Tecumseh furnaces, in Cherokee county. In Cahaba valley ore occurs at intervals from near Centerville, Bibb county, northeast through Shelby and Saint Clair counties to Gadsden, in Etowah county. Furnaces at Briarfield, Bibb county, and of Ashley Iron Company, in same county. In Roup and Jones's valley ore occurs from Clements' mill, Tuscaloosa county, through parts of Bibb, Shelby, and Jefferson counties. Many mines in Bibb and Tuscaloosa counties. In Murfree's valley no mines worked for lack of transportation. In Wills's valley mined at several points between Attala and the Georgia line. Brown's valley in Marshall and Jackson counties; no mining. Sub-Carboniferous formation in the Tennessee valley in northern Alabama carries limonite. Largest bank in Franklin county from Cedar creek to Newburgh. Occurs eastward in Limestone, Lawrence, and Madison counties. Near Vernon, Lamar county (apparently drifted deposit). Many other localities on outcrop of sub-Carboniferous, but in small quantities; also, in drift strata to south.
	Marl	1. Greensand shell marls. Occur at Pleasant ridge, Greene county, &c.; in rotten limestone at Epes' station, Sumter county. In the Tertiary formations in Choctaw, Marengo, Clarke, Wilcox, Monroe, Butler, Conecuh, Coffee, Pike, and Crenshaw counties. 2. Shell marls. Common in calcareous beds of Cretaceous and Tertiary. 3. Gypsum marls. Choctaw and Clarke counties. Beds of gypsum at Gainestown on Albama river, in Clarke county. Marls dug for local use only.
	Marble	White marble four miles west of Talladega, and also at several points southwest near Syllacogga in same county. This is the "Talladega marble." A black marble is obtained in the localities southwest of Talladega. White, crystalline marble at Chewacla lime works, Lee county, and northeast and southwest for several miles. A non-crystalline, compact grey and white marble is quarried at Marion. Many localities in Trenton and magnesian limestone formations in valley of Cahaba river in Bibb and Shelby counties. Variegated marbles (sub-Carboniferous) are widely distributed in the Tennessee valley; works at Dickson, Colbert county; many localities in Lauderdale, Limestone, Madison, and Jackson counties; other outcrops along sub-Carboniferous rocks in the valleys from Georgia line southwest to center of State. A Tertiary white and yellow crystalline limestone occurs at Gainestown, Clarke county.

ALABAMA—Continued.

Mineralogical name.	Common name.	Remarks.
	Millstones and grindstones.	Millstone grit has been quarried at many points in its outcrops for millstones. Near Pikeville, Marion county, a ferruginous conglomerate is widely used. A siliceous rock of Lower Eocene, in Choctaw, Clarke, Monroe, Butler, Crenshaw, and Pike counties, sometimes used as a buhrstone. Granite of Coosa, Tallapoosa, Chambers, and Randolph counties is made into millstones at most of "flat-rock" out-crop. Chewacla lime works—a porphyritic gneiss quarried for millstones. Grindstones are made in southwest part of Talladaga county (magnesian limestone horizon) Whetstones made from sandstones quarried near Eldridge, Walker county.
	Sandstone	Potsdam sandstone in Calhoun and Talladega counties. Sandstone of Coal Measures quarried in Cullman county, and Red Gap, northeast of Birmingham, Jefferson county; Wills's Valley, De Kalb county (Clinton).
Talc	Steatite, soapstone	Dudleyville and southwest for several miles, Tallapoosa county. Oak Bowery, Chambers county, quarried for furnace linings; T. 23, R. 25 E, in Chambers county, used for headstones; Randolph county, Clay county; ancient excavations in Tallapoosa, Chambers, Coosa, Clay, and Lee counties.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asbestus	Asbestus	Near corundum deposits, Tallapoosa county.
Barite	Barytes, heavy spar	Elyton, Jefferson county; Pratt's Ferry, Bibb county; Maguire's Shoals, Cahaba river; Talladega county, several points; near Whiting's Station, Shelby county; near R. Stringfellow's, Clay county (T. 20, R. 1 E.), Chewacla lime works, Lee county; old Benton iron works, Calhoun county.
Cassiterite	Tin ore, tinstone	Rockford, Coosa county, loose crystals in granitoid gneiss.
Covellite	Indigo copper	Sec. 24, T. 19, R. 7 E., Clay county, with pyrite and quartz, in small quantity.
Chalcopyrite	Copper pyrites, yellow copper ore.	Wood's mine, Cleburne county, a bedded lode with pyrite, in mica schist; Smith's mine, near Wood's, Cleburne county; T. 21, R. 6 E., Clay county, with pyrite in quartz rock; T. 20, R. 7 E., and also near Ashland, Clay county; T. 23, R. 22 E., Tallapoosa county; and in small quantities at many other localities in Talladega, Randolph, Clay, Tallapoosa, and Coosa counties.
Corundum	Emery	Near Dudleyville, Tallapoosa county, and 10 to 15 miles to southwest; near Mount Olive, in Coosa county. Veins or seams generally broken stone, and too much altered to be utilized.
Galenite	Galena, lead ore	Benton Iron Works, Cane creek, Calhoun county; also in T. 14, R. 7 E.; near Guntersville, on Tennessee river, Marshall county. Elsewhere in lumps on surface, nowhere in workable quantity.
Lignite	Brown coal, wood coal.	In Tertiary formation of southern and southwestern parts of State. Horse creek and many places eastward, in Marengo, Barbour, Clarke, Choctaw, Monroe, Wilcox, and other counties. Also in the Cretaceous formation, mostly as lignitized trunks, in Pickens, Green, and other counties.
Magnetite	Magnetic iron ore	Impregnating sandstone, Pope mountain, Talladega county; Kennedy's, Clay county, loose; near Fredonia and near Oak Bowery in Chambers county; T. 24, R. 20 E., in Coosa county; south of Wedowee, Randolph county; Millersville, in Clay county. Nowhere mined.
Manganese ore [Pyrolusite?].	Manganese	Near Woodstock station, Calhoun county; one mile south of Candutchkee, Clay county. Used at Woodstock formerly in manufacture of ferro-manganese.

ALABAMA—Continued.

Mineralogical name.	Common name.	Remarks.
Melaconite	Black oxide of copper, black copper.	Wood's copper mine, Cleburne county, with other ores of copper; T. 20, R. 7 E., Clay county (copper mine).
Muscovite	Mica	Old mines in T. 18, R. 11 E., Randolph county, and in T. 20, R. 6 E., Clay county, and near Bowden, Clay county. T. 22, R. 16 E., Chilton county; a little mining some years ago.
	Ochers	Near Bucksville, Tuscaloosa county.
Pyrite	Pyrites	Smith's and Wood's copper mines, Cleburne county, with copper ores, T. 19, R. 7 E., Clay county; a thick bed accompanied by covellite. Montgomery copper mine, Clay county, in large quantity. TT. 20 and 21, RR. 6 and 7 E., Clay county, with copper pyrites. Many other localities as occurrences simply.
Pyrolusite [see Manganese ore].		
Quartz	Quartz	T. 22, R. 16 E., Chilton county, a crumbling quartz rock; also, in Randolph, Tallapoosa, northwest Macon, Lee, Chambers, and other counties.
Quartz (2)	Sand	Near Claiborne, Monroe county, a fire material.
Siderite	Spathic iron ore, carbonate of iron.	T. 9, R. 10 W., Winston county, also in Jefferson and Walker counties, not utilized.
Siderite (2)	Black band ore	Newcastle station and Warrior station, in Jefferson county, in Coal Measures.
	Slate (for roofing)	T. 21, R. 3 E., in Talladega county; Buxahatchee creek, in Shelby county; and in T. 19, R. 7 E., Clay county. No quarries working.
Sphalerite	Zincblende	Wood's copper mine, Cleburne county.

ARKANSAS.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Cerargyrite	Horn silver	Gray Eagle, Montezuma, and other mines, Mount Ida mining district, Montgomery county, associated with tetrahedrite, argentiferous galena, blende, copper pyrites, &c.
Coal	Coal	Coal field has its eastern end in White county; runs thence west in a narrower belt to Indian Territory (semi-anthracite—principal mines: Ouita, Pope county; Fort Smith, Sebastian county; and Spadra, Horsehead, and Coal Hill, Johnson county); Johnson county coal used at Saint Louis. Conway county (semi-bituminous); Crawford county; Franklin county; Johnson county (semi-anthracite). Principal mines: Spadra, Horsehead, Coal Hill); Madison county: Perry county; Pope county (semi-bituminous); Scott county; Sebastian county (mostly "Jenny Lind"); Van Buren county; Washington county; White county; Yell county.
Galenite	Galena	Near Hot Springs, Hot Springs county, mines lately opened; Saline county; Kellogg mine, Pulaski county, worked in 1862, lately reopened and worked for silver lead; Silver City, Mount Ida mining district, Montgomery county. Many mines recently opened in T. 25, R. 23 and 24 W.; Carroll county; Lawrence county; Marion county (argentiferous in one locality); Montgomery county; Newton county; Searcy county (argentiferous); Sevier county (with antimony ores).
Gold	Gold	Silver City, Montgomery county, in quartz.
Lignite	Lignite, brown coal	Ashley county; Bradley county; Dallas county; Greene county; Ouachita county (Camden coal mine); Pike county; Saline county; Union county.
	Limestone	Black, for ornamental inside uses, Independence county. Oölitic limestone near Batesville takes good polish.
	Marble	Carroll county; Newton county; Searcy county; Marion county; Van Buren county. In Marion county, encrinital limestone of Devonian age.

ARKANSAS—Continued.

Mineralogical name.	Common name.	Remarks.
	Marl	Calcareous and shell marls of Tertiary age in Greene, Pulaski, Clark, Hempstead, Pike, Jefferson, and Madison counties. Gypseous marls in Greene and Pike counties.
	Millstone, buhrstone	Independence county; Izard county; Lawrence county.
Novaculite	Oilstone	Several localities in Pulaski county; in Hot Springs county known as "Ouachita oilstone," at Whetstone mountain.
	Silver	[See under Galenite, Tetrahedrite, Stibnite, Cerargyrite.]
Tetrahedrite	Fahlerz	Kellogg mine, 10 miles north of Little Rock, Pulaski county, with argentiferous galena and blende; Silver City, Mount Ida mining district, T. 25, R. 23 and 24 W. Montgomery county, several mines lately opened. Ores: argentiferous galena, blende, copper pyrites, silver chlorides, &c.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Azurite	Blue carbonate of copper.	Sevier county.
Brookite, arkansite.	Titanic acid	Magnet cove, Hot springs county.
Calamine	Silicate of zinc	Wood's mine, Marion county; Calamine and Powhatan, Lawrence county; Kellogg mine, Pulaski county; Bellale mine, Sevier county.
Chalcopyrite	Copper pyrites	With galena, Pulaski county; Sevier county; Hot Springs county; Marion county; Mount Ida mining district silver mines, Montgomery county.
	Fire-clay	Sebastian county.
Granite	Granite	Fourche cove, Pulaski county.
Gypsum	Gypsum	Greene county, in clay on Little Missouri; Pike county.
Halite	Rock salt	Dallas county; Hot Springs county.
Hematite	Iron ore	Lafferty creek, Independence county
Hydrozincite (marionite).	Earthy calamine	Lawrence county; Marion county.
Jamesonite	Gray antimony ore	Antimony Bluff mine, Sevier county.
Kaolinite	Kaolin	Pulaski county.
Limonite	Brown hematite, iron ore.	Carroll county; Fulton county; Lawrence county; Ouachita county; Pulaski county; Randolph county; Saline county; Washington county; White county.
Limonite (2)	Yellow ocher	Greene county.
Magnetite	Magnetic iron ore	Hot Springs county; abounds on surface as loadstone.
Malachite	Green carbonate of copper.	Sevier county.
Niter	Saltpeter	Marion county; Newton county. In caves.
	Potter's clay	Greene county.
Psilomelane	Manganese ore	Independence county, in sub-Carboniferous limestone; Lawrence county.
Pyrite	Iron pyrites	Hot Springs county; vein four yards wide; Kellogg mine, Pulaski county.
Pyrolusite	Gray oxide of manganese.	Pope county; Pulaski county.
Quartz	Rock crystal	Crystal mountain, Montgomery county.

ARKANSAS—Continued.

Mineralogical name.	Common name.	Remarks.
	Sandstone	Franklin county; Searcy county; Van Buren county.
Serpentine	Serpentine	Saline county.
Siderite	Spathic iron ore	Franklin county, thin beds with shales alternating; Madison county; Pope county; Washington county, in black shales; sub-Carboniferous; White county; Van Buren county.
	Slate	Sevier county.
Smithsonite	Carbonate of zinc	In interstices in magnesian limestone at Calamine, Lawrence county, and Bath and Koch mines, same locality. Associated with blende, Wood's mine, Marion county.
Sphalerite	Zinc blende	With calamine and smithsonite in magnesian limestone, Lawrence county; occurs also at Bath and Koch mines, same county. Exposed in openings and in magnesian limestone, Wood's mine, Marion county; Kellogg mine, Pulaski county; Bellale mine, Sevier county; Silver City, Montgomery county; Sharp county; Boone county.
Stibnite	Gray antimony ore, sulphide of antimony.	Several localities in Sevier county; with ocher and jamesonite at Antimony Bluff mine; with jamesonite and galena ores occurs traversing sandstone, Pike county.
Wad	Bog manganese	North fork, White river, Izard county.
Zincite	Zinc oxide	Lawrence county.

CONNECTICUT.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Feldspar	Feldspar	Southeast part of Middletown, Middlesex county, in a granite range; Glastenbury, continuation of vein.
	Flagging stone	Bolton, Tolland county, mica slates noted for their excellence.
Granite	Granite	Plymouth, Litchfield county; North Groton, New London county; Portersville; upper Mystic; Bridgeport, Fairfield county; Derby, New Haven county; Chatham, Middlesex county, syenitic granite.
Limonite	Brown hematite	Ore Hill, Salisbury, Litchfield county; Chatfield ore bed near Salisbury; Indian Pond ore bed, Sharon, Litchfield county; Davis ore bed, Salisbury; Chapin mine, near Chapinville, Litchfield county; Kent ore bed, Kent, Litchfield county; Scoville ore bed, Salisbury; extensive beds and worked steadily, yielding a superior ore.
	Marble	New Preston, Litchfield county, dolomitic limestone; Milford, New Haven county.
Sandstone	Sandstone	Chatham, Middlesex county, celebrated quarries; Farmington, Hartford county; North Haven, New Haven county.
	Trap rock	Rocky Hill, Hartford county; East Rock, New Haven county; West Rock, New Haven county.

Ores, minerals, and mineral substances of industrial importance, and known occurrence, but which are not at present mined.

Apatite	Phosphate of lime	Haddam; Litchfield.
Arsenopyrite	Mispickel, arsenical pyrites.	Derby; New Haven county, in quartzose gneiss; Lane's mine, Monroe, Fairfield county; Wilton lead mine, Fairfield county; and Bethany, New Haven county.
Agate	Agate	Farmington, East Haven, and Woodbury.
Barite	Heavy spar	Cheshire, New Haven county; in sandstone.
Beryl	Beryl	Haddam.
Bismuth (native).	Bismuth	Monroe, Fairfield county; disseminated through quartz in small quantities.

CONNECTICUT—Continued.

Mineralogical name.	Common name.	Remarks.
Bornite	Variegated copper ore, purple copper ore.	Granby, Hartford county; Wolcottville, Litchfield county; with chalcocite and malachite, Bristol copper mine, Hartford county; associated with chalcocite; Rocky Hill quarry, Hartford county; in veins of quartz in trap-rock.
Calamine	Silicate of zinc	Brookfield, Fairfield county; in white limestone with galena and blende.
Cassiterite	Tin ore, tinstone	Haddam, very small vein.
Chalcocite	Vitreous copper	Simsbury mines, Hartford county; occurs with variegated copper and malachite in gray sandstone; southeast part of Cheshire, New Haven county, with barite in sandstone; Wolcottville, Litchfield county, with bornite and malachite; Bristol copper mine, with bornite and chalcopyrite, once extensively worked.
Chalcopyrite	Copper pyrites	Bristol copper mine; Trumbull, Fairfield county, in topaz mine with pyrite, also galena and blende; in chloritic slate of Orange, New Haven county, with pyrite; Litchfield, with pyrrhotite; Mine Hill, Roxbury, Litchfield county; Middletown lead mines, Middlesex county; West Haven, New Haven county.
Corundum	Emery	West Farms, near Litchfield.
	Clay	West of New Milford, Litchfield county, resulting from disintegration of gneiss, also a fire-clay; south part of Kent, Litchfield county, disintegrated graphitic gneiss vein; southeast part of Cornwall, Litchfield county, less pure than others; northwest part of Granby, Hartford county; small deposit.
Galenite	Galena	Middletown, Middlesex county; thin seam in quartz in mica slate; Brookfield, Fairfield county, disseminated through dolomite; Lane's mine, Monroe, Fairfield county, disseminated through quartz (argentiferous); Cobalt mine, Chatham, Middlesex county, and other localities of occurrence in minute quantities.
Garnet	Garnet	Middletown.
Graphite	Plumbago, black lead.	Northwest corner of Ashford, bed in gneiss; west part of Cornwall, Litchfield county, disseminated through rock.
	Hydraulic limestone	Near Berlin in Southington, Hartford county, in thin strata, compact, earthy, and somewhat bituminous; Northford, a gray limestone.
Limonite	Brown hematite, bog iron ore.	Stafford, Tolland county, mostly exhausted; Hebron, Tolland county; Colchester, New London county; and other localities in Tolland, Windham, and New London counties; mainly in towns of Union, Woodstock, Willington, and Tolland.
Magnetite	Magnetic iron ore	New Preston, Litchfield county, occurs with pyrite; Buck's, Mount Sharon, Litchfield county; Reading, Fairfield county, ore in seams traversing quartz; Newtown, Fairfield county, thin seams in quartz and in gneiss; Winchester, Litchfield county, thin stratum in gneiss.
Malachite	Green carbonate of copper.	Simsbury mine, Granby, Hartford county, with bornite and chalcocite; Bristol copper mine, Hartford county; with bornite and chalcocite; West Haven, occurrence; Rocky Hill, Hartford county; Manchester, Hartford county, worked at intervals.
Molybdenite	Sulphide of molybdenum.	Haddam, gneiss quarries.
Niccolite	Copper-nickel	Chatham, Middlesex county; associated with smaltite.
Pyrite	Pyrites, iron pyrites	Brimstone Ledge, North Madison, New Haven county; Newtown, Fairfield county, in mica schist; Winchester, Litchfield county; Windsor, Hartford county, in slate; other localities, but all in small quantities.
Pyrrhotite	Magnetic pyrites	Trumbull, Fairfield county, in a vein with pyrites, fluorite, &c., cutting micaceous limestone; New Fairfield, Fairfield county, on gneiss; Litchfield, occurs with chalcopyrite in hornblendic rock; other localities also in Fairfield county, but inconsiderable in amounts.

CONNECTICUT—Continued.

Mineralogical name.	Common name.	Remarks.
Quartz	Glass sand	On shore of Quasipaug pond, Middletown, very fine quartz; Eastfield, fine-grained, but not so pure as above.
Rutile		Plymouth, Litchfield county, occurrence; Granby, Hartford county, occurrence; North Greenwich, Fairfield county; Monroe, Fairfield county, in mica slate.
Siderite	Spathic iron ore, carbonate ore.	Mine Hill, west bank of Shepaug river, Roxbury, Litchfield county; in a vein of white quartz traversing gneiss.
Smaltite	Gray cobalt ore	Chatham cobalt mine, Middlesex county; disseminated in a bed in mica slate, and thin seam; accompanied by galenite, sphalerite, and niccolite.
Sphalerite	Zincblende	Middletown, Middlesex county, in a galena vein; Brookfield, Fairfield county, with galenite in dolomite; Chatham cobalt mine, Middlesex county; Lane's mine, Monroe, Fairfield county, with galenite; Kensington; Bethany.
Talc	Steatite, soapstone	Somers, in talc slate in gneiss; Bristol.
Topaz	Topaz	Trumbull.
Uraninite	Pitchblende	Middletown, feldspar quarry, Middlesex county.

DELAWARE.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	"Blue rock"	Churchman's quarry on Christiana creek; Clyde's quarry on Brandywine creek; Quarryville quarries, northeast of Brandywine quarries; quarries on Naaman's creek; Shell Rot Hill, northeast of Wilmington; Gilpin's mills on Brandywine, all in New Castle county. This rock is used as building stone.
Clay	Clay	Red clay, three miles south of New Castle on Delaware, New Castle county; white clay (pipeclay), below New Castle, New Castle county; red clay, in Red Lion Hundred and Pincader, New Castle county; Little creek, two miles south of Laurel, New Castle county; northwest of Georgetown, Sussex county; Mispillion creek, near Milford, Sussex county; Ponder's mill on Prime Hook creek, Sussex county; Milton, Sussex county.
Feldspar	Feldspar	"Spar" quarries; Tucker's quarry, northwest of Wilmington, New Castle county. Also Hokessin pits, New Castle county.
Limonite	Brown hematite, bog iron ore.	Iron hill, near White Clay creek, New Castle county. Extensively quarried for supply of Maryland furnaces. Chestnut Hill pits, near Newark, New Castle county; large open pits now worked. Little creek, two miles south of Laurel, Sussex county; near Georgetown (northwest), Sussex county; Collin's ore bed on Green Meadow branch of Deep creek, Sussex county; Green branch, ten miles west of Millsborough, Sussex county; Burton's branch, one mile west of Burton, Sussex county.
Marls	Marls	[See under head of Greensand.]
Greensand	Greensand marl	Saint George's Hundred, Saint George's; Middletown, three miles west, on Bohemia creek at head of tidewater; Cantrell's bridge, north side of Appoquinimink; Silver run; Dwyer's run; Noxentown branch of Appoquinimink; Port Penn; Latman's mill on branch of Dwyer's creek; Scott's run. All in New Castle county.
Kaolin	Porcelain clay	Hokessin, New Castle county. Extensive pits where kaolin of superior quality is dug. A disintegrated feldspathic rock.
Limestone	Limestone	Jeane's, on Pike creek, New Castle county; Klair's, two miles west of Centreville, New Castle county; Bullock's, on Brandywine, near Pennsylvania line, New Castle county.

DELAWARE—Continued.

Ores, minerals, and mineral substances of industrial importance, and of known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Asbestus	Asbestus	Feldspar quarries, northwest of Wilmington, New Castle county.
Serpentine	Serpentine	Six miles northwest of Wilmington, New Castle county.
Succinite	Amber	Near Chesapeake and Delaware canal, Kent county.

FLORIDA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Limestone	Coquina stone	Saint Augustine quarries; for building stone.

Ores, minerals, and mineral substances of industrial importance, and known occurrence, but which are not at present mined.

Lignite	Brown coal	On Suwannee river, once worked for fuel.
Limestone	Limestone	Fort Brooke, head of Tampa bay; Manatee river, Manatee county; Charlotte harbor; Jackson county, Campbelltown to Marianna; Saint Mark's, Wakulla county; Ocala and Silver spring, Marion county; Rock spring, Orange county; Alachua county; Dade county (coral rock); Hernando county; Hillsborough county; Leon county; Marion county; and many additional localities.
	Marl	Fort Brooke, head of Tampa bay; near mouth of Manatee river, Manatee county.
	Phosphate rock	Clay county; Alachua county; between Wakulla and Saint Mark's river, Wakulla county; Duval county; Gadsden county, undeveloped and of uncertain extent.

GEORGIA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Buhrstone, millstone	Early, Burke, Screven, Bullock, and Jefferson counties.
Chalcocite	Vitreous copper, copper glance.	Canton mine, Cherokee county; other localities with chalcopyrite.
Chalcopyrite	Pyritous copper ore, yellow copper ore, copper pyrites.	Canton mine, Cherokee county; other localities in Lumpkin, Fannin, Towns, Fulton, Carroll, Murray, Paulding, Haralson, Greene, and Lincoln counties.
Coal	Coal	Bituminous coal. Dade county, on west brow of Lookout mountain; Coal Measures, in Chattooga county and in Walker county.
Gold	Gold	Auriferous district occupies one-third of State from North Carolina and Tennessee southwest and west to Alabama, occupying a large number of counties. Deep mines and placers, worked chiefly in Rabun, Lumpkin, Dawson, White, Hall, and Union counties. The mining centers are at Dahlonega and vicinity, and about Auraria, in Lumpkin county. A third district is on east side of State, in McDuffie, Lincoln, and Wilkes counties. Gold occurs in quartz seams and veins, which traverse micaceous, talcose, chloritic, and hornblendic schists. The soils, disintegrated rocks and gravels, and sands also, are gold-bearing over wide areas.
Hematite	Red hematite, fossil ore.	Lookout mountain, Dade county, a continuous stratum one to three feet thick; McLemore's cove, Dade county; Iron Ridge, Walker county; Whitfield and Floyd counties,

GEORGIA—Continued.

Mineralogical name.	Common name.	Remarks.
Hematite	Specular iron ore	Allatoona hills, along Etowah river, Cherokee county, extensive deposits; valley of Etowah river, in Cass, Floyd, Murray, and Paulding counties.
Limonite	Brown hematite	Mine of Cherokee iron works, five miles east of Cedarstown, Polk county, very extensive bed; Ætna iron works ore bank, Ætna, Polk county; ore banks of Ridge valley iron works, Floyd county; Hall's station banks and Barton iron works, Floyd county; Peach-tree bank, Barton county; iron ore reported also in Fannin, Gilmer, Whitfield, Catoosa, Gordon, Haralson, Milton, Hall, Habersham, White, Jackson, and Walker counties, in northwest and north part of State; in Greene, McDuffie, and Burke, in central belt.
	Marble	Near Van Wert, Polk county, white; Fannin, Gilmer, Whitfield, Floyd, Richmond, Walker, Catoosa, and Chatooga counties, all in northwest part of State.
	Marl	Bibb, Chattahoochee, Stewart, Quitman, Thomas, Randolph, Clay, Crawford, Washington, Houston, Pulaski, Charlton, Burke, Screven, Effingham, Chatham, Bullock, Emanuel, and Jefferson counties. These counties occupy central and southern parts of State. Marls have limited use in immediate vicinity of diggings.
Muscovite	Mica	Warren, Pickens county; Heard, Cherokee, Gwinnett, Towns, and Carroll counties.
	Slate (roofing)	Gentry's quarry, near Van Wert, Polk county; Rockmart, Polk county; Gordon and Barton counties.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Amethyst	Amethyst	Rabun, Cobb, and Oglethorpe counties.
Arsenopyrite	Mispickel	Canton mine, Cherokee county.
Asbestus	Asbestus	Rabun, Fulton, Towns, Habersham, De Kalb, Paulding, and Troup counties.
Barite	Barytes, heavy spar	Near Allatoona, Barton county, extensive bed; Murray and Barton counties.
Corundum	Emery	Rabun, Towns, and Union counties.
Covellite	Indigo copper	Canton mine, Cherokee county, with chalcopyrite and chalcocite.
Diamond	Diamond	White and Hall counties. Only few finds thus far.
Galenite	Galena, sulphide of lead.	Harris mine, Hall county, argentiferous galena with pyrite; Cohutta mountains; Murray, Floyd, Lincoln, Habersham, Hall, and Union counties.
Garnet	Garnet	Turner's mill, Paulding county.
Granite	Granite	Stone mountain; Gwinnett, De Kalb, Heard, Oglethorpe, Clarke, Muscogee, Columbia, Richmond, and Wilkes counties.
Graphite	Plumbago, black lead	Pickens and Carroll counties (specimens); Habersham, Cherokee, Carroll, Clarke, Elbert, and Hart counties.
Itacolumite	Flexible sandstone	Hall county.
Kaolinite	Kaolin, porcelain clay.	Cherokee, Pickens, Heard, McDuffie, Columbia, and Richmond counties.
Magnetite	Magnetic iron ore	Near Rome, Floyd county, near Villa Rica, Carroll county, no well-defined vein; Lumpkin and Carroll counties.
	Manganese ore	Towns, Lincoln, and Barton counties. In latter has been mined for use in manufacture of ferro-manganese.
Molybdenite	Sulphide of molybdenum.	Heard county.

GEORGIA—Continued.

Mineralogical name.	Common name.	Remarks.
Novaculite	Oilstone	McDuffie, Oglethorpe, and Lincoln counties.
Opal	Opal (fire-opal)	Fire-opal, Washington county; good specimens as gems; Bullock county; hyalite in Burke and Screven counties.
Pyrite	Pyrites, iron pyrites	Fulton and Carroll counties.
Sapphire	Sapphire	Blue sapphires have been found on Sequale creek.
Serpentine	Serpentine	Rabun, Towns, and Union counties.
Silver, native	Silver	Union, Hall, and Murray counties.
Talc	Steatite, soapstone	Dalton, Whitfield county; Cobb, Union, Fannin, Gilmer, Hall, Habersham, White, De Kalb, Fulton, Murray, Jasper, Paulding, Elbert, and Clayton counties.
Tetradymite	Tellur-bismuth	Polk, Lumpkin, Paulding, and Cherokee counties.
Tripolite	Infusorial earth	Murray, Whitfield, and Lincoln counties.

ILLINOIS.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal, var. bituminous.	Coal, bituminous coal.	Coal Measures occupy three-fourths of area of State, from La Salle southward to Ohio river. Aggregate thickness, 1,400 feet. The coal seams are all above the conglomerate, excepting in extreme southern part of State. There are six or seven seams each from 6 inches to 3 feet thick in the Upper Measures; and Nos. 1 to 9 each from 6 inches to 9 feet thick in the Lower Measures. The principal mining localities are: Murphysborough and Carbondale, Jackson county (some block coal); Belleville seam, in southeast part of Randolph county; Du Quoin mines, Perry county; the Belleville district, in Saint Clair county, at Caseyville and other points; Exeter coal seam, near Alton, Madison county; Neeleysville, Scott county; Howlett and Pleasant Plains, Sangamon and Gallatin counties; Macon county; Colchester, McDonough county; Danville, Vermilion County; Cuba, Fulton county; Peoria county, along Illinois river; Bloomington, McLean county; Kewanee, Cleveland, and Galia, in Henry county; Coal valley mines, Rock Island county; La Salle and Streator, La Salle county; Morris, Grundy county, and Wilmington, Will county.
	Clay	Anna, Union county [see under Fire-clay also]; Golconda, Pope county, a superior porcelain clay.
	Fire-clay	In Coal Measures, under coal seams. Under coal 1 A, Madison county; Wolf's Run coal mines, a thick bed; Winchester, Scott county, under Exeter coal seam, and 3 feet to 12 feet thick; near Lowell, La Salle county, used largely for pottery; Ripley and La Grange, Brown county; near Rushville, Schuyler county; Avon, Fulton county; Rock Island county; Colchester, McDonough county, used for firebrick, &c. Generally the clay under seam No. 1 is most refractory.
	Flagging stone	Alton, Madison county; Thebes, Alexander county (known as "Thebes sandstone"); Joliet, Twelve-mile Grove, and Wallingford, in Will county; Columbia and Monroe, in Monroe county, a blue limestone extensively quarried; Fairfield, Wayne county; in Wabash, White, and Hamilton counties, a sandstone in Coal Measures.
Galenite	Galena, lead ore	Upper Mississippi lead district, in northwest part of State, in Jo Daviess and Stephenson counties, an area of about 700 square miles. Principal groups of "diggings" are: Galena and vicinity, Vinegar Hill, Council Hill, Apple River, Elizabeth, and Warren. Ore occurs in vertical crevices and in flat sheets in Galena limestone. Rosiclare lead mines and Lead Hill mines, Hardin county; galena with fluorspar, and at Rosiclare with blende, also, in Saint Louis limestone—argentiferous. Pope county, several localities, accompanied by fluorite, but in small quantities. Southwest part of Jackson county, in very small pockets, in cherty limestone.

ILLINOIS—Continued.

Mineralogical name.	Common name.	Remarks.
Halite	Common salt, brines	Near Equality, Gallatin county, salt made from brines. Salt formerly made in large quantity from brines, Brownsville, Jackson county; Central City, Marion county; Salt and Middle Forks, Vermilion county; and on Saline river, near Harrisburg, Saline county.
	Hydraulic limestone, cement rock.	Southwest corner of Saint Clair county, from limestone at base of Saint Louis group; Piasa creek, Madison county; bluffs of Piasa creek, Jersey county, lower part of Saint Louis limestone; Utica, La Salle county; beds in calciferous limestone.
	Limestone	The limestone formations furnish stone at many localities. Following are more prominent: Randolph county; Madison county; Nauvoo, Hancock county; Warsaw, Hancock county; Rosiclare limestone, Hardin county; Thebes, Alexander county; near Jonesboro and Anna, Union county, (Saint Louis limestone); Bald rock quarries, Jackson county; Grafton quarries, Jersey county, in the Niagara limestone; Jerseyville, Jersey county (Burlington limestone); near Carrollton, Greene county; La Salle, La Salle county, in Trenton beds; Athens, Cook county, known as "Athens marble"; Lemonte, also in Cook county, "Lemonte marble" (these are largely used in Chicago); Quincy, Adams county, large quarries in Burlington limestone; Batavia and Aurora, in Kane county, quarries in horizon of Niagara limestone; Saratoga, Grundy county, also in Trenton; Will county quarries largely worked in the Niagara limestone at Joliet, Lockport, and Wallingford (stone known as "Joliet marble"); Sagetown, Henderson county; Cedar creek, Warren county; Dunleith, Jo Daviess county; Freeport, Stephenson county; Savannah, Carroll county; Harlem and Cherry valley, in Winnebago county; Buffalo creek, Ogle county; Big Springs and Franklin, Lee county; Sterling, Whiteside county. Many other points for local use.
Quartz	Sand, glass sand	La Salle county, Saint Peter's sandstone is quarried for glass manufacture at La Salle, Peru, and Ottawa; Rock river, Ogle county and Lee county; Cap au Gres bluff, Calhoun county.
	Sandstone	T. 1 N. R. W., Saint Clair county; Drury creek, Jackson county; Greenbush and Berwick, Warren county; Andalusia, Rock Island county; along Kickapoo river, Peoria county; west of Springfield, Sangamon county; Xenia, Clay county; all in sandstones of Coal Measures or in conglomerate sandstones. Many other localities for limited use.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asphaltum	Bitumen	Western limits of Chicago and elsewhere in Niagara limestone, in small quantities. Carroll county, in black shales of Cincinnati group.
Cerussite	Carbonate of lead, white lead ore.	Upper Mississippi lead region, with galena; rare.
Chalcopyrite	Copper pyrites	Rosiclare lead mines, Hardin county, with fluorspar and galena.
Copper, native	Copper	On drift in northern counties, more rare at south.
Fluorite	Fluorspar	Rosiclare lead mines, Hardin county, large quantities with galena; Lead hill, same county; several places in eastern part of Pope county.
Gold	Gold	Vermilion county, in drift gravel.
Hematite	Hematite, red iron ore	Cooper's quarry in Jersey county, thin bed; Whitaker's creek, Greene county.
Lignite	Wood coal, brown coal	Pulaski county; Alexander county, thin seams, Tertiary.

ILLINOIS—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite	Brown hematite	Several localities in Hardin county, formerly worked for supply of local furnaces; Iron mountain, Union county; near Avon and Utica in Fulton county, thin beds; Marsden lead mine, Galena, with lead ore in small quantities.
	Marl	T. 38, R. 12. Cook county. A freshwater shell deposit.
Niter	Niter, saltpeter	In caves, Jackson county, and on Cave creek.
	Peat	Cook county, several localities; west of Utica, La Salle county; Carpenterville, Rutland, and Hampshire, in Kane county; McHenry and Lake counties; Florence, Stephenson county; Boone township, Boone county; Monroe, Ogle county; Lee county; Cat-tail slough, in Whiteside county, very large body.
Petroleum	Petroleum	Near Chicago, in Cook county, in cavities in Niagara limestone, but not of economic importance.
Pyrite	Pyrites, iron pyrites	In lead region of Jo Daviess and Stephenson counties.
Silver	Silver	Traces in galena, upper Mississippi lead region; also in galena of Hardin county mines.
Siderite	Carbonate of iron, kidney ore, clay limestone.	Seller's landing, Hardin county; Sugar creek, T. 2, R. 1 E, Schuyler county; near Palestine, Crawford county; T. 1 S., R. 10 E., Edwards county; several localities in Wayne county; these and other localities in Coal Measures, beds thin, from 1 to 2 feet thick.
Smithsonite	Carbonate of zinc, "dry-bone."	Associated with galena and blende in lead mines, Jo Daviess county.
Sphalerite	Zincblende, "black-jack."	Jo Daviess and Stephenson counties, with galena in small quantities. On Little Vermilion river, Vermilion county; Rosiclare lead mines, Hardin county, with galena.

INDIANA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Coal, bituminous coal.	The coal field of this State has an area of 7,000 square miles, occupying Warren, Fountain, Vermilion, Parke, Vigo, Clay, Owen, Sullivan, Green, Daviess, Pike, Spencer, Perry, Vanderburgh, and Posey counties, in which many mines are opened, and others where less work has been done. The so-called "block coal" field occupies 600 square miles, stretching in a belt from 3 to 10 miles wide, from Warren county south to the Ohio river. It has been mined extensively at Brazil and Carbon city, Clay county; also in Vigo, Parke, Owen, and Spencer counties. Twelve coal seams are recognized in Indiana, and five are generally accessible, varying from 6 inches to 11 feet in thickness. The aggregate thickness of the eight block coal seams is 21 feet. Four are workable, varying from 1½ to 4 feet thick.
	Fire-clay	South Otter creek, Clay county; Brazil and vicinity, also in Clay county; used extensively for firebrick and pottery; Reelsville, Putnam county; Parke county, and in many other localities as bottom bed to coal seams in Coal Measures area.
	Flagging stone	Laurel, Franklin county, several quarries; Wabash and vicinity, Wabash county; near Paoli, Orange county; other localities for local use.
	Grindstone	French Lick quarries, Orange county. Widely used and known as "Hindostan stone"; Dishman's quarry, northwest part of Orange county.
Halite	Common salt, brines	Coal creek, Fountain county; salt made on small scale from brines; Salt creek, Franklin county; near Hartford, Vigo county; Ott and Benham wells, Crawford county; Salt Lick, near Hartford, Dearborn county; Lodi, Fountain county, in borings in sub-Carboniferous rocks; artesian well, Terre Haute, Vigo county; Reelsville, Putnam county; also bores in sub-Carboniferous rocks.

INDIANA—Continued.

Mineralogical name.	Common name.	Remarks.
	Hydraulic limestone, cement rock.	On Ohio river and Silver creek, in Clarke county. Hydraulic limestone is extensively quarried at Cementville, Clarksburg, and Sellersburg. Brown's landing, Cedar grove, and Briggs' farm, in Harrison county, a bituminous, shaly limestone; Somerset, Wabash county.
Kaolinite [Indianite in part].	Kaolin....	Huron, Lawrence county; a very pure clay, widely used; Shoals, Martin county.
	Limestone	Magnesian limestone (Upper Silurian) is quarried at many points in a belt extending from the Ohio across the State to the Wabash, in Huntington, Wabash, Miami, Cass, and Carroll counties. The oölitic limestone (Saint Louis group) is largely quarried in Lawrence, Monroe, and Owen counties. Principal localities of quarries are: Ellettsville and Stinesville and Bloomington, in Monroe county: Spencer, in Owen county; Bedford and vicinity, Lawrence county, a gray, oölitic stone, and large quarries; Wabash, Wabash county; Logansport, Cass county; Kokoma, Howard county; Eaton, Delaware county; Anderson, Madison county; Greencastle and Ocala, in Putnam county; Longwood, Fayette county; Laurel and vicinity, Franklin county; New Point and Saint Paul, Decatur county; Fort Ritner, Jackson county; North Vernon, Jennings county; Osgood, Ripley county; Salem, Washington county; New Albany, Floyd county; King's cave quarry and Mauckport, Harrison county; T. 4, R. 2 E., Jackson county; Bennington, Switzerland county; Saint Leon and Weisburg, Dearborn county.
	Ocher.................	Patterson, near Salisbury, Greene county; Alfordsville, Daviess county.
	Peat	Beds of great extent in Elkhart, Noble, Steuben, and other counties; not used as fuel.
Quartz.........	Sand, glass sand	De Pauw's and other localities along Ohio river, Harrison county; knobs on line of Floyd and Clarke counties. These localities supply large works at New Albany.
Quartz (2)......	Ganister	Knightsville, Clay county.
	Sandstone	Chester sandstones (sub-Carboniferous) well developed in Warren county, and thence in a belt traceable to Ohio river. Quarries at Williamsport and Attica in Warren county; French Lick and Paoli, in Orange county; East Cannel-town, Perry county; TT. 7 and 6, R. 4 W., Greene county; near Attica and Portland, in Fountain county. Some of these quarries are actively worked and furnish large amounts of stone.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Copper, native .	Copper	In drift, very sparingly and rare.
Gold, native ...	Gold..................	Northeast corner of Brown county, in drift, once worked. Also found in Franklin, Warren, and Pike counties, but in minute quantities.
Limonite	Brown hematite	Clay county, at base of millstone grit, thin bed; Greene county; Eugene, Vermilion county; many places in Martin county; Fayetteville, Lawrence county; thin beds at all these.
Limonite (2) ...	Bog iron ore	T. 10, R. 6 W., Clay county; Norton's creek and Helton's prairie, Vermilion county; several localities in Daviess county; Laporte and Saint Joseph counties; Ore prairie, Noble county; Jasper county.
Pyrite	Pyrites	Disseminated through some strata of Coal Measures along Silver creek, in Clarke county. Elsewhere common in small quantity.

INDIANA—Continued.

Mineralogical name.	Common name.	Remarks.
Siderite........	Carbonate of iron, clay iron-stone.	Eaglesfield, Putnam county, formerly mined; Parke county; Coal creek and on Wabash river, in Fountain county; Brouillet's creek, Vermilion county; Browntown branch, same county, beds 18 inches to 3 feet thick; Henryville, Clarke county; Vienna and Finley townships, Scott county, very lean, but manganiferous ores; sixteen beds, each 10 inches, down to 2½ inches, thick, separated by shaly strata 2 to 3 feet thick; in Vigo county; White county. Some of these beds were formerly worked.
	Marls..................	Rome city, Noble county; Lake James, Steuben county, and other localities in northern part of State.
Niter	Saltpeter, niter........	Caves in Harrison and Crawford counties.
Petroleum	Petroleum, rock oil....	Borings and oil wells. Terre Haute, small product temporarily; several localities in Crawford county in sufficient flow to be productive; Anderson creek and Oil Creek, Perry county, wells, little oil obtained; Rensselaer, Jasper county, oil in crevices in rocks; wells unsuccessful; Parke county, several localities.
Sphalerite	Zincblende.	In Coal Measures sparingly, along Little Vermilion river, Vermilion county.
Tripolite.......	Infusorial earth.......	Ferdinand, in Dubois county, in cavities in limestone.

INDIAN TERRITORY.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal	Coal, bituminous coal.	Valuable mines at McAlister.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

	Copper ore............	Wichita mountains, southwest part of Territory.
Gold?..........	Gold?..................	Do.
	Granite	Ozark hills, in eastern part.
Coal, var. lignite	Lignite	In Cretaceous formation near Red river, southeast part of Territory.

IOWA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal, var. bituminous.	Coal, bituminous coal.	The Iowa coal field occupies about one-third of the State at southwest, and an area of 7,000 square miles. The Lower Coal Measures, or coal-producing territory, occupies a belt 175 miles long and 50 miles broad, which is traversed by the Des Moines river. Thickness, 200 feet. The principal mining localities are in Lee county; Hillsborough and Farmington, in Van Buren county; mines in Henry county; Coveport and Fairfield, in Jefferson county; Ottumwa, in Wapello county; Oskaloosa, in Mahaska county; Pella and Otley, in Marion county; in Warren county; Des Moines, Polk county; Newton, Jasper county; Boonesborough and Moingorra, Boone county; Hamilton county; Fort Dodge, Webster county; Eldora, Hardin county; Muscatine and Davenport, in outlying patches, in Scott and Muscatine counties; Nodoway county, thin seams for local use.
	Fire-clay	Danville, Des Moines county; True Blood and Hyatt's Mill, Henry county; Portland and Cedar creek, in Van Buren county; Jefferson and Wapello counties.

IOWA—Continued.

Mineralogical name.	Common name.	Remarks.
	Flagging-stone	Denmark, Lee county, limestone.
Galenite	Galena, sulphide of lead.	Lead district near Mississippi river, northeast part of State, area of about 700 square miles. Valley Tetedes Morts diggings, Dubuque county (abandoned); vicinity of Dubuque, from Catfish creek to Little Makoqueta river, a belt three to four miles wide, area 15 square miles, has been very productive in many diggings; Buena Vista diggings, Clayton county; Benebalt creek, Clayton county; Gutenberg on Mississippi and on Miners' creek; Mineral creek and near New Galena, Alamakee county. In lower magnesian limestone.
Hydraulic limestone.	Water-lime, cement rock.	Buff beds at base of Trenton used for hydraulic limes; other magnesian limestone also used.
Limestone	Limestone	Prairie du Chien on Mississippi river; near Wakon, Alamakee county; Dubuque, quarries in galena limestone; Makoqueta, Jackson county, extensive quarries in the magnesian limestone (Niagara); Des Moines county, quarries in limestone of Carboniferous age known as Burlington limestone; the Keokuk limestone (Carboniferous age) is also extensively quarried near asylum, Mount Pleasant, Henry county; Lee county, on Mississippi (Keokuk limestone), Des Moines, Van Buren, Wapello counties; Iowa City, Johnson county, quarries in limestone of Hamilton group; Guttenberg, Clayton county, Trenton limestone is extensively quarried; Le Clare, Scott county, limestone, magnesian.
	Marble	Chequest creek; Van Buren county. Known as Chequest marble, white.
Sphalerite	Zincblende, "black-jack."	In lead district, Dubuque and Clayton counties, associated with galena in flat crevices and fissures in Galena limestone; near Fairfield, Marion county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Anglesite	Sulphate of lead	In small quantities only, with galena.
Barite	Barytes, heavy spar	Accompanies galena; frequently in galena limestone.
Cerussite	White lead ore, carbonate of lead.	Rare in lead region, associated with galena.
	Fire-clay	Occurs in Coal Measures in southwest counties.
Gypsum	Gypsum	Near Fort Dodge, on Des Moines river, Webster county, thick beds of great extent.
Limonite	Brown hematite	Jackson county, not in workable amount; Clinton county, numerous localities in Niagara limestone, but not of economical importance; on Skunk river, Henry county, a lean ore.
Smithsonite	Carbonate of zinc, "dry-bone."	Common in lead region with blende in small quantity; on Little Makoqueta river, Dubuque county, in quantity.

KANSAS.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Calamine	Silicate of zinc	Short creek lead mines, with galenite and blende worked for zinc.
Cerussite	Carbonate of lead	Short creek diggings, with galena and blende.
	Clay	Fire-clay in Coal Measures, Fort Scott, Bourbon county, under the coal; Lawrence, Douglas county; thence to near Leavenworth, Leavenworth county; Mill creek.

KANSAS—Continued.

Mineralogical name.	Common name.	Remarks.
Coal	Coal, bituminous coal.	Coal Measures in eastern part of State, 22,000 square miles. Twenty-two beds from few inches to 7 feet thick; lower beds thicker; southeastern part of the State, south of the Kansas and east of the Shawnee, has workable beds in nearly every county; aggregate thickness of beds exceeding one foot thick is 25 feet. This coal is of good quality, some of it very free from sulphur; it cakes and cokes well; beds crop out in Brown, Doniphan, Miami, Bourbon, Neosho, Woodson, Coffey, Osage, Shawnee, Jackson, Atchison, Leavenworth, Linn, Cherokee, Allen, Greenwood, Franklin, Douglas, Wabaunsee, and Nemaha counties; Upper Carboniferous in northeast part of State is worked for local supply in Jefferson, Brown, Doniphan, Atchison, Jackson, Leavenworth, and Shawnee counties, and perhaps others, not in quantity for market; three principal seams worked in Coal Measures area in southeastern part of State; one, Osage vein, Osage county, a good gas coal and cokes well, bed 15 to 20 inches thick; Fort Scott coal in Bourbon and Linn counties, near Missouri line, irregular in extent, a good gas coal, rarely 2 feet thick. Cherokee coal enters from Indian Territory across southeast part of Labette, Cherokee, and Crawford, or southeast corner of State, thence northwest into vicinity of Booneville; cokes well; good gas coal and more free from impurities than other beds; from 15 to 54 inches thick.
Galenite	Galena	Potosi, Linn county, in shales of Coal Measures in fissures in sandstone; Pleasanton, unsuccessful attempts at mining several years ago; Baxter Springs, same; Standley mines, many openings, worked at a loss to get ore in quantity; Short creek diggings, T. 34, R. 25 E., in chert conglomerate in cavities in clay, and as float ore with blende, worked for lead and zinc.
Gypsum	Gypsum	Quarried in places in Saline, Dickinson, and Marshall counties as a building material.
Halite	Common salt, brines	Extensive deposits in central part of State; Osawatomie, Miami county, several wells; near Hamlin, Brown county springs; Valley of Fall river, Greenwood county; Mound City, Linn county, brine in wells; Marmiton, brine in wells; Emporia, Lyon county; valleys of Fall and of Verdigris rivers, salt springs; State salt springs and other salt marshes in a belt of country crossing Republican, Solomon, and Saline valleys, 80 by 35 miles; rock salt, south of great bend of Arkansas River, in beds 6 to 28 inches deep; salt industries at Solomon city, Saline county; Junction City, Davis county.
Hydraulic limestone.	Water-lime, cement rock.	Magnesian limestones at Fort Scott; Lawrence; Leavenworth, to some extent hydraulic (works at Fort Scott), manufactured at Lawrence also; Atchison county.
Lignite	Brown coal	Extensive beds in the Tertiary strata, Smoky Hill Valley; beds of good brown coal over large part of western Kansas, range from 3 to 7 feet thick; few beds in Dakota (cretaceous) group, always of inferior quality; most important seam is traceable for 170 miles from north to southwest across the State, 10 to 40 inches thick, friable, much ash and in places much pyrite of cheap value in some localities; found in Washington, Republic, Cloud, Mitchell, Lincoln, Ottawa, Saline, Ellsworth, McPherson, Rice, and Barton, and perhaps other adjoining counties.
Limestone	Limestone	Near Lawrence, Douglas county; Manhattan, Atchison, Leavenworth, etc.; near Fort Scott, in Bourbon county, a fine black marble; dolomitic limestone, resembling marble, white, gray, and cream-colored, abounds in Triassic formation in valley of Blue, Republican, and Neosho rivers; Junction City, extensively used, soft and easily dressed.
Smithsonite	Carbonate of zinc, "dry bone."	Short creek (lead diggings), in small quantities with galena, blende, etc.
Sphalerite	Blende, "black jack".	Standley mines with galena, many openings unsuccessful; Short Creek diggings with galenite and cerussite, mines worked for lead and zinc, extension of Jophin creek zinc district.

KANSAS—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Gypsum	Plaster, gypsum	Inexhaustible beds in central part of State; deposits up to 50 feet thick crop out along the Blue, the Republican, the Kansas, and the Turkey creeks, and divides between Gypsum and Holland and Turkey creeks and Crotonwood; Chase county, thick bed on Gypsum creek 16 feet thick, also on Solomon, Saline, and Smoky Hill rivers; near Cimarron river, southern part of State, massive beds.
Limonite	Bog iron ore	Many localities in small quantities.
Petroleum	Petroleum	Numerous places in State; Wyandotte county and near border of Indian Territory; Baxter Springs, Cherokee county; in Brown, Atchison, Leavenworth and Riley counties; no wells are productive of oil in marketable quantities; gas wells at Iola, Fort Scott, Kansas City, and Rosedale.
Pyrite	Pyrites	Short Creek diggings, lead mines, with galena and blende.
	Sandstone	Many localities, near Fort Scott, quarries in a buff sandstone; bluffs of South fork of Pottawatomie.
Siderite........	Spathic iron ore, kidney ore.	In Coal Measures on Marais des Cygnes; near Fort Scott; on the Neosho and many others, interstratified with beds of good coal.
Sulphur	Sulphur	Wabaunsee county, associated with lignite.

KENTUCKY. (*a*)

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal	Coal, bituminous coal.	Coal Measures occupy eastern part of State, a part of the Appalachian coal field; bituminous variety along Big Sandy river, 12 distinct beds are known, 8,900 sq. miles; western Kentucky coal field borders Ohio river and in valley and Green river, area 4,000 sq. miles; 12 beds identified 2 to 6 feet thick, carry more sulphur than the coals of the Appalachian field; many collieries near railroad lines; cannel coal in Breckenridge county, south of Cloverport, on Ohio river; mines at Bennetsville; head branches of Far fork, Hancock county, bed 24 to 33 inches thick; Adams fork, Ohio county; 36 inches thick in Breathitt county; 5 feet in Perry and Morgan counties; of workable thickness in Johnson, Letcher, Pike, Harlan, Greenup, Jackson, Owsley, Magoffin, Wolfe, and Knox counties; coking coal from 7 to 9 feet thick in Pike, Letcher, and Harlan counties.
	Fire-clay	In Coal Measures in Greenup, Carter, and other counties of eastern coal field, and Edmonson, Muhlenburg, and other counties of western coal field; Boone furnace property, Carter county, bed 8 to 10 feet thick; Londer's bank, near Kenton furnace, Greenup county; Pea ridge, Schultz creek, Greenup county; excellent fire-clay in Tertiary, Ballard, Hickman, and Fulton counties; near Blandville, Ballard, McCracken, Fulton, and Hickman counties; Waco, nine miles east of Richmond, Madison county, Upper Silurian; also in western counties; west of Proctor, Tennessee river, in Tertiary shales.
Halite	Salt, brines	Brine is obtained from wells in the eastern coal fields, and sub-carboniferous limestones in western part of State; worked in Meade county; weak brines in Washington, Nelson, Boyle, Lincoln, and other central counties from the Lower sub-Carboniferous and the upper Hudson river beds; a spring flows from the clayey limestones in Mercer county.
Hematite	Red iron ore, fossil ore.	Red river iron region embracing parts of Estill, Lee, Powell, Menifee, and Bath counties; Lawrence county.

a Corrected by Prof. John R. Proctor, State Geologist.

KENTUCKY—Continued.

Mineralogical name.	Common name.	Remarks.
Hydraulic limestone.	Hydraulic limestone..	Jefferson, Oldham, Meade, and Grayson counties; Ohio river falls, Louisville; Chenowick creek, Jefferson county; Mitchell's springs, Meade county; La Grange, Oldham county; Curry's fork of Floyd's creek, Oldham county; Bardstown, Nelson county; Grayson's springs, a magnesian limestone; Jeptha Knobs, Shelby county; some layers generally in the base of the Trenton limestone, but have not been used for cement.
Limonite	Brown hematite.......	Red river iron region, between Licking and Kentucky rivers, ores at base of Coal Measures; Hanging rock region, embracing whole or parts of Greenup, Boyd, Carter, Lawrence, and Johnson counties, in northeast part of State. Iron made from these ores noted for its excellence for castings. In abundance from Ohio river southward tosou thern part of Carter county; Bath county, Cumberland river iron region, embracing whole or parts of Trigg. Lyon, Livingston, Crittenden, and Caldwell connties, in western part of State; occurs in clay and chert above Saint Louis, or sub-Carboniferous limestones, irregular shape and uncertain extent, but aggregate of ore immense; most extensive deposits are between the Tennessee and Cumberland rivers, and of excellent quality, Nolin district in Edmonson, Butler, Muhlenburg, and Grayson counties; ores occur near base of Coal Measures.
	Lithographic stone...	Glasgow junction, Barren county, and Estill county; localities in Wayne, Pulaski, Warren, and Rockcastle counties.
Marble.........	Marble.................	Lower Silurian formation, excellent building material, found along Kentucky river—a buff and cream-colored marble convenient to transportation; dolomites of sub-Carboniferous formation; öolitic limestone is extensively quarried at Bowling green, Warren county; near Clay's Ferry, on Kentucky river, Fayette county; Cane ridge, east of Paris, Bourbon county; Glasgow junction, Barren county; Hopson's quarry, Coon creek; on Ohio river, Trimble county; in Nelson and Bullitt counties in Niagara group, dolomites of excellent quality and in vast quantities, quarried to some degree; the Birdseye and Chazy groups on the Kentucky and rivers contain fine durable stones.
Marl...........	Marl....................	Bullitt and Spencer county line, Lower Silurian; in all counties of Lower Silurian; in Clinton and Niagara shales of Madison, Garrard, Lincoln, Washington, Marion, and Nelson counties; in the Chester group of sub-Carboniferous in many counties is a marly shale with from four to six per cent. of potash, one to two per cent. of phosphoric acid, and fifteen per cent. of lime.
Petroleum.....	Petroleum............	Crocus creek, Cumberland county; upper Cumberland in Hudson rocks; Barren county wells, Devonian; Wayne, heavy lubricating oil; Pulaski county.
Sandstone	Freestone	Cumberland sandstone in basin of Cumberland river, a greenish colored stone. Waverly period: Sandstones of this period have been extensively quarried; worked along the Ohio river and southeast of Mount Sterling, in Montgomery county; occurs along Licking, Kentucky, Salt, and Green rivers, also commonly known as "Buena Vista stone;" used largely in Cincinnati, Louisville, and other western cities; Bullitt's lick and Belmont furnace, Bullitt county; Triplett's creek, mouth, edge of Rowan county, knob building stone.
Sandstone	"Cement rock," ferruginous sandstone.	Mouth of Clark's river, McCracken county; Ballard's ford and others in Quaternary of McCracken, Ballard, Hickman, Graves, Fulton, Calloway, and Marshall counties.
Siderite	Carbonate ore, clay ironstone.	Red river district, stratified ore in the sub-Carboniferous limestone; Hanging Rock region in parts of Greenup, Boyd, Carter, and Lawrence counties, numerous local beds; Nolin river district in Edmonson, Grayson, Hart, Butler, and Muhlenburg counties, near base of Coal Measures, largely undeveloped; in Whitney county near Cumberland falls.
Siderite (2)	Black band ore	Lawrence and Muhlenburg counties; Jackson county, on top of lower coal; Green river valley.

KENTUCKY—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Apatite	Phosphate of lime	Phosphatic limestone in Cincinnati group, quarry 3 miles north of Lexington; in very small quantities in nearly all the rocks of State.
Barite	Barytes, heavy spar	Near Paris, Bourbon county; near Lexington, Fayette county; Anderson, Mercer, Owen, Henry, Franklin, Nicholas, Jessamine, Woodford, Boyle, and Garrard counties.
Epsomite	Epsom salt	In limestone caves; in Clinton shales of Madison, Garrard, Lincoln, and Marion counties; in Hudson river group of Boyle county.
Fluorite	Fluorspar	North of Columbia lead mines, Crittenden county, large deposit; Memphis mines; in Trenton limestones of Boyle, Mercer, Garrard, Jessamine, Fayette, Woodford, Anderson, Franklin, Henry counties.
Galenite	Galena, lead ore	Occurs sparingly at many localities in Saint Louis group of rocks; only mining done has been in western part of State; Columbia mines, Crittenden county; Anderson, Fayette, Livingston, Owen, and Cumberland counties, associated in places with barite and fluorspar; occurs in Carter county, in eastern part of State, and in Boyle, Mercer, Garrard, Jefferson, Fayette, Woodford, Anderson, Franklin, Henry, and Owen counties, in center of the State.
Lignite	Brown coal	Fort Jefferson bluff and near Blandville, Ballard county; Graves and Hickman counties.
Niter	Saltpeter	Mammoth cave, Edmonson county; in small quantities in hundreds of caves in southern and central part of State, in limestones of the Trenton and Saint Louis groups.
Sphalerite	Blende, black jack	Sulphur lick, Monroe county, with galena; Columbia mines, Crittenden county; in Lincoln, Garrard, Boyle, and Washington counties, in the Upper Silurian; in Boyle, Garrard, Mercer, and Jessamine counties, in the Trenton associated with barytes and galena.
Witherite	Carbonate of baryta	Near Lexington, Fayette county, with barite. In Lincoln, Garrard, and Boyle counties in Upper Silurian; in Boyle county in Subcarboniferous.

LOUISIANA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Gypsum	Gypsum	Rayburn's salt works, southern part of Bienville parish, occurs in rounded masses in gypseous clay; Petit Anse, T. 13, R. 5 E., Vermilion parish, specimens only; boring for petroleum penetrated 148 feet of gypsum at Calcasieu parish, 13 miles from Lake Charles; near Grand View; selenitic clay 85 feet thick at Grand View, on Wachita river, Caldwell parish.
Halite	Rock salt	Petite Anse island, parish Saint Mary, 4 miles west of Vermilion bay, Tertiary age, large deposit; worked actively during the war, and now producing.
Marl	Marl	Montgomery, in Grant parish, "Zeuglodon marl" contains glauconite; green-sand marl in bluff at Natchitoches, calcareous; Sicily Islands.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

	Clay	White clay in Grand Gulf group of Tertiary; Catahoula parish; 10 miles southeast of Fort Jessup, in Natchitoches parish; Chalk Hills, near Harrisonburg, in Catahoula parish; good for pottery and brick.

LOUISIANA—Continued.

Mineralogical name.	Common name.	Remarks.
Halite	Brines	Drake's salt works, artesian boring for brine, T. 12 N., R. 5 W., Winn parish; Price's. T. 13 N., R. 5 W., same parish; Rayburn's salt works; also King's, in Bienville parish; old salt works in Natchitoches parish. (These are brine wells in calcareous rocks, at work during civil war, now abandoned.)
Lignite	Brown coal	West Shreveport, Caddo parish; northwest part of De Soto county; southwest of Natchitoches; T. 14, R. 3 E., in Caldwell parish; near Columbia, Caldwell parish; southeast corner Winn parish; eastern part of Bienville; near Homer, Claiborne parish (the above in Jackson group of Tertiary, others in northwest part of State, west of Ouachita river); Coalkill creek, 6 miles east of Fort Jessup, Sabine parish.
Petroleum	Petroleum	Thirteen miles from Lake Charles, Calcasieu parish, boring, but too small quantity to pay.
Sandstone	Sandstone	Many localities in Grand Gulf group of Tertiary; in western central counties; in Sabine, Rapides, Grant, and Catahoula; also in eastern part of State bordering Alabama.
Sulphur	Sulphur, brimstone	Thirteen miles from Lake Charles, Calcasieu parish, 100 feet pure sulphur, then 148 feet of gypsum and sulphur at depth of 423 feet, in boring for petroleum.

MAINE.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Argentite	Sulphide of silver, silver glance.	Sullivan mines, Sullivan, Franklin, and Hancock, Hancock county, accompanying galena and ores of silver.
Bornite	Purple copper ore, "horseflesh ore."	West Quoddy Head, Lubec, Washington county, with chalcopyrite and pyrrhotite in veins; Blue Hill copper belt in Blue Hill, Hancock county, a belt of copper ores in quartzite and gneiss rocks, four miles long, worked in everal mines.
Cassiterite	Tin ore, tinstone	Paris, Oxford county, in a vein in granite sparingly; Hebron, Oxford county; Winslow, Kennebec county, in thin veins traversing slate rock; worked.
Cerargyrite	Chloride of silver, horn silver.	Sullivan mine, Sullivan, Hancock county; with argentiferous galena, pyrargyrite, and other ores of silver.
Chalcocite	Vitreous copper, "copper glance."	Blue Hill copper mine, Hancock county; occasionally with chalcopyrite and other ores of copper.
Chalcopyrite	Copper pyrites, yellow copper ore.	Campo Bello island, with pyrite in a vein in trap rock; West Quoddy Head, in Lubec, Washington county, with pyrrhotite in veins; mines in Lubec, accompanying silver lead ores; Gouldsboro' and Sullivan mining belt, Hancock county, accompanying silver-lead ores; Blue Hill copper belt, on Blue Hill bay, Hancock county, in veins in granular quartzite and gneiss, belt four miles long by half a mile wide, predominating ore accompanied by bornite, cuprite, and other ores of copper, several mines producing copper; Machias, Washington county, and on islands off coast.
Cuprite	Red oxide of copper	Blue Hill copper mines, Blue Hill, Hancock county; quite common with chalcopyrite, bornite, and other copper ores.
	Flagging stone	Phippsburg, Sagadahoc county, mica schist; Acton and Lebanon, York county; Winthrop, Kennebec county; mica schists at these and other localities are available; also sandstones in northern part of State.
Galenite	Galena	Lubec, Trescott, and Whiting, Washington county, argentiferous, with blende and copper pyrites, in veins traversing slate. Several mines opened. Sullivan mining district, Gouldsboro', Sullivan, Hancock, and Franklin townships, Hancock county, argentiferous galena with stephanite, argentite.

MAINE—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite (continued.)	Galena (continued.)	With native silver and pyrite, in quartzitic slates. Several mines producing silver and gold. Blue Hill belt, on Blue Hill bay, Hancock county, with copper ores and blende; argentiferous; mass of ore worked for copper; Acton and Lebanon, York county, argentiferous, occurring with mispickel and blende in quartzose veins in granite; several openings worked for silver and lead; Parsonsfield, York county, argentiferous, in quartz veins in gneiss; Denmark, Oxford county; near Bingham, Somerset county, with blende in small veins; southern part of Dexter, Penobscot county, argentiferous, with pyrites, copper pyrites, and blende in quartz; Deer Isle and Sedgwick, Hancock county; mines working.
Gold	Gold	Along Saint Croix river above Calais, auriferous quartz veins in mica schist; Calais, Columbia, and Cutler, Washington county; Gouldsboro' and Hancock, Hancock county, with silver lead ores; Cherryfield and Harrington in very small quantities in quartz in syenitic and quartzose rock; Blue Hill mines, on Blue Hill bay, Hancock county, very sparingly in copper and lead ores; Orland. Hancock county, in drift; Dexter, Corinna, and Hampden, Penobscot county; Carmel, Penobscot county, in quartz veins traversing slate; Albion, Kennebec county, in veins of quartz; Madrid and Phillip, Franklin county, in sands of Sandy river; Bingham, Moscow, and New Portland, Somerset county, in quartz; Acton and Saco, York county, in slate; Parsonsfield, York county, sparingly in quartz veins in gneissic rocks.
Granite	Granite, gneiss, syenite.	Kennebunk, York county, several quarries, a dark-colored granite; Hallowell, Kennebec county, a gray gneiss quarried on west of Kennebec river, extensively quarried and widely known; Brunswick, Cumberland county; Phippsburg, Sagadahoc county; Wiscasset, Lincoln county; Edgecombe, Lincoln county, a dark-colored granite; Seal Harbor, Lincoln county, several quarries; Mount Waldo, Penobscot bay, porphyritic granite; Mosquito and Treat mountains on Penobscot bay; Blue hill, Hancock county, several companies; Brooksville, Hancock county; Sullivan, Hancock county, immense quarries; islands in Knox and Lincoln counties; immense extent on shore of Hancock and Washington counties; also in Katahdin range, unworked; hundreds of quarries and localities along coast.
Limestone	Limestone and marble.	Limestones of Rockland, Thomaston, Hope, and Camden may be termed marble, but not used largely as such; on Saint George's river, Warren, and Union, several quarries; Aroostook county, T. 7, R. 6; Helderberg rocks running from Matagamon river northeast in Aroostook county.
Malachite	Carbonate of copper.	Blue Hill copper mines, sparingly with other ores of copper.
Muscovite	Mica	Edgecombe, Lincoln county.
Pyrargyrite	Ruby silver	Sullivan, Franklin, and Hancock, Hancock county, with galena, native silver, silver glance, pyrite, chalcopyrite, &c.
Sandstone	Sandstone	Devonian sandstone, in Washington county, especially in Perry and Machiasport, small quarries.
Silver, native	Silver	Sullivan mining district, Hancock county, associated with galena and silver sulphides; Byard's Point, Sedgwick, Hancock county, Edgemoggin silver mine.
Slate	Slate (roofing)	For roofing; Brownville, Piscataquis county; Caratunk in Somerset county, thence in a belt to the Penobscot river; Foxcroft, Sebec, Barnard and Williamsburg towns; T. 13 R. 3, Aroostook county, and doubtless many other localities in this county; above Bingham and Concord on Kennebec river.
Sphalerite	Blende	Lead mines, Lubec, Washington county; Gouldsboro', Sullivan and Hancock in Hancock county, accompanying galena, mines worked for silver lead; Blue Hill copper belt, Blue Hill bay, Hancock county; near Bingham, Somerset county, with galena in small veins; Acton mining belt, Acton and Lebanon, York county, sparingly with argentiferous galena and silver lead ores in veins in granite—openings for galena and silver; Deer Isle silver mine, Hancock county, with galena; Sedgwick, Hancock county; Chesterfield, Washington county, with blende, very rich in silver.

MAINE—Continued.

Mineralogical name.	Common name.	Remarks.
Stephanite	Silver glance, brittle silver ore.	Sullivan mining district, Hancock county, accompanying galena and ores of silver.
Talc	Steatite, soapstone	Orr's Island, bed 14 feet wide; Vassalboro', Kennebec county; Harpswell; Jaquish.
Tetrahedrite	Gray copper ore	Blue hill copper mines, Blue hill, Hancock county, occasionally with ores of copper; Hampden, Harrington and other mines, Hampden and Carmel, Penobscot county, opened for silver, occurs with galena and greenstone in a slate belt; Steuben, Washington county, ore very rich in silver, not worked.
Wad	Bog manganese	Dodge's mount, Thomaston, Knox county; Dover; Paris, Oxford county; Mount Agamenticus; Osgood's mount, Blue hill, Hancock county, a large bed; Hodgdon.

Ores, minerals, and mineral substances of industrial importance, and of known occurrence, but which are not at present mined.

Arsenopyrite	Mispickel	Blue hill, Hancock county, at copper mines; Owl's Head, Thomaston, Knox county; Bond's mount, Newfield, York county; Titcomb's hill, Farmington, Franklin county; Corinna; Greenwood, vein in granite; Clinton and Skowhegan, in bog-iron ores; Lebanon and Acton, York county, accompanying silver lead ores.
Barite	Barytes, heavy spar	Deer Isle silver mine, Hancock county, in gangue of lead silver vein.
Feldspar	Feldspar	Edgecombe, Lincoln county; common in granitic region of State.
Graphite	Plumbago, black lead	Belfast, Waldo county, disseminated through clay slate; Woodstock, sparingly in granite and mica slate; Rumford, Oxford county; Gardiner, on the Kennebec river, Kennebec county.
Hematite	Red iron ore, red hematite.	T. 13, R. 4, Aroostook county, Waite plantation; Currier's, Aroostook county.
Limonite	Brown hematite	Waite plantation, Houlton, Linneus, Aroostook county; Katahdin iron works, Piscataquis county, large deposit from 3 to 20 feet thick over many acres; Trescott, Washington county.
Limonite (2)	Bog-iron ore	New Limerick, Aroostook county; Katahdin iron works; Newfield; Dover, several deposits of large size; Pemaquid ledge; Rumford; Skowhegan, several large deposits.
Löllingite	Arsenical iron	Paris, Oxford county.
Magnetite	Magnetic iron ore	Marshall's island, Hancock county, in bed 3 feet wide; Mount Desert island, Black's island, Hancock county; Buckfield, Oxford county; Linneus, Aroostook county, impregnating slaty rock; Union, Knox county; Raymond, Cumberland county, in thin sheets or strata in epidotic gneiss; Patricktown, with pyrite; Winslow, Kennebec county, associated with tin ore.
Marl (calcareous).	Marl	All in northern part of State.
Molybdenite	Sulphide of molybdenum.	Blue Hill copper mines, Blue Hill, Hancock county, occasionally with copper ores.
Muscovite	Mica	Mount Mica, Paris, Oxford county, in large plates.
Ocher	Ocher	Red ocher at Paint mine, Rumford, Oxford county.
Pyrite	Pyrites, iron pyrites	Campo Bello island, with chalcopyrite in a vein cutting traprock; Jewell's island, Casco bay, in three wide beds of mica schist; Cape Elizabeth, in mica schist; Brooksville, opposite Castine, Hancock county, great abundance in clay slate; Troy, Waldo county, in clay slate, large bed; Norton's ledge and Powder House hill, in Farmington, large deposits; Drew's mill, New Limerick; Anson, Somerset

MAINE—Continued.

Mineralogical name.	Common name.	Remarks.
Pyrite	Pyrites, iron pyrites ..	county, in slate; Concord, Somerset county, west bank of Kennebec river; Gouldsboro' and Sullivan mining belt, Hancock county, with silver lead ores; Blue Hill copper mines, Hancock county, with copper ores in veins in quartzite and gneissic rocks; Vinalhaven isle, Penobscot bay, in large quantities.
Pyrolusite	Manganese oxide	Osgood's farm, Blue Hill bay, Hancock county; Dodge's mount, Thomaston, Knox county.
Pyrrhotite.....	Magnetic pyrites	Blue Hill copper mines, Hancock county, accompanying pyrite, chalcopyrite. &c.
Quartz.........	Glass sand	Liberty, Waldo county, pure, granular quartz; Camden, Knox county; abundant at these localities.
Serpentine.....	Serpentine	Deer isle, Hancock county, large deposit.
Stibnite.........	Sulphide of antimony.	Blue Hill copper mines, Blue hill, Hancock county, accompanying ores of copper, quite common.

MARYLAND.

Minerals and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Bornite	Purple copper ore.....	Finksburg, Carroll county, mine worked for many years for copper; Mineral hill, southwest of Finksburg, Carroll county; Dolohyde mine, in Linganore copper region, Frederick county, with chalcopyrite and pyrite in limestone and elsewhere in this Linganore copper region—not worked; Roop farm, near New Windsor, Carroll county, with chalcopyrite, malachite and gray copper ore.
Chalcocite.	Vitreous copper, sulphide of copper.	Between Taneytown and New Market, with other ores of copper; Liberty mine, Frederick county, with malachite and black copper.
Chalcopyrite...	Copper pyrites........	Finksburg, Carroll county, with purple copper ore; old copper mine, Bare hills, Baltimore county, abandoned; Gunpowder river forks, Harford county, with chromite; Springfield mine, Sykesville, Carroll county, with magnetic iron ore, worked for years as an iron and then as a copper mine; Dolohyde mine, Frederick county, with bornite and pyrite in dolomite; other localities in the Linganore copper region, but not worked; Roop farm, near New Windsor, Carroll county, with other ores of copper.
Chromite	Chrome iron ore.......	Near Louisville, Cecil county; Rising Sun, Cecil county, near Pennsylvania line, used as pigments; near headwaters of Seneca creek, Montgomery county, occurring in beds in serpentine; Bare hills, Baltimore county, irregular masses in serpentine; Coopstown, Harford county, worked for many years; Soldiers' Delight, Baltimore county; Gunpowder river forks, Harford county; chrome ores extend in a belt from near New Lisbon in Carroll through Montgomery county nearly to Potomac.
Clay........	Kaolin clay, porcelain clay.	Near head of Big Elk creek, Cecil county, in granite; near Annapolis, Anne Arundel county; near Abingdon, Harford county, a large body; elsewhere in region of feldspathic rocks in Montgomery, Howard, Carroll, Baltimore, Harford, and Cecil counties.
Clay (2)........	Pottery clays, stoneware clays.	On banks of Bohemia, Cape, John, and Sassafras creeks, Cecil county.
Coal............	Coal	Semi-bituminous coal, Cumberland coal, Frostburg, Westernport, Lonaconing, Alleghany county; Potomac basin, between Savage and Davis mountains—Frostburg is in it—32 beds of coal, each from 14 feet to a few inches thick (50 by 5 miles); Meadow Mountain basin, between Meadow mountain and Negro mountain, 50 square miles; mined for local use; Youghiogheny basin, partly in West Virginia; Briery mountain on west—5 to 8 miles wide in the State—area, 100 square miles; Meadow Mountain and Youghiogheny coal basins are in Garrett county.

MARYLAND—Continued.

Mineralogical name.	Common name.	Remarks.
Fire-clay	Fire-clay	Mount Savage, near Frostburg, Alleghany county, noted for excellence and widely used; northeast, in Cecil county; not now worked.
	Flagging stone	Emmittsburg, Frederick county, New Red Sandstone; Catoctin mountain, Frederick county; High Knob, near Frederick, Frederick county, tiling of variegated slates.
Granite	Gneiss, syenite	Syenite quarried extensively near Port Deposit on Susquehanna, superior building stone; Woodstock, Howard county, quarries; Ellicott City, Howard county; Anne Arundel county, "porphyroidal granite."
Hematite	Specular iron ore	Sykesville, on Patapsco river, Howard county; Wills mountain, Alleghany county, fossil ore; between Monocacy creek and Parr's bridge, Frederick county, richest ore of kind in State; Catoctin mountain, Frederick county, in small quantities; near Mount Airy, Carroll county, mines opened; Sideling hill, Washington county; Town hill.
Hydraulic limestone.	Cement rock, water lime.	Cumberland, Alleghany county; near Hancock, Washington county.
Kaolin		See Clay.
Limonite	Brown hematite	Northeast village in Cecil county; Flint hill, near Elkton, Cecil county; head of Sassafras, Cecil county; Snowden's bank, Prince George's county; head of Deep run, seven miles from Baltimore; Curtis creek; near Joppa, near Abingdon and Bush river, Harford county; near Oregon furnace and also near Hereford in Baltimore county; also near Towsontown, Baltimore county; Owingsville, Anne Arundel county; Parr's Spring ridge, Carroll county, several extensive deposits, openings near Westminster; west base of Catoctin mountain, Frederick county, worked for Catoctin furnace; "pipe ore" on Potomac two miles above Harper's Ferry, Washington county; also near North mountain and Potomac, Washington county; Sideling hill, beyond Canoloway, Washington county; Snowhill, Worcester county, large deposit of bog ore; many localities in eastern shore, greater parts of Somerset and Worcester counties and part of Caroline.
Malachite	Green copper ore, carbonate of copper.	Finksburg copper mine, Carroll county; copper mine in serpentine (with chalcopyrite), Bare hills, Baltimore county, abandoned; Mineral hill, Carroll county, with chalcopyrite; Liberty mine, Liberty, Frederick county, with chalcocite, and elsewhere in Linganore copper region; localities between Middlebury and Big Pipe creek, Carroll county, sparingly disseminated in rock; Roop farm, near New Windsor, Carroll county.
Marble	Potomac marble, brecciated limestone.	Valley of Monocacy river, west side Frederick county; New Market, Liberty, and Sam's creek, all in Frederick county; Texas and Cockeysville, Baltimore county, a white marble; Parr's ridge, Carroll county; Frederick county, white or light bluish, worked extensively; Mount Saint Mary's, Frederick county, a verd antique marble.
Marls	Greensand	Head of Sassafras river, Kent county, elsewhere in northern and middle parts of county; heads of creeks in Cecil county; Sassafras neck, Bohemian manor, and Pond neck, all in Cecil county; head of South river, Prince George's county.
Marls (2)	Shell marls	At many localities on eastern shore; localities on Choptank river, Talbot county; also on western shore along Chesapeake bay, and on Potomac river, in counties of Prince George's, Charles, Saint Mary's, and Calvert.
Melaconite	Black copper	Liberty mine, Frederick county, with malachite and chalcocite.
Sandstone	Sandstone, freestone	Near mouth of Seneca creek, Montgomery county, extensively quarried, "Seneca sandstone;" southwest slope of Sugar Loaf mountain, Frederick county.
Serpentine	Serpentine	Northern part of Cecil county; Bare hills, Baltimore county; Soldiers' Delight, Baltimore county; Coopstown, Harford county.

MARYLAND—Continued.

Mineralogical name.	Common name.	Remarks.
	Slate (roofing)	Bush creek, Frederick county; Unionville, Frederick county; most extensive quarries in Slate ridge from Peach Bottom ferry, on Susquehanna, southwest, in Harford county, known as "Peach Bottom slates;" Gainsville, Linganore, and Hyattstown, all in Frederick county.
Smithsonite	Carbonate of zinc	Zinc mine near New Windsor, Carroll county, with blende and calamine.
Sphalerite	Zinc blende	Near Jones's falls, in gneiss, Baltimore, thin veins of blende and galena; near New Windsor (zinc mines), Carroll county, with calamine and smithsonite.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asbestus	Asbestus	Northern part of Cecil county, with talc, in serpentine; Bare hills, Baltimore county.
Calamine	Silicate of zinc	Zinc mine near New Windsor, Carroll county, with blende and smithsonite.
Carrollite	Cobalt ore	Patapsco mine, near Finksburg; Mineral hill, seven miles southwest of Finksburg; Springfield mine, Sykesville; localities in Carroll county. Occurs in small quantities with chalcopyrite and chalcocite.
Chrysocolla	Silicate of copper	Sparingly in red sandstone between Middleburg and Big Pipe creek, Carroll county.
Copper (native)	Copper	Catoctin mountains, Frederick county, specimens only.
	Emery	Twenty-one miles north of Baltimore, Baltimore county.
Galenite	Galena	Unionville, Frederick county, vein in limestone; Jones's falls, near Baltimore; Dolohyde copper mine (argentiferous), Frederick county, in small quantities.
Gold	Gold	Mines in Montgomery county; Mineral hill, Carroll county, in small quantities; Catonsville, Baltimore county, in quartz.
Graphite	Plumbago, black lead.	Gunpowder creek, Baltimore county.
Gypsum	Gypsum	Saint Mary's county, sparingly disseminated through Tertiary clays.
Lignite	Brown coal	In clays sparingly in Kent and Cecil counties; Chesapeake city, with pyrite in clay; Pines region, Montgomery county; on western shore, Prince George's county.
Linnæite	Siegenite, cobalt pyrites.	Mineral hill copper mines, Finksburg, Carroll county, with chalcopyrite, carrollite, bornite, and pyrite in chlorite slate in small quantity; Mineral hill, seven miles southwest of Finksburg, Carroll county, in small quantity with chalcopyrite, blende, and carrollite in chlorite slate.
Magnetite	Magnetic iron ore	Deer creek, Harford county, titaniferous, not used; near Cockeysville, Baltimore county; near Bare Hills copper mine, Scott's mills, and Gunpowder creek forks, all in Baltimore county; Sykesville, Carroll county, ores occur in mica slates and associated with chlorite slate, worked as copper mine for a time; near Mount Airy, Carroll county.
	Manganese ore	Near Brookeville, Montgomery county; abandoned.
Molybdenite	Sulphide of molybdenum.	Baltimore county.
Ocher	Ocher	In clay deposits.
Pyrite	Pyrites	Cape Sable, Anne Arundel county, occurs in clay, has been worked extensively; Round bay, Anne Arundel county; Oxen creek, Prince George's county.
Pyrolusite	Black oxide of manganese.	Brookeville, Montgomery county; abandoned mine.

MARYLAND—Continued.

Mineralogical name.	Common name.	Remarks.
Siderite	Clay ironstone	Many localities on western shore of Chesapeake bay, near head of same, in nodular masses in clays, following shore in a belt crossing State from Washington to Elkton. Low in sulphur and phosphorus; Polish mountain, near Potomac, Alleghany county; near Lonaconing, George's creek coal basin, Alleghany county.
Siderite (2)	Black band ore	Koontz run and Mill run, Alleghany county; in George's creek coal basin.
Talc	French chalk	Northern part of Cecil county, in serpentine; six miles from Rockville, on Darnestown road, Montgomery county.
Talc (2)	Soapstone	Patterson's, on west branch of Northeast river, Cecil county; New Leeds, on Little Elk, Cecil county; near Rockville, Smell's bridge and Clopper's mills, all in Montgomery county; Elk ridge, Anne Arundel county.
Tripolite	Tripoli, infusorial earth.	Near Nottingham, on Patuxent river, thence to Lower Marlboro and throughout greater portion of Calvert and Anne Arundel counties. A large deposit, 5 to 30 feet thick.
Zaratite	Emerald nickel	Chrome ore mines, northern part of Cecil county, in small quantities.

MASSACHUSETTS.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Flagging stone	Washington, Berkshire county, a quartz rock; Gill, Connecticut valley, a gray micaceous sandstone; Montague, red micaceous sandstone.
Granite	Granite, gneiss, syenite.	Quincy granite quarries extensive and afford widely known stone; Gloucester quarries, north side of Cape Ann; Danvers, lighter colored; Fall river, in Troy, lighter colored than Quincy granite; Dedham, fine-grained and white; Westford, a pure granite; Fitchburg and other localities in eastern part of State; in western part of State, in Hampshire and Hampden counties; gneiss occurs in western part of Worcester and eastern parts of Hampden, Hampshire, and Franklin counties; *e. g.*, Milbury stone used at Worcester; Monson noted for large monoliths.
Hematite	Specular ore, micaceous ore.	Hawley iron mine, Franklin county, a thin vein, worked to some extent; Montague, several beds; Malden, thin veins.
Limonite	Brown hematite	Extensive deposits in Berkshire county; Leet ore beds, and Goodrich ore bed, West Stockbridge, Berkshire county; Cheever ore bed; Cone mine; Bank mine; Cook mine; Branch mine; Bacon ore bed, near Richmond, Berkshire county; Sherman ore bed, Lanesboro; Mason and Bliss ore bed, Cheshire, Berkshire county; ores occur with ochery clays in large bodies between walls of mica schists; brown clay ironstone, Gray's Head, on Martha's Vineyard.
Marble	Marble	Berkshire marbles quarried at several localities in Berkshire; New Ashford; North Adams; Lanesburgh; West Stockbridge; Great Barrington; Lee, noted quarries whence stone for Capitol, Washington City, was taken.
Peat	Peat	Numerous deposits in swamps and bogs, principally in eastern and central parts of State.
Pyrite	Pyrites	Rowe mine, near Charlemont, Franklin county, cupriferous.
Quartz	Sand	Cheshire, Berkshire county; sandrock mined and widely used in glass manufacture; Squam, Gloucester county.
Sandstone	Sandstone	Connecticut valley, Wilbraham, Longmeadow, blood-red color and uniform grain; West Springfield, Westfield, Deerfield, coarser grained; Granby, gray and coarse grained.
Slate	Slate	Lancaster, quarries for local use.

MASSACHUSETTS—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Agate	Agate	Amherst and Conway.
Amber	Amber	Gay's Head, in fragments in clay.
Anglesite	Sulphate of lead	Southampton lead mine, with galena and cerussite.
Apatite	Phosphate of lime	Norwich, crystals in gray quartz; Bolton, abundant; sparingly elsewhere.
Arsenopyrite	Mispickel	Worcester, with galena in mica slate; Sterling; northern vein, Newburyport lead mines, Essex county, with galena and quartz.
Barite	Barytes, heavy spar	Southampton lead mine, as gangue; Leverett, gangue formation in vein; Hatfield, small vein, containing galena, a large deposit; Greenfield copper mine, as gangue material.
Beryl	Beryl	South Royalston, in vein in coarse granite; Barre, in granite; Pearl hill, Fitchburg.
Bornite	Variegated copper, purple copper ore.	Southampton lead mines, with galena in small quantity.
Cassiterite	Tinstone	Chesterfield; Goshen, a few crystals with albite; Norwich.
Cerussite	White lead ore, carbonate of lead.	Southampton, sparingly with galena.
Chalcopyrite	Copper pyrites	Leverett, with galena in vein; Greenfield, with malachite; Hatfield; middle vein, Newburyport lead mines, Essex county, with galena, pyrite, &c.; Southampton lead mine, in small quantity.
Chromite	Chromic iron ore	Blanford, narrow vein in serpentine; Chester.
	....Clay	Alum clay, Martha's Vineyard, used on continent formerly; fire-clay, Martha's Vineyard, Gay's Head.
Coal	Coal, anthracite coal	I. Anthracite; the Rhode Island coal field extends northeast into this State, and coal beds are opened in Bristol, Plymouth, and Norfolk counties; area of the field 400 square miles in the two States; mines were opened years ago in West Bridgewater, Middleborough, Wrenshaw, and Mansfield.
Coal (2)	Bituminous coal	II. Bituminous coal, very thin beds and nodules only a few inches in diameter, and of no economic importance, in Red Sandstone formation of Connecticut valley; Worcester and Mansfield a graphitic anthracite.
Corundum	Emery	Chester—corundum and emery and magnetite in a large vein; has been worked largely; is now worked. (?)
Feldspar	Feldspar	Chesterfield, albite; Brimfield, adularia; Barre and South Royalston.
Galenite	Galena, lead, ore	Newburyport mines, Essex county, a number of mines were opened and worked for the argentiferous galena several years ago; galena associated with blende, tetrahedrite, chalcopyrite, arsenopyrite, pyrite, and siderite; Southampton, old mine abandoned, a vein with quartz and barite; Leverett, small vein in granite; Sterling; Hatfield, in a vein with barite; many localities of occurrences only, especially in Hampshire county.
Garnet	Garnet	Carlisle, in geodes with scapolite; pyrope at many localities in Worcester county.
Gold, native	Gold	Dedham.
Graphite	Plumbago, black lead.	Sturbridge, Worcester county, a bed in gneiss, long worked; Worcester and Millbury, mixed with anthracite.
	Grindstone, whetstone, millstone.	Charlestown: Malden; Quincy, an argillaceous slate; Enfield; Bellingham, mica slate for whetstones; Norwich, mica slate; Washington, Berkshire county, employed for millstones.
Hydraulic limestone.	Water-lime, cement, rock.	Springfield limestones.

MASSACHUSETTS—Continued.

Mineralogical name.	Common name.	Remarks.
Kaolinite	Kaolin	Andover.
Lignite	Wood coal	Gay's Head, Martha's Vineyard, in clay.
Limonite	Bog-iron ore	Common nearly everywhere; formerly the supply of many furnaces, especially in southeast part of State.
Magnetite	Magnetic iron ore	Hawley iron mine, Franklin county, worked for a time, but narrow vein; Chester, very narrow bed in hornblende slate; Beartown mountain, Tyringham, narrow vein in quartz; Bernardstown, bed in limestone; Warwick, thin beds in mica slate.
Muscovite	Mica	Common rock constituent; not worked.
	Ocher	Richmond, with limonite; Williamstown, once worked.
Pyrite	Pyrites	Hubbardstown, bed formerly worked; Hawley.
Pyrolusite	Gray oxide of manganese.	Plainfield, with rhodonite in small beds; West Stockbridge, with limonite at iron mines; Conway, large beds with quartz gangue.
Serpentine	Serpentine	In great abundance, particularly in Hoosac mountain range; Middlefield, Hampshire county, very extensive bed; Westfield, Blanford, Zoar, Windsor, Lynnfield, Newburyport, in eastern part of State; others in western part, in Berkshire county.
Siderite	Spathic iron ore	Sterling, with arsenopyrite in mica slate; West Stockbridge, with limonite ore; Newburyport, with galena at the silver lead mines in middle vein in small quantities; Gay's Head, Martha's Vineyard, in clay.
Sphalerite	Zincblende	Leverett, sparingly with galena; Southampton, in lead mine with galena; Norwich, southernmost veins; Newburyport lead mines, Essex county, with galena, worked prior to 1878.
Talc	Steatite, soapstone	Middlefield, Windsor, Cheshire, Savoy, Hinsdale, Blanford, Granville, Zoar, Rowe, Andover, Worcester, Groton, Chester, and other places, but of small extent generally, commonly associated with serpentine.
Tetrahedrite	Gray copper ore	In middle vein lead mine Newburyport, Essex county, in small quantities with galena, pyrite, chalcopyrite, and siderite.
Wulfenite	Molybdate of lead	Southampton lead mines in small quantities with galena, cerussite, &c.

MICHIGAN.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal, var. bituminous.	Coal, bituminous coal.	Coal field occupies an ellipsoidal area, extending from Saginaw bay south and southwest to Jackson and Kalamazoo. The measures are 300 feet thick, and include several seams, varying from a few inches to four feet thick. The principal mines are in vicinity of Jackson; Corunna, in Shiawassee county; Owasso, same county; and at Flushing, in Genesee county. Local uses absorb nearly whole production.
Copper, native.	Copper	Lake Superior copper region, in Upper Peninsula. The "copper belt" stretches from Keweenaw point southwest to Wisconsin, and thence across that State to Minnesota. Its length is 130 miles, and with an average breadth of six miles. It crosses the counties of Keweenaw, Houghton, Isle Royale, and Ontonagon. The native copper occurs in masses in amygdaloid trap-rock and sandstone, and also in grains distributed through amygdaloidal and conglomerate rocks. Beginning at northeast there have been many mines opened from Keweenaw point to southwest, in T. 58, RR. 28, 29, 30, and 31, Keweenaw county; the Portage Lake group of mines come next, to southwest, including among others the celebrated Calumet & Hecla mine, in Houghton county: the Ontonagon district covers the mines in T. 51, RR. 37 and 38 W., besides others, in Ontonagon county; the Isle Royale group of mines, Isle Royale in Lake Superior.

MICHIGAN—Continued.

Mineralogical name.	Common name.	Remarks.
	Fire-clay	Spring Arbor coal mines, Jackson county, Batcheldor place, Jackson county, worked for firebrick and sewer-pipe at Jackson. Other localities in Coal Measures.
	Flagging stone	Napoleon, Jackson county.
	Granite	Montello, Marquette county, stone resembling Scotch granite, recently opened. Abundant in Upper Peninsula in Archæan formation.
Gypsum	Gypsum, plaster	Grand river from Grand Rapids to Grandville, Kent county, very large quarries. Thick beds in upper sub-Carboniferous. Also at Alabaster point, Iosco county, where it is largely quarried. Other localities are headwaters of Aux Gres river, Iosco county, and in borings at Bay City and Kawkawlin in Bay county.
Halite	Common salt, brines	Saginaw valley, in counties of Iosco, Bay, Saginaw, Midland, and Huron.
Halite (2)	Rock salt	Marine city, Saint Clair county, discovered recently in borings.
Hematite	Specular ore, red iron ore.	Vast beds in Upper Peninsula. The iron-bearing belt begins near Lake Superior and runs southwest into Wisconsin. Ores are interstratified with quartzites, diorites, and ferruginous schists of Huronian age. The mines are grouped in the Marquette district, Teal lake range, North range, Cascade range, Negaunee mines, Menominee range, Felch Mountain range, and the Agogebic iron range. The principal mines are in vicinity of Marquette, Ishpeming, Negaunee, Michigamme, in Marquette county; in T. 49, R. 33, in Baraga county; in T. 42, R. 28, southern part of Marquette county; along the Menominee river, in Menominee county; and the mines in TT. 44, 45, 46, and 47, R. 47 W., near Montreal river, in Ontonagon county.
	Limestone	Grand Rapids, Kent county (Carboniferous); North Rainsville, Stony creek.
Magnetite	Magnetic iron ore	Marquette region, Upper Peninsula, occurs with the specular ores [see under Hematite for localities]. As a constituent of granitic and other crystalline rocks of Archæan age, common in Upper Peninsula. More abundant, with specular ore, in eastward extension of the Penokie range from Wisconsin line to Lake Gogebic, in Ontonagon county.
	Sandstone	The sandstone of Coal Measures has been quarried at Flushing, Genesee county; numerous quarries in Springport, Sandstone, and Parma, Jackson county; also at Napoleon (for both building and flagging stone); these are in sub-Carboniferous. Large quarries near Marquette, Marquette county, and at L'Anse, Baraga county, in Potsdam sandstone. Isle Royale, in Lake Superior, a red sandstone.
	Slate	Huron Bay Slate Company, T. 51, R. 31, Houghton county; quarry reopened recently.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Amethyst	Amethyst	Keweenaw point, in trap-rock; Point aux Peaux, Monroe county.
Barite	Barytes, heavy spar	Isle Royale, Lake Superior, in large veins, in sandstone.
Chalcopyrite	Copper pyrites	Occasionally with native copper in mines in Upper Peninsula.
Domeykite	Arsenical copper	Michipicoten Island, Lake Superior, with copper nickel.
Gold, native	Gold	Ropes, in quartz veins traversing slate; Emmet iron mine, Menominee county.
Graphite	Plumbago, black lead	Near Humboldt, Marquette county.
Limonite	Brown hematite	

MICHIGAN—Continued.

Mineralogical name.	Common name.	Remarks.
Silver, native	Silver	In copper-bearing belt of Upper Peninsula, occasionally with native copper.
Siderite	Carbonate of iron	Along Shiawassee river; elsewhere in coal field.

MINNESOTA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Fire-clay	New Ulm, Brown county; Redwood falls.
	Granite	Sauk rapids, Benton county; Saint Cloud and Rockville, Stearns county; along Minnesota valley from New Ulm to Big Stone lake (mostly red variety); Duluth, Saint Louis county; Motley, Cass county, large areas in central and northern part of State where granitic rocks occur, but are not developed.
Hematite	Specular ore	Near Vermilion lake, Saint Louis county, mines being opened.
	Limestone	Between Stillwater and Winona in Mississippi valley at several points quarries are opened; Caledonia, Houston county; Lanesboro and Rushford in Fillmore county; Mankato, Blue Earth county; Shakopee, Scott county; Ottawa, Kasota, and Saint Peter in Le Sueur county. At these localities in southern central part of State the stone is more quartzose, stronger, and easily cut into ornamental shapes. The Trenton limestone is quarried at Fountain, Fillmore county, and at Minneapolis, Saint Paul, Northfield, and Faribault. At Mantorville, Spring valley and other points in Fillmore and Olmstead counties, quarries in Galena limestone. Devonian limestones occur suitable for quarrying at Le Roy, Monroe county, and in Fillmore county.
Magnetite	Magnetic iron ore	Minnesota mines, Vermilion lake district; Mesabic iron range, T. 59 and T. 60 N., R. 14 W.; Iron lake, Lake county; near Grand Marais, Lake county, localities opened and partially developed.
	Quartzite	New Ulm, Brown county, and in Cottonwood, Watonwan, Rock, and Pipestone counties, a very hard and durable stone, used little near its outcrop.
	Sandstone	Red sandstone, Fond du Lac, Carlton county, similar to "Isle Royale brownstone," used in Chicago and Detroit. Freestone is quarried for heavy work at Hinckley, in Pine county. "Jordan sandstone" in lower Minnesota valley, at Jordan, Scott, and other points. At Austin, Mower county, a Devonian sandstone is quarried. Saint Peter's sandstone at and above Fort Snelling, on Mississippi.
	Slate (roofing)	Thomson, Carlton county, quarries opened for roofing slate, most western in United States.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Barite	Barytes, heavy spar	Pigeon point, north shore Lake Superior, Lake county.
Chalcocite	Copper glance, vitreous copper.	Taylor's falls, Chisago county; argentiferous.
Chalcopyrite	Copper pyrites	Vermilion lake, Saint Louis county, with pyrite.
Copper, native	Copper	French river, Saint Louis county, north shore of Lake Superior, in trap-rock; near Duluth; on Kettle river, in amygdaloid and feldspathic rocks, with quartz, calcite, and epidote; Shakopee, Hennepin county. In drift, Taylor's falls, Chisago county, and along Kettle river, Pine county.
	Flagging stone	Redstone, Nicollet county, and New Ulm, Brown county, and valley of Minnesota (red quartzite); Shakopee limestones on Mississippi, from Winona to Hastings; also at Shakopee, Ottawa, Kasota, and Mankato, on the Minnesota river.

MINNESOTA—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite	Galena	Near Duluth. Elsewhere in many places on surface as "float ore."
Gold, native	Gold	Vermilion lake, Saint Louis county, in quartz in talcose state also with pyrite. Workings abandoned. In drift in very small quantities in Fillmore, Olmstead, and other counties.
Gypsum	Gypsum	Big Stone lake, Big Stone county. Scattering crystals in Cretaceous shales.
Kaolinite	Kaolin	In granitic rocks.
Lignite	Brown coal	Near Redwood falls, on Cottonwood and Redwood rivers; also on Crow creek, in thin, irregular beds (Cretaceous).
Limonite	Brown hematite	On Le Sueur river, near its mouth, western part of Fillmore county.
	Peat	Lura station, Faribault county. Formerly manufactured into fuel. Many other localities.
Pyrite	Iron pyrites	Pigeon point, Lake Superior, with chalcopyrite. Vermilion lake, Saint Louis county; auriferous.
Silver, native	Silver	Near Pigeon point, north shore Lake Superior.
Sphalerite	Zincblende	Stillwater, Washington county.

MISSISSIPPI.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Clay	White pipeclay, Tishomingo county, in T. 5 and T. 4., R. 11 E.; Clingscales, S. 8, T. 5, R. 11 E. (answer for fire clay); White cliffs, Adams county; Woodville, Wilkinson county; yellow or cream-colored clays, common in orange sand formation. Pottery clays, Holly Springs, Marshall county; northern part of Tippah county, S. 7, T. 25, R. 7 E., Yalobusha county; Calhoun county; two miles north of Oxford, Lafayette county, and generally in northern Tippah, eastern Marshall, western Pontotoc, eastern Lafayette, eastern Yalobusha, Calhoun, and western Chickasaw counties; southeast Itawamba county at S. 32, T. 10, R. 10 E.
Gypsum	Gypsum	Well near Cato, Rankin county. (See note under Marl.)
	Hydraulic limestone	In Carboniferous formation, at Eastport, Tishomingo county; along Yellow creek, same county (Billings's mill).
Marl	Marl	Glauconitic of Cretaceous in Tippah, Pontotoc, and Chickasaw counties, fit for local use only; Tertiary, Shongala greensand marl, Carroll county and northern Attala county; Calcareous marls, Vicksburg, Warren county; northern Hinds, and Madison counties, near Jackson, Canton, Calhoun, Byram station, Brandon, McNutt hills; also northern Rankin and Scott counties, and Newton; yellow calcareous marls in Smith, Jasper, Clarke, and Wayne counties. These are in a belt stretching from Vicksburg easterly across State, and in Jackson, Vicksburg, and calcareous Claiborne group of Tertiary. Localities: Enterprise, Clarke county, near Quitman, and in Garland's creek. Calcareous marls of Tertiary; local deposits, e. g., Homochittoo hills, Franklin county; Barnes' White bluff and Burnett's bluff, Marion county. Gypseous marls (for local use only), southern Carroll, Attala, Leake, Holmes, northern Madison, Hinds, Rankin, and Scott counties.

Ores, minerals, and mineral substances of industrial importance, and of known occurrence, but which are not at present mined.

Lignite	Brown coal	In northern lignitic group of Tertiary; occurs in Tippah, Marshall, Lafayette, Yalobusha, Calhoun, Kemper, Lauderdale, Panola, Choctaw, Holmes, Carroll, Winston, Madison, and Yazoo counties, generally thin, not mined; Garlandsville, Jasper county; Vicksburg, Warren county.

MISSISSIPPI—Continued.

Mineralogical name.	Common name.	Remarks.
	Limestone	Limestone of Ripley group, Cretaceous, suitable for local use only; limestone at Vicksburg of Claiborne and Vicksburg groups.
Limonite	Brown hematite	Common in orange sand, but unimportant; Iuka lake, Tishomingo county.
	Ocher (red)	McDouglas mill, Tishomingo county.
	Sand (for glass) quartz.	Pearl river (Recent), near Eastport, Tishomingo county, on Big Bear creek, locally known as "chalk," very fine-grained.
	Sandstone	Ferruginous sandstone of Orange sand formation in Marshall, Lafayette, Tippah, Yalabusha counties; siliceous sandstone of Orange sand formation; some of latter like whetstone, sandstone of Carboniferous, Big Bear creek, below Scott's mill, Gardner, Bay spring, Rock creek (these in Tishomingo county, also suitable for flagging stone); sandstones of Grand Gulf region, of inferior quality.

MISSOURI.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Barite	Barytes, heavy spar	Southeast part of State, as gangue in lead veins; Miller, Morgan, Moniteau, Cole, and other counties in central lead region of State, in veins and vein-like deposits and in workable quantity near Muddy creek, Pettis county; Pleasant Hill, Cass county; Amos' quarry, Jackson county; T. 40, R. 3 E., Jefferson county, a large vein.
Calamine	Silicate of zinc	Granby district, Newton county; Joplin creek diggings, Jasper county; Valle mines, Jefferson county; Mine la Motte, Madison county, besides other localities, generally occurring with blende and galena, the most abundant and valuable zinc ore of State.
Cerussite	White lead ore	Granby mines, Newton county; Center creek district, Jasper county; Valle mines, Jefferson county; Mine la Motte, Madison county. Mined as an ore of lead in southwest Missouri.
Chalcopyrite	Copper pyrites, pyritous copper, yellow copper ore.	Cornwall, Swansea, and Herzog mines, Sainte Genevieve county, with other ores of copper, in second magnesian limestone; Mine la Motte, Madison county; Hinch and Rives mines, Crawford county; Old circular diggings, Cole county, besides other localities, often accompanying lead and zinc ores in lead-ore districts. Worked at a few places only.
Coal	Coal, mineral coal	Missouri Coal Measures occupy an area of 23,100 square miles, including 8,400 square miles of upper and barren measures. The productive coal field is in northern central and western central counties, extending from Missouri river to Iowa line, and on south of Missouri west of Osage river. The southwest coal field is in Bates, Vernon, and Barton counties. Principal mines are in Henry, Pettis, Johnson, Cass, Howard, Randolph, Macon, Linn, Adair, Sullivan, Livingston, Buchanan, Bates, and Vernon counties. There are small outlying patches at east in Saint Louis, Saint Charles, Lincoln, Warren, and other counties, and at southwest in Moniteau, Jasper, and Sabine counties. The Middle and Lower Coal Measures include eight workable seams from 1 to 4½ feet thick.
Cuprite	Red oxide of copper	Copper mines, Sainte Genevieve county, with copper pyrites, vitreous copper, and carbonates, and in quantity.
	Fire-clay	Cheltenham, Saint Louis county, extensively used as glass pot clay; Evans mines, Montgomery county; also, in Coal Measures territory, but not developed.
	Flagging stone	Brownsville, Saline county, a siliceous rock, much used; Clinton, Henry county; Sainte Genevieve, Sainte Genevieve county, second sandstone and first magnesian limestone extensively quarried; O'Bannon's quarry, Madison county.

MISSOURI—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite	Galena, lead ore	Southeast Missouri, in Franklin, Jefferson, Washington, Saint François, Madison, Sainte Genevieve, Crawford, and Bollinger counties, most important mines are: Mine La Motte in Madison, Valle mines in Jefferson and Saint François counties. Central or middle Missouri, principally in Miller, Cole, Morgan, and Moniteau counties. Southwest Missouri lead region includes Granby mines in Newton county, Joplin creek in Jasper county, and Center creek also in Jasper county, besides lesser mines in Green, Dade, McDonald, Barry, Stone, and Christian counties. Galena occurs in southern central region; also in La Clede, Dallas, Webster, Texas, and other counties. In the southeast district ore occurs in the third magnesian limestone (calciferous); in the southwestern part of State and in parts central district also it is in the Archimedes or Keokuk limestone (sub-Carboniferous). The galena occurs with calamine, smithsonite, blende, and barite, and smaller amounts of pyrite and chalcopyrite, and in flat sheets, fissures, veins, and irregular masses in the rock. Worked for lead and zinc (in places); too poor in silver for its extraction.
	Granite	Knob lick, Saint François county, large quarries; Iron mountain, Iron county, a red granite; Madison and Sainte Genevieve counties, unworked.
Hematite	Specular iron ore	Iron Mountain district in southeast Missouri, including among others the noted Iron mountain in northeast quarter of Saint François county (a huge vein of specular ore in porphyry), Pilot Knob, Shepherd's mountain, Cedar hill, Buford Hill, and Lewis mountain, in Iron county. These occurrences are in porphyry rocks of the Archæan. The central region includes many ore banks in Crawford, Phelps, and Dent counties, besides more scattering deposits in Franklin, Maries, Washington, Miller, Camden, Pulaski, and Shannon counties. The ore occurs in second sandstone (of Lower Silurian).
Hematite (2)	Red hematite	Occurs with specular ores at Scotia bank, Crawford county; Saint James district, in Phelps county; and in TT. 45 and 46, R. 10 W., in Calloway county; T. 48, R. 19 W., Cooper county; T. 43, R. 25 W., Henry county; TT. 39 and 40, R. 24 and R. 25 W., Saint Clair county; in the sub-Carboniferous, in ferruginous sandstone; also in Coal Measures in small deposits or thin seams in Linn, Adair, Sullivan, Vernon, and Barton counties; in Carboniferous rocks in Saint Charles, Boone, and Montgomery counties.
	Limestone	Mine la Motte, Madison county; Amazonia and Savannah, Andrew county; many quarries opened; Kansas City, Jackson county, an oölitic stone; Pleasant Hill, Cass county; Mooresville, Livingston county; Princeton, Mercer county; Chilicothe, Lincoln county; Liberty, Clay county; Forest City, Holt county, many quarries; Missouri City, Clay county; and Sainte Genevieve, Sainte Genevieve county. Many other localities in outcrops of Silurian and Carboniferous rocks in all parts of State.
Limonite	Brown hematite	Southeast district covering small deposits in Sainte Genevieve, Perry, and Cape Girardeau counties, and richer and larger bodies in Bollinger, Madison, Wayne, the southern part of Iron, Butler, and Stoddard counties. These deposits lie on the shales and limestones of Upper Silurian and partly on Second Magnesian limestone. Moselle, Franklin county, deposits on Third Magnesian limestone. Central ore region. Scattering beds in Crawford, Phelps, Dent, Pulaski, Maries, and Osage counties. On the Third Magnesian limestone. Osage district, the most important limonite ore district of State. Numerous banks along valley of Osage, in Osage, Miller, Camden, Morgan, Benton, and Saint Clair counties. They are on Third Magnesian limestone, excepting those on Upper Osage, which are on sub-Carboniferous. Southwestern ore region, in valley of White river and Ozark county. Brownsville, Saline county, and T. 34, R. 28, Cedar county, in Coal Measures.
Limonite (2)	Bog ore	In swamps and bogs, southeast counties, generally manganiferous.

MISSOURI—Continued.

Mineralogical name.	Common name.	Remarks.
Magnetite	Magnetic iron ore	Iron county, with specular ore in small quantity.
	Marble	Cape Girardeau, quarries formerly worked in Trenton and Niagara limestones; on Big creek, Marble creek and Stout's creek, Iron county, and on Marble creek and Leatherwood creek, in Madison county; also, in southeast part of Reynold's county. These marbles are of different colors—buff, gray, flesh-colored, red, and variegated. Limestones capable of high polish occur in Saint Louis, Saint Charles, Warren, Montgomery, Ralls, Callaway, Lincoln, Cooper, Pettis, Cass, Jackson, Clay, and Livingston counties.
	Millstone	Near Cedar creek, Cedar county; in Jasper and Newton counties, not utilized; White Oak mills, Vernon county, sandstone used for grindstone also; T. 31, R. 31, Barton county; Forest City. Holt county; granites of Ozark range in southeast part of State—formerly used.
Quartz	Sand, glass sand	"White sand cave," west of Sainte Genevieve; T. 42, R. 4, on Big river, Jefferson county; other localities in Perry, Saint Charles, Warren, Lincoln, near Elston and Marion, in Cole county; Saint Louis, Franklin, and Gasconade counties.
	Sandstone	Warrensburg, Johnson county, extensively quarried; near Miami, in Carroll county, these are in Coal Measures; north part of Atchison county; Brownsville, Saline county; Clinton, Henry county; Sainte Genevieve.
Smithsonite	Carbonate of zinc, "dry-bone."	Mine la Motte, Madison county; Valle mines, Saint François county; Frumet mine, Jefferson county, an immense vein; Granby mines in Newton county; Joplin district and Center creek district, in Jasper county; central lead district of State, in Moniteau, Morgan, Miller and Cole counties. Generally associated with blende and silicate of zinc and a valuable ore in southwest part of State.
Sphalerite	Zinc blende, "black jack."	In southeast lead district of State and also in central and southwest lead districts. In largest quantities in Granby and Joplin district in Newton county, and Valle mines in Jefferson and Saint François counties. Associated minerals are calamine, smithsonite, pyrite, chalcopyrite and barite. Worked as an ore of zinc at southwest. Other localities, where it occurs very sparingly.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asbolite	Earthy cobalt	Mine la Motte, Madison county, with lead ores, carrying 10–11 per cent. of nickel; St. Joe mines, Saint François county.
Asphaltum	Bitumen, mineral pitch	Joplin mines, Newton county, with galena or blende in limestone crevices; Center creek district, Jasper county, sparingly; Barton creek; Vernon county; Bates county; also in Ray, Lafayette, Jackson, Cass, and Johnson counties, but in small quantities.
Azurite	Blue carbonate of copper.	Lead mines, central part of State, in small quantity and accompanied by malachite; also at copper mines, with other ores of copper.
Chalcocite	Vitreous copper ore	Sainte Genevieve county copper mines, with copper pyrites, cuprite and carbonates, in small quantity.
Cobaltite	Cobalt glance	Mine la Motte, Madison county, with earthy cobalt and lead ores in clay slate; Saint Joe lead mines, Saint François county.
Gold	Gold	In drift sands of northern part of State, sparingly.
Greenockite	Sulphide of cadmium	Southwest part of State, with blende.
Gypsum	Gypsum	Vicinity of Knobnoster, Johnson county; Simsbury, Chariton county; common in blue shales of Carboniferous, sparingly.

MISSOURI—Continued.

Mineralogical name.	Common name.	Remarks.
Halite	Common salt, brines	Valley of Blackwater, Saline county; also in valley of Ferris creek and along Salt fork of Blackwater; Saline creek, Saint Genevieve county, abandoned salt works; Meramec, Jefferson county; salt formerly made here.
	Hydraulic limestone	Amazonia, Andrew county, limestone of Coal Measures; Saint Louis limestone in some localities.
Hydrozincite	Zinc bloom, earthy calamine.	Valle mines, Jefferson county; Granby mines, Newton county; and other localities in lead and zinc districts, with blende and smithsonite, but in too small quantity for economic working alone.
Kaolinite	Kaolin	Pilot Knob, Iron county, and elsewhere in southeast Missouri; in Coal Measures of central and northern parts of State.
—	Lithographic stone	Pike county; Ralls county.
Malachite	Green carbonate of copper.	Collins' diggings, Cooper county; Abbott and Gantt bank, Miller county, and other localities in central lead region, in small quantities; Mine la Motte, Madison county; Hinch's mine, Crawford county; Rives mine, Crawford county; Sainte Genevieve copper mines, Sainte Genevieve county (worked with other ores of copper); also in Dade, Green, Ozark, Wright, and Shannon counties.
Niccolite	Copper-nickel, arsenical nickel.	Mine la Motte, Madison county, accompanying lead ores in clay slate.
Niter	Saltpeter	Caves in Pulaski, Maries, Callaway, and Ozark counties. It occurs in second and in third magnesian limestones. No longer gathered.
	Ocher	Common in Coal Measures of western part of State, near Calhoun, Henry county; Knobnoster, Johnson county. Many exposures in this vicinity. Other localities in Atchison, Daviess, Livingston, Carroll, Jackson, Lafayette, and Henry counties. A red ocher at Amazonia, Andrew county, and at Hickman Mills, in Jackson county. Others in Ray, Buchanan, and Lafayette counties.
Pyrite	Iron pyrites	Southeastern Missouri lead district, with lead ores, also with copper ores; certain lead mines in the Joplin district, Jasper county, associated with bitumen; in lead mines of Central Missouri, but in small quantities; cupriferous. It occurs in large masses in T. 38, R. 9 W., Maries county, and in T. 22 N., R. 15 W., Ozark county.
Pyromorphite	Phosphate of lead, green lead ore.	Granby lead mines, Newton county, rare.
Siderite	Clay ironstone, carbonate of iron.	Near Clinton, Henry county; Grand river, Carroll county; Clear fork, Johnson county; in Vernon and Barton counties, in thin seams in Coal Measures; also in Phelps county; a thin seam.
	Silver	Very sparingly in lead ores. Mine la Motte, Madison county, galena has 4 ounces of silver per ton; other galenas average under 1 ounce.
Smaltite	Gray cobalt ore, speiss cobalt.	Mine la Motte, with lead ores and earthy cobalt, in clay slate; Saint Joe lead mines, Saint François county.

NEBRASKA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Clay	Louisville, Cass county, used for pottery; Dakota city, Dakota county; Webster county.
Coal	Bituminous coal, coal	Nebraska City, on Missouri, Otoe county, seam 15 inches thick in a boring. Rulo, Richardson county; Nuckolls bed in Otoe, Cass, and Johnson counties, 8 to 18 inches thick, worked for local use. Aspinwall, bed 24 inches thick. Lincoln, 30-inch seam struck in boring; T. 1 N., R. 13 E. of sixth meridian. Richardson county, seam 18 to 30 inches, opened and worked extensively.

NEBRASKA—Continued.

Mineralogical name.	Common name.	Remarks.
	Hydraulic limestone ..	Beatrice, cement manufactured from limestone.
	Limestone	Salem, Richardson county, quarries; other localities in Richardson county; Pawnee City, Pawnee county, cream-colored stone; Gage county, siliceous limestone; Johnson county, siliceous limestone quarried near Tecumseh; Brownsville, Nemaha county, opened and worked; Plattsmouth, Cass county, quarries worked; La Platte quarries, Cass county; Stout's quarry, on Platte, opposite South Bend; Syracuse, Otoe county, large quarries for use at Lincoln. "Chalk rock" used in Knox and Cedar counties.
	Sandstone	Brownville, Nemaha county. Fine-bedded, micaceous stone. Several quarries in center of county—opened; Dakota county, quartzite quarried.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

	Fire-clay..............	On Coal Measures of southeast part of State.
Galenite	Galena.................	Lead ore; galena only as float ore.
Gold	Gold....................	In sands of Platte river in minute quantities.
Gypsum	Gypsum................	Occurs crystallized in northern part of State, along Missouri bluffs near Niobrara on the Republican.
Halite	Common salt..........	Salt creek, Lancaster county, several springs.
Lignite	Brown coal............	Dakota and Dixon counties. Bed 6 to 16 inches thick in the Cretaceous.
Limonite.......	Brown hematite	In Dakota group, but too thin to be worked profitably.
	Lithographic stone ...	Near Syracuse, Otoe county.
	Marl....................	Abundant in western part of the State, along Republican, and south of Culbertson, on Niobrara; on Loup river.
	Ocher..................	Along Missouri from Plattsmouth to Brownville, large bodies of brown and yellow ochers; also along the Republican and on the Missouri in northwest part of the State.
	Peat....................	Widely distributed, Broome county, on the Loups and on their tributaries; on the Logan, T. 28 N., 1 and 2 E.; along tributaries at headwaters of Elkhorn, Blue, and Stinking rivers; many localities in west.
Sphalerite	Zincblende	Float ore found.

NEW HAMPSHIRE.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Bornite........	Purple copper ore	Wheeler hill, Littleton and Dalton in Grafton county, with chalcopyrite, opened for copper; Jackson, Carroll county, associated with copper pyrites and tin ore; Shelburne, Coos county, in copper and zinc ores.
Chalcopyrite ..	Copper pyrites, pyritous copper, yellow copper ore.	Gardner's mountain copper mines; Lyman, Bath, and Littleton, in Grafton county, with argentiferous galena, blende, and pyrite in massive bunches, with quartz. Ore belts are in upper Huronian rocks, Milan, Coos county, with pyrite, galena, and blende. Several openings for copper, Berlin, Coos county. Warren zinc mine, Grafton county, with galena and blende and pyrite in a bed of tremolite; Croydon, Sullivan county, large mass of copper and iron pyrites in gneissic rocks, opened. Neal mine, Unity, Sullivan county, with pyrite. Additional noteworthy localities are at Franconia, Haverhill, Lyme, Orford, and Monroe, all in Grafton county; Madison and Jackson, Carroll county; Plainfield, Sullivan county, and Westmoreland, Cheshire county; Shelburne, Coos county.

NEW HAMPSHIRE.—Continued.

Mineralogical name.	Common name.	Remarks.
	Flagging stone	Slates and schists quarried for local use at localities in Connecticut valley.
Galenite	Galena	Near Madison, Carroll county, argentiferous galena and zinc blende; Shelburne lead mine, Shelburne, Coos county. Galena associated with blende and pyrite, Gardner's mountain copper mines, Lyman. Galena highly argentiferous, blende and pyrite in fissure veins; gold mine at Lyman, Grafton county, in veins of quartz in clay slate, argentiferous; Stevens copper mine, Bath, Grafton county, vein of argentiferous galena; Canaan and Enfield, Grafton county. In minute quantities in pyrrhotite, Wakefield, argentiferous, recently opened (?).
Gold	Gold	Headwaters of Indian stream, Pittsburg, Coos county, in alluvial sands. Ammonoosic gold field; occurs with galena in quartz veins traversing Cambrian clay slates. Mines have been opened and worked in eastern Lyman; also in Bath, Grafton county. Occurs in quartzoze conglomerate rock of same formation at Lisbon and Landaff.
	Granite	Near Concord, Merrimack county, large quarries supplying a wide market. Stone known as "Concord granite" Hookset quarries, Merrimack county; Salem, Rockingham county; Gage's Mill, near Pelham, Hillsborough county, several quarries; Nashua, Hillsborough county; Milford, Hillsborough county, several quarries; Fitzwilliam, Cheshire county, a number of quarries; Troy, Cheshire county; Roxbury, Cheshire county, large quarries; Swanzey, Cheshire county; Plymouth, Grafton county; Manchester, Hillsborough county; Mason, Hillsborough county; Sunapee, Sullivan county; Farmington, Haverhill, Grafton county, quarries worked for nearly 100 years; Lebanon, Grafton county; Colebrook, Coos county; Stark, Coos county; a red granite worked at Saint Johnsbury mountain; immense undeveloped localities in White mountain region.
Graphite	Plumbago, black lead.	On Sunapee mountain, Goshen, Sullivan county; bed in mica schist has been worked for many years. Antrim, Hillsborough county, bed irregular thickness; Chester, Rockingham county, in veins in mica slate; Sutton, Merrimack county, in quantity; Mount Monadnock. Other localities of occurrence are towns of Barrington, Bedford, Troy, Walpole, Washington, Hillsborough, Keene, Wentworth, Oxford, &c.
Malachite	Green carbonate of copper.	Gardner mountain copper mines, Littleton, Lyman, and Bath, Grafton county; sparingly with azurite and copper pyrites.
Muscovite	Mica	Isinglass hill, Grafton county; a number of openings, which are worked steadily; Alstead, Cheshire county, long worked; Hoyt Hill, Orange county. Other mines are opened in Alexandria, Grafton county; New Hampton, Belknap county; Wilmot, Merrimack county; Marlborough, Cheshire county; Acworth, Sullivan county; Groton, Grafton county; Springfield, Sullivan county.
	Ocher	Hookset, Merrimack county. Other localities of bog iron ores of nature of ochers, not developed.
Quartz	Quartz	Lyndeborough, Hillsborough county; used for glass making. Abundant in range through Hillsborough, Rockingham, and Strafford counties; also from Cheshire to Grafton on west side of State.
Talc	Steatite, soapstone	Francestown, Hillsborough county; a large quarry, and worked for a long time actively. Weare, Hillsborough county; Warner, Merrimack county; Canterbury, Merrimack county, quarries here; Haverhill, Grafton county. These localities have been opened and worked. Other localities are in Richmond, Swanzey, and Orford.
Tripolite	Infusorial earth	Fitzwilliam, Cheshire county; a large deposit worked; Umbagog lake, Coos county; Stark, Coos county; Stamp Act island, Wolfborough, Carroll county; Tamworth, Carroll county. Other and smaller deposits are: Bemis lake, Livermore, Littleton, Laconia, Bristol, Chalk pond in Newbury, Epsom, Bow, Concord, Manchester, Durham, Grafton, and Exeter.

NEW HAMPSHIRE—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Amethyst	Amethyst	Surry, Mount Crawford, Waterville, Westmoreland.
Arsenopyrite	Mispickel	Jackson, Carroll county, with pyrites. In several towns along Connecticut river; in quartzites and schists in Francestown, Haverhill, Lebanon, Weare, Groton, Lisbon, Lyman, Middleton, and Alton.
Azurite	Blue carbonate of copper.	With other copper ores; Gardner's mountain mines, Grafton county, in small quantities.
Beryl	Beryl	Grafton, Grafton county; Acworth, Sullivan county, besides other localities.
Bismuth	Bismuth	Native; Sunapee mountain, near Newbury, Merrimack county.
Cassiterite	Tinstone, tin ore	Jackson, Carroll county, in veins traversing mica schist; ores associated with chalcopyrite, arsenopyrite, fluorite, molybdenite, and native copper; Lyme, in minute quantities.
Copper, native	Copper	Eastman's hill, Jackson, with copper ores; in small quantity (Carroll county); Lyman and Oxford, in dendritic forms.
Feldspar	Feldspar	Common in granitic rocks, particularly in range extending from Surry to Easton; in large masses; common.
Fluorite	Fluorspar	Westmoreland, Cheshire county; vein of considerable size; elsewhere of mineralogical importance only.
Galenite	Galena	Silverdale mine, Pittsfield, Merrimack county, with blende and pyrites in a quartzose vein; in gneissic rocks; argentiferous. Loudon, Merrimack county; Rumney, Grafton county, with blende, following veins of quartz; argentiferous. Other localities in North Woodstock, Hookset, Bath, Haverhill, Epsom, Nashua, Lyndeborough, Dunbarton, Tamworth, Sandwich, Lyme, &c.
Garnet	Red garnet	Hanover, Acworth, Grafton; all in granite, suitable for cutting.
Garnet (2)	Cinnamonstone	Franconia, Haverhill, Unity, Warren, Lisbon.
Hematite	Specular iron ore, red hematite.	Piermont, Grafton county; disseminated through quartzite and lean. Black hill, Benton, Grafton county; Bartlett, Carroll county, with magnetite; mines opened; apparently in small pockets. Franconia and Lisbon, in Grafton county, and Rindge, in Cheshire, are localities of occurrence.
Limonite	Brown hematite, bog ore.	Bedford, Hillsborough county, once worked; Amherst, Hillsborough county, once worked; Merrimack, Hillsborough county, once worked; Black mountain, Haverhill, Grafton county; and in small deposits at many other localities.
Magnetite	Magnetic iron ore	Ore hill Franconia mine, Lisbon, Grafton county, being in gneiss; mine abandoned; Piermont, Grafton county; Iron mountain, in Bartlett, Coos county, with hematite in veins in granitic rock; opened; Swanzey, Cheshire county, in granite, sparingly; Winchester, Cheshire county, beds of lean ore in gneiss; Jackson, Carroll county, veins in granite; Berlin, Coos county, Lebanon, Benton, and many other localities in small quantities as rock constituents.
	Marls	Lime pond, in Columbia, Coos county; Hollis, Hillsborough county.
Molybdenite	Sulphide of molybdenum.	Westmoreland, Cheshire county, in micaceous gneiss. Workings abandoned, though mineral is apparently abundant; Landaff, Grafton county; Franconia, Grafton county; and other localities of occurrence.
	Peat	Numerous localities, especially in northern part of State. A bog in Rochester, Stafford county, worked during war for manufacture of fuel.

NEW HAMPSHIRE—Continued.

Mineralogical name.	Common name.	Remarks.
Pyrite	Iron pyrites	Croydon, Sullivan county. Long vein of mixed pyrite, pyrrhotite, and copper pyrites in gneiss; worked. Neal mine, in Unity, Sullivan county; a long outcrop of iron and copper pyrites, in gneiss. Gardner mountain copper mines, in Littleton, Bath, and Lyman, in Grafton county. Shelburne lead mines, Coos county, with galena and blende; Warren mine, Warren, Grafton county, with blende; Haverhill, Grafton county; Monroe and Lebanon, Grafton county; Enfield, Grafton county; Richmond, Cheshire county; Moultonborough, Carroll county; Claremont, Sullivan county; besides many localities, sparingly.
Pyrolusite	Oxide of manganese	With rhodonite (silicate of manganese) in Winchester and Hinsdale, Cheshire county. In small quantity. Rhodonite bed large.
Pyrrhotite	Magnetic pyrites	Croydon, Sullivan county; a large deposit associated with chalcopyrite and blende. In considerable quantity in Enfield, Orford, Haverhill, East Hanover, Lyman, and Grafton, all in Grafton county.
	Slate	Quarries opened in Littleton, Hanover, and Lebanon, in Grafton county; also in Croydon mountain, Cornish, Sullivan county.
Sphalerite	Zincblende	Madison lead mine, Grafton county, with galena in quartzite; Warren mine, Warren, Grafton county, worked for long time for zinc ore; Gardner's mountain, Lyman, Grafton county, with galena; Shelburne lead mine, Coos county, also a black blende. Other localities are: Haverhill, Rumney and Monroe, all in Grafton county; Croydon, Sullivan county, with copper and iron pyrites.
....	manganese	Occurs in some of bogs, with limonite.

NEW JERSEY.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Calamine	Silicate of zinc	Sterling hill, Sussex county.
	Conglomerate and sandstone.	The Green-pond mountain conglomerate is a most durable and beautiful building material, and is abundant in Passaic and Morris counties. Potsdam sandstone is quarried at Oxford furnace, near Washington and Danville in Warren county, and at Franklin furnace in Sussex county.
	Flagging stone	Quarried at Flagstone hill, Sussex county, Milford on the Delaware; and Woodsville, Mercer county, Bearport mountain, Passaic county.
Franklinite	Franklinite	Sterling hill and Mine hill, Sussex county; important ore of zinc mines.
	Fire-clay	Woodbridge, north shore of Raritan, Perth Amboy, South Amboy, Sayreville in Middlesex county clay district, along Delaware river, Florence, Burlington county, Pensauken creek, Camden county, and generally in belt crossing State from Raritan bay and Staten Island sound to Delaware river in Burlington and Camden counties.
Granite (gneiss)	Granite	Common in Archæan highlands. Quarries—Dover, Morris county, near Franklin and near Lockwood in Sussex county, Bloomingdale and Charlotteburg, Passaic county, near Port Murray and Washington in Warren county.
Graphite	Black lead, plumbago	Mine near Bloomingdale, Passaic county, worked; mine near Peapack, Somerset county, abandoned; in gneiss at Chester, Morris county; High Bridge, Hunterdon county, localities near works, but idle. Elsewhere common in gneiss; sparingly disseminated.
Hematite	Red iron ore, red hematite.	Marble mountain, Bridgeville, Warren county; Edsall, Simpson and Cedar hill mines, Sussex county, not worked; also in some magnetic ore mines.
	Hydraulic limestone	Limestone of Water-lime group occurs in Nearpass bluff, Montague, Sussex county. It is not quarried.

NEW JERSEY—Continued.

Mineralogical name.	Common name.	Remarks.
Kaolinite	Kaolin	See localities under "fire-clay."
Limonite	Brown hematite	Mines in Sussex, Warren, and Hunterdon counties, at numerous localities; Beatyestown and Carpentersville; the most important ore occurs in and near Magnesian limestone. Bog iron ore in many localities in southern part of State and near Mount Hope, Morris county; no longer worked.
Magnetite	Magnetic iron ore	Many mines in Passaic, Morris, Sussex, Warren, and Hunterdon counties. Ore occurs in beds interstratified with gneissic rocks (Archæan). Large mines at Ringwood, Hibernia, Mount Hope, near Dover, Hurdtown, near Danville, Oxford, West End, &c., &c.
Marble	Marble	Rose-crystal marble, Jenny Jump mountain. White marble, Marble mountain, Upper Harmony, Warren county. Verd antique, near Montville, Morris county; Augusta, Sussex county. These are not worked to any extent.
	Marl	Greensand marls are found throughout a belt 90 miles long from Sandy Hook and the Atlantic to Salem on Delaware Bay. They are dug everywhere in this belt and used as a fertilizer. Calcareous marls occur in Cumberland county, at Stow creek; also at many places in Warren and Sussex counties in form of shell marl.
	Sandstone or freestone	Quarries in Red Sandstone district at many localities. More important at Paterson, Little Falls, Belleville, Newark, Orange, Washington Valley, Princeton, Greensburg, Stockton, and Mliford. [Potsdam sandstone. See "Conglomerate."]
	Slate	Several quarries opened and worked for a time in Sussex and Warren counties. Most important are at Lafayette and Newton, Sussex county, and Delaware water gap, Warren county.
Smithsonite	Carbonate of zinc	Coating on zincite in mines, Franklin, Essex county.
Willemite	Silicate of zinc [troostite.]	Zinc mines, Stirling hill and Mine hill, Sussex county.
Zincite	Red oxide of zinc	Zinc mines, Stirling hill and Mine hill, Sussex county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Apatite	Phosphate of lime	Hurdtown, Morris county, with magnetite and pyrrhotite; Mine hill, with magnetite, forming a bed of ore, Morris county; elsewhere in small quantity in Archæan district.
Arsenopyrite	Mispickel	Jenny Jump mountain, Warren county.
Asbestus	Asbestus	Montville, Morris county.
Azurite	Carbonate of copper, blue carbonate of copper.	Copper mines, Belleville, Essex county, with other ores of copper; Raritan mine; Bridgewater mine; Griggstown copper mine, Somerset county, and other mine holes and copper mines in the Red Sandstone district.
Barite	Barytes, heavy spar	Near Newton, Sussex county; Hopewell, Mercer county; near New Brunswick, openings; deposits too small for profitable working.
Brucite	Hydrate of magnesia	Hoboken.
Chalcopyrite	Copper pyrites	Belleville, Essex county; Somerville, Griggstown, and other places in Red Sandstone district; also, Jenny Jump mountain, Warren county, in gneissic rocks.
Chrysocolla	Silicate of copper	Copper mines in Red Sandstone district.
Coal	Bituminous coal	Few localities, in thin seams, not workable.
Copper (native)	Copper	Copper mines in Red Sandstone district; New Brunswick, in shale; Somerville, in shale.

NEW JERSEY—Continued.

Mineralogical name.	Common name.	Remarks.
Cuprite	Red oxide of copper	Copper mines in Red Sandstone district.
Erubescite	Variegated copper	Copper mines in Red Sandstone district.
Galenite	Lead ore, galena	Sussex lead mine and Andover iron mine, Sussex county, in small quantities. German Valley, Morris county, with limonite.
Garnet	Garnet	Franklin, Sussex county.
Lignite	Brown coal	Jacksonville, Middlesex county, bed four feet thick in clay; elsewhere in clays, but not in sufficient quantity for mining.
Magnesite	Carbonate of magnesia, brown spar.	Hoboken, with serpentine.
Malachite	Green copper ore, carbonate of copper.	Copper mines of Red Sandstone district; Pahaquarry, Warren county, mine now abandoned.
Molybdenite	Sulphide of molybdenum.	Hude mine, Sussex county, in small quantities.
Muscovite	Mica	Mine near Broadway, Warren county, abandoned; near Uniontown, Warren county. Also common as rock constituent.
Pyrite	Pyrites, iron pyrites	Many localities, but nowhere worked. Brasscastle, Warren county, carrying traces of nickel; Jenny Jump mountain, Warren county, &c., &c.
Pyrrhotite	Magnetic pyrites	Hurdtown, Morris county, unimportant.
Sapphire	Sapphire	Blue variety near Sparta, Franklin, and Vernon, Sussex county.
Serpentine	Serpentine	Montville, Morris county, with chrysotile; Marble mountain, Morris county; other localities with calcite, in Archæan.
Silver, native	Silver	Occurs in copper ores in Bridgewater, Belleville, and other copper mines of the Red Sandstone formation. Too minute quantities for extraction profitably.
Sphalerite	Blende, zincblende	Andover mine, Sterling Hill, Sussex lead mine, Sussex county; near Oxford, Warren county; at none in workable quantities. German valley, Morris county.
Succinite	Amber	In Greensand marl, southern part of State.
Talc	Talc	Marble mountain, Warren county; other unimportant localities.
Tripolite	Infusorial earth	Drakesville, Morris county; used formerly for manufacture of giant powder; near Andover, Sussex county; neither locality now worked.

NEW YORK.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Asbestus	Asbestus	Near Tomkinsville, in Serpentine hill, Staten Island. Worked at intervals for a long time; also found at Stony point, Rockland county; on Hudson, Phillipstown, Putnam county; Patterson, Putnam county; near Greenwood furnace, Orange county.
Feldspar	Feldspar	Chester, Warren county; High Island, near Alexandria, Jefferson county; Tarrytown, Westchester county; at numerous other localities in crystalline rock.
	Fire-clay	Near Rossville, Staten Island, used largely in manufacture of firebrick; near Glen cove, Roslyn, and Northport, on north shore of Long Island.
	Flagging stone	[See under "Sandstone."]

NEW YORK—Continued.

Mineralogical name.	Common name.	Remarks.
	Granite	Highlands of Hudson, and in Adirondack region of northern New York. Quarries on Hudson river at Stony Point, Orange county, and north of West Point; north of Cold Spring, Break Neck mountain, Putnam county; large quarry on Grindstone island, Jefferson county. Inexhaustible amount in Adirondack region undeveloped.
Graphite	Plumbago, black lead.	Mines in Hague, Warren county; Ticonderoga, Essex county, a noted locality and long worked; Johnsburg, Warren county; south of Fishkill Landing, Dutchess county; near Peekskill, Westchester county; near Saranac river, Clinton county; localities opened and worked. Others are: Duck Cedar pond, Orange county; near Carmel, Putnam county; Fort Ann, Washington county; common in crystalline limestones of Archæan.
Gypsum	Gypsum, plaster	Quarries south of Erie canal, in Lenox, Sullivan, and Smithfield, and Stockbridge townships, Madison county; near Camillus, Manlius, Marcellus, and Dewitt, in Onondaga county; very large quarries, and worked actively; Brutus, Mentz, and Springport towns in Cayuga, also large quarries; Seneca Falls, Seneca county; in towns of Le Roy, Stafford, and Elba, in Genesee county; in Phelps and near Victor in Ontario county; Lockport, Niagara county; also in southern part of Monroe, in Wayne, in Livingston, in Tompkins, in Oneida, and (in Stark) in Herkimer counties. In Onondaga and Water-lime groups.
Halite	Common salt, rock salt, brine springs.	Rock salt occurs in Warsaw, Wyoming county. Brine springs or salines are known from Oswego county west to Niagara river, at numerous localities. Most celebrated are at Syracuse, Salina, Geddes and Liverpool, Onondaga county. Others are at Montezuma, Cayuga county; Galen, Wayne county; Elba, Genesee county; and in Orleans, Monroe and Livingston counties.
Hematite	Specular iron ore, red hematite.	Gouverneur, Fullerville, Saint Lawrence county; Philadelphia and Antwerp, Jefferson county; productive mines. Occurs in Hermon, Edwards, Fowler and Canton, in Saint Lawrence.
Hematite (2)	Fossil ore, lenticular clay iron ore.	Verona, Westmoreland, New Hartford and Clinton, Oneida county; Ontario, Wayne county, working mines. Also, occurrences in Madison county, in thin beds.
	Hydraulic limestone, cement rock.	Very large quarries (and mines) in Kingston, near Rosendale, at Lawrenceville, Whiteport and High Falls, along valley of Rondout creek, in Ulster county. Quarries at Howe's cave, Schoharie county; Fayetteville, Manlius and Jamesville, Onondaga county; and at Akron, in Erie county. The formation crops out in many localities from Schoharie west to Niagara river and eastward in Herkimer, Montgomery and Albany counties.
Kaolinite	Kaolin, porcelain clay.	East Fishkill, Dutchess county; Athol and Johnsburg, Warren county; near McIntyre, Essex county; and near Southold furnace, Orange county. First-named is only one worked.
	Limestone	Kingston, Ulster county, extensive quarries; Catskill, Greene county; Glen's Falls, Warren county; Sandy Hill, Washington county; Crown Point and Burlington, Essex county; Amsterdam, Tribes Hill and Canajoharie, in Montgomery county; Howe's Cave and Cobbleskill, Schoharie county; Prescott, Oneida county; Lowville, Lewis county; Fairmount, Manlius, Onondaga, Onondaga county; Auburn and Union Springs, in Cayuga county; Waterloo, Seneca county; Rochester, Monroe county; Lockport, in Niagara county; Buffalo and Williamsville, in Erie county; Leroy, in Genesee county. The quarries in Montgomery, Saratoga, Warren, Essex, Clinton, and Lewis counties are in Trenton limestone; the Niagara limestone is the horizon for the quarries of Monroe and Niagara counties; the Onondaga, in Onondaga, Cayuga, and Seneca counties; the Lower Helderberg, in Schoharie county. The magnesian limestone (calciferous) is quarried for local use at many points in Orange county, and the Helderberg in the Hudson Valley. [For other limestones see "Marble."]
Limonite	Brown hematite	East Fishkill, Sylvan lake, Beekman, Bowling, Dover, Unionvale, Amenia, Sharon, Millerton and Mount Riga, in Dutchess county; Copake, Ancram and Boston Corners, in Columbia county; mines at these localities producing largely. Townsend mine, Cornwall, Orange county; Castleton Four Corners, New Dorp, and Toad Hill, Staten Island.

NEW YORK—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite (2)	Bog iron ore	Numerous localities and many small deposits in northern and eastern parts of State. Formerly worked to small extent, but now abandoned. (?)
Magnetite	Magnetic iron ore	Two principal districts—(1) Highlands or southeastern, (2) northern New York or Adirondack. In the first, mines largely worked at Sterling, near Greenwood, and Forest of Dean, besides many smaller mines in Orange county; numerous openings in northern part of Westchester and southwestern and central part of Putnam, on east of the Hudson (Croft's, Mahopac, Theall, Brewster's, &c.). In northern part of State ore occurs at many localities in Washington, Saratoga, Warren, Essex, Clinton, Franklin, Saint Lawrence, Lewis, Herkimer, and Fulton counties. Mines worked at Mount Hope in Washington, near Crown Point, Paradox lake, in vicinity of Port Henry in Essex county, with very large deposits unworked at Adirondack and in Westport; Palmer hill, Arnold ore bed, and Chateaugay in Clinton county; Clifton (idle) in Saint Lawrence county; occurrences are noted in Jefferson county also. Magnetic iron sand is found to some extent on northern shore of Long Island, on western shore of Lake Ch.mplain, and on Hudson and smaller streams in northern part of State. An aluminous magnetic iron ore occurs near Peekskill, Westchester county; self-fluxing; not now worked, though in large deposits.
	Marl	Calcareous marls occur in many localities and widely diffused. Dutchess, Columbia, Orange, Ulster, Greene, and Albany counties have many small deposits; in central and western New York large deposits are in Onondaga and Madison counties, particularly the Conasalon swamp; in Cayuga, Wayne, Seneca, Ontario, Monroe, Genesee, Niagara counties, material at a very few points used as a fertilizer.
	Marble	Tuckahoe, West Farms, Eastchester quarries, in Westchester county, largely worked; Sing Sing, on Hudson; Patterson, Putnam county; Dover, Dutchess county; Becraft's mountain, near Hudson ("coral-shell marble"), extensively quarried; Glen's Falls, Warren county, a black marble; Plattsburg, Essex county; Gouverneur, St. Lawrence county, quarried in large amount for "western trade"; quarries formerly worked at Kingsbridge, New York. The white, crystalline limestones of the Highlands and of northern New York afford many outcrops.
Petroleum	Petroleum	Four-mile district, Cattaraugus county; northeast extension of the Bradford oil region.
	Peat	Widely-distributed localities; not utilized excepting as a fertilizer.
Quartz	Quartz	Fort Ann, Washington county, quarried for manufacture of wood filling; large, massive outcrops in Shawangunk mountains, Ulster and Orange counties; also at Chatham, Columbia county.
Quartz (2)	Sand	Cleveland and Bernhard's Bay, Oswego county; and near Durhamville, Verona, and Dunbarton, in Oneida county, all on or near shore of Oneida lake.
	Sandstone	Nyack, Rockland county (Triassic beds); Haverstraw, Rockland county (Triassic beds); Aqueduct quarries, near Schenectady; Moira and Bangor, Franklin county; Potsdam and Hammond, Saint Lawrence county (noted Potsdam sandstone), extensively quarried; Oneonta, Otsego county; Gifford and Smithville, Chenango county; New Hartford, Oneida county; Brockport, Monroe county; Albion, Hulburton, and Medina, in Orleans county, producing the widely known "Medina sandstone"; Lockport, Niagara county; Warsaw and Castile, Wyoming county; Jamestown, Chautauqua county; Olean, Cattaraugus county; Belfast, Allegany county; Corning, Steuben county; Watkins, Schuyler county; Othaca and Trumansburg, Tompkins county.

NEW YORK—Continued.

Mineralogical name.	Common name.	Remarks.
	"Bluestone"	Very many quarries in the Hudson river valley, in Kingston, Woodstock, Hurley, Olive, Marbletown, Shandaken, and Saugerties township, Ulster county; and in Catskill, Greene county; in Berne and Westerlo, Albany county. They yield a large aggregate of the well-known "Hudson river bluestone." The same formation is worked in vicinity of Middleburg, in Schoharie county, and in the Helderberg mountain, in western part of Albany county. Near the Delaware it is quarried near West Brookville, Sullivan county; at Pond Eddy and Barryville, same county. Other localities are in the Catskill region, in Delaware county, along line of Ulster and Delaware railroad. Flagging stone is obtained from the Chemung group, in Tompkins and Chemung counties; at Atwater, Cayuga county; Covert, Seneca county; Warsaw, Wyoming county, and Olean, Cattaraugus county. Other stones are employed for flagging also, *e. g.*, the Medina sandstones, the Lockport sandstones, &c.
Siderite	Spathic iron ore, carbonate of iron.	Near Catskill station and Linlithgo, Columbia county, an immense deposit being developed; Napanock, Ulster county, formerly worked; in Dutchess county in small quantity; Antwerp, Jefferson county, in crystals only.
	Slate	Granville, Washington county, and Hampton and Salem, same county, several quarries.
Talc	Steatite, soapstone	Gouverneur, St. Lawrence county, quarries; near Tompkinsville, Staten island, in serpentine; near Amity, and also near Monroe, in Orange county; near Peckville; Fishkill, Dutchess county, a large bed opened.
	Trap rock	Quarries for Belgian paving stone, Graniteville, Staten island; Rockland lake, Rockland county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Apatite	Phosphate of lime	Hammond, Saint Lawrence county, crystalline, with calcite, zinc ore and feldspar; near Gouverneur, Saint Lawrence county, crystals in calcite; Vrooman lake, Jefferson county; Greenfield, Saratoga county; near Hammondsville, Essex county; with magnetite in some of iron ores near Port Henry. Other localities of occurrence.
Arsenopyrite	Mispickel, arsenical iron.	Near Edenville, Orange county, with arsenical iron and orpiment, in a vein in white limestone; near Pine pond in Kent, and near Boyd's Corner, Putnam county. These localities have been opened, but not worked for arsenic.
Barite	Barytes, heavy spar	Ancram, Columbia county; near Schoharie Court House, with strontianite, in Water-lime group; Carlisle, Schoharie county; near Little Falls and Fairfield, Herkimer county; near Syracuse, Onondaga county; Pillar Point, Jefferson county, in large veins; Hammond and De Kalb, Saint Lawrence county.
Calcite	Calcareous tufa, travertine.	Vicinity Scoharie Court House, Scoharie county; Sharon springs, a large deposit; Howe's cave, Schoharie county; near Catskill, Greene county; head of Otsquaga creek, Stark, Herkimer county; Saratoga Springs; near Syracuse and in Onondaga valley, Onondaga county; between Camillus and Canton, same county; near Arkport, Steuben county; near Ellicott's mills, Erie county; and many lesser deposits.
Cerussite	Carbonate of lead, white lead ore.	Rossie, Robinson, Ross, and other lead mines, in Saint Lawrence county; Martinsburg, Lewis county; near Sing Sing, on Hudson, associated with galena, in small quantity.
Chalcopyrite	Copper pyrites, pyritous copper.	Ancram lead mine, Columbia county; Bockee mine, Columbia county; near Edenville, Orange county, with arsenopyrite; near Wurtsborough, Sullivan county, with galena, in considerable abundance; Ellenville and Red Bridge lead mines, Ulster county; near Rossie, and also near Canton, in Saint Lawrence county, once worked. Many additional occurrences are reported where it is in small quantity.

NEW YORK—Continued.

Mineralogical name.	Common name.	Remarks.
Chromite	Chrome iron ore	In serpentine, Philliptown, Putnam county; Wilk's mine, Monroe, Orange county.
Coal	Coal	Woodstock, Ulster county, thin vein in Catskills, worked out; in the seams interstratified with shales, in Chautauqua, Erie, Livngston and Seneca counties.
Cuprite	Red oxide of copper	Near Ladentown, Rockland county, in thin seams, in traprocks.
Fluorite	Fluorspar	Muscalonge lake, Alexandria, Jefferson county, very fine crystals; Lowville, Lewis county; Niagara county, at Lockport; Auburn, Cayuga county; Rossie and Mineral point, Saint Lawrence county. Nowhere in quantity to be of much economic importance.
Galenite	Galena	Otisville, Orange county; Ellenville and Red Bridge, Ulster county; with copper pyrites and blende in a gangue of quartz in Oneida conglomerate, mines no longer worked; Wurtsborough, Sullivan county; near Sing Sing in Westchester county; northeast township, Dutchess county; Ancram, Columbia county; strings of galena, blende and pyrites in limestone; White Creek, Washington county; Martinsburg, Lewis county; Spraker's Basin, Montgomery county; Rossie and vicinity, St. Lawrence county; mines largely worked years ago; ore occurs in vein with blende, pyrites, and copper pyrites. These mines have all been idle for several years.
Lignite	Brown coal; wood coal	Near Rossville, Staten Island, thin seam in clay. Also in Suffolk county in clays.
Magnesite	Carbonate of magnesia	Near Rye, Westchester county; Warwick, Orange county; New Rochelle, Westchester county; Stony Point, Rockland county; Serpentine hills, Staten Island; everywhere in thin seams and strings. Not worked.
Menaccanite	Titanic iron	Edenville, Monroe, and Greenwood, Orange county, in small quantity; associated with magnetite in some of magnetic iron ore beds in Essex and Clinton counties.
Millerite	Sulphide of nickel	Sterling iron mine, Antwerp, Jefferson county, famous for crystalline forms.
Molybdenite	Sulphide of molybdenum.	West Point and near Warwick, Orange county; Phillip mine, Putnam county; Clinton county, but sparingly, in granitic rocks.
Muscovite	Mica	As a rock constituent, common. In large plates near Warwick and at Greenwood at Mount Basha pond, in Orange county; Pleasantville, Westchester county, once opened and mined; Henderson, Jefferson county; Potsdam and Edwards in Saint Lawrence county.
Petroleum	Rock oil, "Seneca oil"	Seneca oil spring, Cuba, in Allegany county; Fredonia and Laona in Chautauqua county; Seneca lake, Seneca county; Cauquaga creek, Erie county; oil-bearing territory in parts of Chautauqua, Cattaraugus, Allegany and Steuben counties.
Pyrite	Pyrites, iron pyrites, "sulphur."	Anthony's nose, Montgomery, Westchester county, mine formerly worked; Phillip ore bed, Philliptown, Patterson, southeast of Carmel and near Ludington mills, in Putnam county; with galena at Wurtsborough lead mine, Sullivan county; Flat Creek, Montgomery county; near Canton, Saint Lawrence county, in extensive beds; Duane, Franklin county, large bed; Matinsburg, Lewis county; Eighteen-mile creek, Erie county; and many other localities, sparingly in rocks.
Serpentine	Serpentine	Staten Island, Richmond township; Tompkinsville, near New Rochelle and near Rye, Westchester county; Philliptown, Putnam county; near Amity, Orange county, verdantiane; Johnsburg and Warrensburg, Warren county; Shelving rock, Lake George, Washington county; Gouverneur, Fowler, Edwards, and Pitcairn townships, in Saint Lawrence county; other localities of occurrence in small quantity.

NEW YORK—Continued.

Mineralogical name.	Common name.	Remarks.
Sphalerite	Zincblende	Associated with galena at lead mines in Sullivan, Ulster, and Orange counties; Ancram, Columbia county; Flat creek, Montgomery county; Salisbury, Herkimer county; Martinsburg, Lewis county; Cooper's Falls, Mineral Point, and in Fowler, Saint Lawrence county. Generally not in sufficient quantity to be worked as an ore.
Wad...........	Earthy manganese, bog manganese.	In town of Austerlitz, Columbia county, are several localities; also in Hillsdale and Canaan, same county; smaller deposits near Houseville, Lewis county, and southeast of Warwick, Orange county.

NORTH CAROLINA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Agalmatolite ..	"Soapstone"	In Huronian rocks in a range crossing Chatham and Montgomery counties. Worked for use in wall paper, soaps, &c.
Agate	Agate	Moss agate near Hillsborough, in Orange county; agates near Harrisburg and Concord in Cabarrus county; also in Mecklenburg county.
Asbestus	Asbestus	Near Bakersville, Mitchell county, very fine; southern part of Jackson county, fine and fibrous; near Baker mine, in Caldwell county; Nautelsh river, Macon county; Brushy mountains, and many other localities.
Argentite......	Vitreous silver, silver glance.	Silver Hill, Davidson county; McMakin mine, Cabarrus county, in small quantities with silver (native); also in slates, Montgomery county; Cheek mine, Moore county; Higdon's mine, Swain county.
Bornite	Variegated copper ore, purple copper ore.	Clegg's mine, Chatham county; Peach Bottom mine, Alleghany county; Gap Creek mine, Ashe county; near Concord, Cabarrus county; Gardiner Hill mine, Guilford county. At these localities with other copper ores.
Barite	Barytes, heavy spar ..	Crowder's mountain, Gaston county, in a bed seven feet thick; Chandler's, near Marshall, Madison county; Latta mine, near Hillsborough, Orange county; localities in Cabarrus, Union, Wilkes, and other western counties.
Chalcocite	Vitreous copper, copper glance.	Ore Knob mine, Ashe county; Gap mine creek, Ashe county; Waryhut and Wolf Creek mines, in Jackson county; Gillirs and Mill creek mines, in Person county; Pioneer Mills mine, Cabarrus county; Nichol's, Swain county.
Chalcopyrite...	Copper pyrites, yellow copper ore, pyritous copper ore.	The principal copper ore of copper mines in the State. Occurs with pyrite and other sulphurets in gneissic and hornblende slate rocks in copper belt of Ashe and Alleghany counties; Gardiner Hill mine, Guilford county; in the gold mines of Guilford, Cabarrus, Mecklenburg, and Davidson counties; also those of Union, Rowan, and Gaston counties; Macphelor Church, Lincoln county; near Hillsborough and Chapel Hill, in Orange county: near Raleigh, Wake county; in Granville, Surry, Yadkin, Macon, Mitchell, Swain, and other counties, but sparingly; Clegg mine, Chatham county; Waryhut, Cullowhee, Savannah, and other mines in a copper belt in Jackson and Haywood counties; Elk Knob and Gap Creek mines, in Watauga county; Ore Knob mine, Ashe county; Peach Bottom mines, Alleghany county.
Coal	Coal	Deep river coal field on Deep river, in Chatham and Moore counties. Mines at Egypt, Farmville, and the Gulf. Five seams from 1 to 7½ feet thick. Bituminous and semi-bituminous. One seam at Evans' Mills is anthracite. Dan river coal field is in Rockingham and Stokes counties. It is opened by mines at Leaksville, in Rockingham county, where the seam worked is three feet thick; and at Germantown, Stokes county, where there are two seams each 18 inches thick, separated by shale one foot thick. Coal is semi-bituminous.
Copper (native)	Copper	In small quantities in several copper mines; also in quartz and epidote rock at Harris mountain, Person county, and Wolf creek, Jackson county.

NORTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Corundum	Emery	Near Franklin, on Cullasaja hill; Jacob's and Hassett's mines, on Elijah creek; at Robinson's mine, on Sugartown fork, in Macon county. In large beds; worked extensively. Buck creek, Clay county; near Bakersville, in Mitchell county; many localities in the chrysolite rock range in western counties; also in Guilford titaniferous magnetite range.
Cuprite	Red oxide of copper	At many of the copper mines, near the surface; Caldwell, Lincoln, Alleghany, and Ashe counties; Clegg's mine, Chatham county; Waryhut mine, Jackson county; McGinn mine, Mecklenburg county; copper mines of Guilford county.
Galenite	Galena, lead ore	Silver hill, Davidson county, with blende, native silver, &c. Argentiferous, and worked for silver: Hoover and Boss mines, Randolph county; McMakin mine, Cabarrus county; Long mine, Union county; with blende, argentiferous, also limonite mine, same, King's mountain, Causler, Shuford, and Long creek mines, in Gaston county, with blende; with gold ores, Murphy, Cherokee county; Beech mountain, Watauga county, several localities. Highly argentiferous: Flint knob, Wilkes county; other localities in Caldwell, Burke, Union, Chatham, Alleghany, Macon, Swain, Surry, and Montgomery counties.
Gold	Gold	Many localities. It occurs in quartzose veins, with limonite, pyrite, chalcopyrite, and other minerals in gneissic, granitic, chloritic, talcose, and other crystalline rocks of Laurentian and Huronian ages; also in soils, decomposed rocks, and gravels. The principal gold-bearing belt traverses the central part of the State and the counties of Guilford, Randolph, Davidson, Rowan, Cabarrus, Mecklenburg, and Stanley and Gaston are in it. The Gold Hill mine, in Rowan county; King's Mountain mine, in Gaston county; North State mine, in Randolph county; the mines about Lexington, in Davidson county; the Rhymer, Bullion, Dunn Mountain, Southern Belle, and Yadkin mines, in Rowan county; the Concord mines, in Cabarrus county; the Charlotte district, in Mecklenburg county, are the more important localities. Many of them are now working. Auriferous gravels occur over large areas in Franklin and Nash counties at the east, and in the western part of the State in Montgomery, Burke, McDowell, and Rutherford counties. The Portis mine, in the former, and the gravel deposits on the headwaters of First and Second Broad rivers, Muddy creek, and Silver creek, in the latter, are the most noted localities. Gold-bearing gravel districts are also in Caldwell county, Polk county, and on the west of the Blue Ridge, in Cherokee, Jackson, and Watauga counties.
	Granite	Common, except in eastern section of State. Many localities where quarried. Near Raleigh, Wake county; Hendersonville quarry, Granville county; along Wilmington and Weldon railroad, in Edgecomb and Wilson counties; Dunn's mountain, near Salisbury, Rowan county, a white granite and of great extent; large quarries. Other quarries along railroad lines in the granite belt of Piedmont and mountain sections in Henderson, McDowell, Caldwell, Iredell, Gaston, Richmond, Anson, and other counties.
Graphite	Plumbago, black lead	Widely distributed in Laurentian and Huronian rocks. Wake county, beds 2½ miles west of Raleigh; a range 16 to 18 miles long, from northeast to southwest; two beds each, from two to four feet thick. Eastern one is worked extensively. Graphite occurs in quartzitic and talco-argillaceous slates; impure beds in a range in Gaston, Lincoln, and Catawba counties opened near Catawba station, in Catawba county; near Briar's springs, Cleveland county; others in Stokes, Person, Yancey, Alleghany, and Johnson counties.
Hematite	Specular iron ore, red iron ore.	Near Gaston, Halifax county, beds in Huronian slates, opened and of considerable extent; Evans's and Kelley's ore beds, Ore Hill; Buckhorn mines, in Chatham county; latter a large deposit of manganiferous iron ore; near Haywood, Chatham county, beds in red sandstone and with limonite; Chapel Hill, Orange county, large veins in grey granite and syenite, opened but idle; Mount Tirzah, Person county, vein worked during the war; near Franklinville, Randolph county; near Ashborough, Randolph county; near Troy, Montgomery county; Hopewell, Mecklenburg county, much loose ore on surface.

NORTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Itacolumite....	Flexible sandstone...	Linville, Burke county; Sauvatorore mountains, Stokes county; Bending Rock mountain in Wilkes county.
	Limestone............	Belt crossing Stokes, Catawba, Lincoln, and Gaston counties. Quarries for local use. Nantahalah river and valley river, in Cherokee county.
Limonite......	Brown hematite......	Large beds at Ore hill, Chatham county; near Smithfield, Johnston county; High shoals, Gaston county; in Lincoln and Catawba counties; Cherokee county at Nottla and along Valley river; many valuable beds in a northeasterly direction from Jacobi fork of Catawba river, in Burke county, to Brushy mountains, in Wilkes county. Many localities have been worked; Linville mountains, McDowell county; Mitchell, Buncombe, Watauga, McDowell, Surry, Haywood, Macon, Henderson, Transylvania, Davidson, Wake, and other counties; Ore knob copper mines, Ashe county, accompanying copper lodes in upper part.
Limonite (2)...	Bog iron ore..........	Many deposits in eastern part of State, in New Hanover, Duplin, Jones, Nash, Pender, and other counties.
Magnetite.....	Magnetic iron ore.....	Magnetite occurs in the Laurentian and Huronian formations in central and western parts of State at many localities. Those important are: Near Gaston, Halifax county, with specular ore; near Tar river, Granville county, beds in Huronian rocks; Pegram mine, Chatham county; ore belt from headwaters of Abbott's creek, in Davidson county, northeast through Guilford county to Haw river, in Rockingham county, titaniferous magnetic ore opened at several points; Mecklenburg and Cabarrus counties; ore range from King's mountain, on southeast border, to Anderson mountain on Catawba river, in Catawba county; Big, Yellow Ridge, Ferguson, Ellison, and Costner, and other ore banks in Gaston, Lincoln, and Catawba counties; ore ranges from near Danbury, in Stokes county, and from near Virginia line in Surry county, southwest to Yadkin and Davie counties; Hobson mines, Big ore bank, and others in it; near Patterson, Caldwell county; Cranberry ore bank, on western slope of Iron mountain, in Mitchell county, a great extent of rich ore long worked in open quarries; Rock creek, foot of Roan mountain, Mitchell county; near Jefferson, Ashe county; western slope of Black mountain, in Madison county; Wilkins creek in Haywood county; also, in large beds, in Jackson, Macon, Iredell, and Swain counties.
Malachite......	Carbonate of copper..	At nearly all of the copper mines in the State. Copper mines in Guilford, Cabarrus, Mecklenburg, Davidson, Chatham, Alleghany, Ashe, Watauga, Jackson, and Macon counties, besides numerous other localities.
Marls..........	Greensand, or glauconitic marls.	Southeast counties, from Neuse river to Cape Fear river, along Cape Fear river; Livingstone's creek, Black river, South river, Neuse river and its tributaries; Contentnea, Moccasin, and on Tar river; Brunswick, New Hanover, Bladen, Sampson, Duplin, Jones, Lenoir, Wayne, Johnson, Wilson, Nash, Halifax, and Franklin counties.
Marls (2).......	Calcareous marls.....	Occur in limited patches on beds in all the eastern counties from South Carolina to Virginia throughout an area equal to one-fourth of the State. Used locally in many places.
Melaconite....	Black oxide of copper.	Cullowhee mine, Jackson county; Silver hill, Davidson county; McGinn mine, Mecklenburg county.
	Millstone.............	Sandstone of Anson county quarries used as grindstones during the war; Triassic conglomerates, McLennan's creek, Moore county, used for millstones for a long time; Laurel river, Madison county, quartzite, used for millstone; granite and gneisses also used; shell rock, silicified, in eastern section.
Muscovite.....	Mica..................	Granitic ledges on waters of Nolachucky, between Black and Roan mountains, in Mitchell and Yancey counties. Mines near Bakersville, Mitchell county; Burnsville, in Yancey county; Richland creek, in Haywood county; near Jefferson, Ashe county, and in Jackson and Macon counties; on east side of Blue Ridge, quarried in Burke, Cleveland, Catawba, and Buncombe counties. Many localities in granitic regions of western counties.

NORTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Novaculite	Whetstone	Few miles west of Chapel Hill, Orange county, extensively quarried; near Roxborough, Person county; near Wadesborough, Anson county. These quarries in Huronian belt. Other quarries elsewhere for local uses.
Opal	Opal	Concord, Cabarrus county, fine specimens for gems.
	Phosphatic nodules	In Brunswick county, eleven miles from Wilmington, opened.
Siderite	Black band ore and ball ore.	Beds in the coal and shales series of Deep river, opened at Egypt, Farmville, Gulf, &c., in Chatham county.
	Sandstone	I. Sandstone of Triassic period, Wadesborough quarries, Anson county; Chatham, near Egypt, in Chatham county; near Durham, in Orange county, used at Raleigh; other quarries in the Dan river belt; Rockingham and Stokes counties, and in narrow belt stretching from Granville county, southwest through Durham, Chatham, Moore, Richmond, and Anson counties. II. Sandstones of Huronian belt, also used to limited extent.
Serpentine	Serpentine	Patterson, Caldwell county, quarried, very fine and dark colored and admits of fine polish; Baker mine, Caldwell county; Buck creek, Coundentine, Clay county; Asheville, Buncombe county; also in Wake and Forsythe counties; yellowish green variety occurs in Caldwell, Wilkes, Surry, Yancey, Stokes, Orange, and Wake counties; also in chrysolite beds of western part of State.
Spodumene	Beryl	Warren plantation, White Plains, Alexander county, deep green crystals introduced as gems.
Talc	Soapstone, steatite	Cherokee and Macon counties, on Nantahalah river, Valley river, and Nottla, extensive beds; in South mountains, Burke county; near Waynesville, Haywood county; Belts bridge, near Iredell county; north part of Wake county; Ashe county; and in many places west of the Blue Ridge, noted in thirty counties as occurring.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Antimony (native.)	Antimony	With antimony oxide in small vein in Burke county.
Arsenopyrite	Mispickel	Gold mines in Union, Gaston, Cabarrus, and Watauga counties, but only sparingly with other ores.
Azurite	Blue carbonate of copper.	Less common than the green carbonate. Clegg's mine, Chatham county; Cheek mine, Moore county; copper mines in Mecklenburg, Cabarrus, and Gaston counties; rarely at copper mines in copper region in northwest part of State.
Barnhardtite	Copper ore	Barnhardt's and Pioneer mills mines, Cabarrus county; Cambridge, Guilford county; McGinn and Wilson mines, Mecklenburg county; Elk knob, Watauga county.
Bitumen	Oil shales	In Triassic rocks at Egypt.
Cerussite	Carbonate of lead	Silver hill, Davidson county, with galena and silver ores; Murphy, Cherokee county; Baker mine, Caldwell county.
Chromite	Chrome iron	Associated with titaniferous iron ore in Guilford county, in small quantities; in chrysolite beds at Cullasaja, Higdon's, Elijah's creek, Moore's mine, Macon county; near Webster, Jackson county; Hampton, Yancey county, in quantity at least two localities; also in Clay, Mitchell, Burke, and Watauga counties.
Chrysocolla	Silicate of copper	At many of copper mines, with other copper ores. Unimportaut as an ore of copper.
Diamond	Diamond	Brindletown creek ford, Burke county; Switty's mine, Rutherford county; Cottage House, Lincoln county; Todd's branch, Mecklenburg county; Portis mine, Franklin county; headwaters of Muddy creek, McDowell county.

NORTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Feldspar	Feldspar	Many localities as constituent of granite and gneiss.
	Fire-clay	On coal series Deep river coal field; also in some of eastern counties in Tertiary and Quaternary formations. (?)
Halite	Common salt, brines	Brine wells in Chatham, Orange, and Rockingham counties, in Triassic beds.
Kaolinite	Clays, kaolin	Near Greensboro, Guilford county; near Newton, Catawba county; at Mica mines in Mitchell, Yancey, and Macon counties; also in Lincoln and Burke counties; Spout Springs, Harnett county; Shoe Heel depot, Robeson county; near Clayton, Johnson county. Other localities in Chatham, Ashe, and Wake counties, and many sedimentary clays in Tertiary and Quaternary formations of eastern part of State.
Lignite	Brown coal	In marl beds in the eastern counties, common; in Triassic rocks on Tar river, Granville county; Brown creek, Anson county.
Magnesite	Carbonate of magnesia:	Webster, Jackson county; Hampton's, Yancey county; McMakin's mine, Cabarrus county.
	Marble	Nantahalah river valley ranges of limestone, in Macon and Cherokee counties. Far from transportation. Marbles of various colors and susceptible of polish.
Molybdenite	Sulphide of molybdeum.	Pioneer mills mine, Cabarrus county; Peach Bottom mine, Alleghany county; Hackett's, Macon county; sparingly, in small scales, at these localities.
	Peat	Abounds in eastern part of State, particularly in the seaboard counties.
Platinum	Platinum	Burke and Rutherford counties. A few grains only in gold-bearing sands. (?)
Psilomelane	Black hematite	Near Lenoir, Caldwell county, in a vein four feet wide, in gneissic rocks; Danbury, Stokes county, thin seam; Buckhorn iron mine, Chatham county, interlaminated with hematite; Beck's ore bank Gaston county; Bakersville and Gillespie's gap, in Mitchell county; Cove creek and Richland creek, Haywood county.
Pyrite	Pyrites, iron pyrites	Common almost everywhere in the State, with copper pyrites at copper mines [see localities of chalcopyrite]; also in gold-bearing belt in auriferous quartz ore veins. Large veins of massive pyrite occur in Gaston county.
Pyrolusite	Black oxide of manganese.	Murphy's, Cherokee county; Hickory, Catawba county; McMakin's silver mine, Cabarrus county, and at localities of psilomelane, but nowhere in large quantity; also associated with wad.
Siderite	Spathic iron ore, carbonate of iron.	Halifax and Granville counties, in grayish-brown nodules; common in veins as gangue material at gold mines, also at some copper mines; other localities of mineralogical notice.
Silver (native)	Silver	Silver hill, Davidson county, in considerable quantities; Baker mine, Caldwell county; Scott's hill, Burke county, in veins of gold-bearing quartz; Gap Creek mine, Ashe county, with copper ores; McMakin mine, Cabarrus county, with tetrahedrite and zincblende; Asbury mine, Gaston county; also alloyed with gold in gold-bearing belt.
	Slate	In Huronian belts of rocks.
Sphalerite	Zincblende	Silver hill, Davidson county, with galenite and silver ores; McMakin mine, Cabarrus county, with galenite and silver ores; Stewart, Long, Lemmond, and Moore gold mines, Union county; Dobson mine, Cedar cove, McDowell county, in limestone; Macon, Gaston, Madison, Montgomery, and Allegheny counties, in small quantities.
Tetradymite	Tellur-bismuth	Beck's mine, west of Silver hill, and Allen mine in Davidson county; also in minute scales at copper mines in Cabarrus county, Gaston county, Burke county, and McDowell county.

NORTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Tetrahedrite...	Freibergite, argentiferous fahlerz.	McMakin mine, Cabarrus county, with silver, zincblende, galena, etc.; Sudwick's mine, Cabarrus county, with copper pyrites, etc., arsenical ores.
Wad............	Bog manganese......	Murphy, Cherokee county, with pyrolusite; other localities in small quantity in western part of State.

OHIO.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal............	Coal, bituminous coal.	The Appalachian coal field, which extends into the eastern part of Ohio, covers an area of 12,000 square miles in that State, from Trumbull county on the north to the mouth of the Scioto river on the south. Twenty-one counties are wholly within its limits, and fourteen are partly in it or have outliers, or small, detached coal basins. The Coal Measures include (in an ascending order) coal seams Nos. 1 to 7, inclusive, in a thickness of 400 feet; then barren measures with local seams, 400 feet; and beginning with the Pittsburgh seam, coals Nos. 8 to 13 inclusive, in 350 feet, making in all 1,150 feet. The aggregate thickness of the coal seams at the southeast is about 50 feet. At the north, coal seam No. 1 is very extensively worked in Geauga, Portage, and Summit counties; in the Mahoning valley, Trumbull and Mahoning counties; Tuscarawas valley, Stark county, and in Holmes county. It is locally known as "Briar hill," "Mahoning valley," and "block coal," The higher seams are the basis of coal mining to southward. Mines are worked on Yellow creek and on the Ohio, in Columbiana county; Leesville, Harlem, etc., in Carroll county; near Zoar and at Mineral Point, Tuscarawas county (coal No. 5); the "Strawbridge" in Licking and Holmes counties; coal Nos. 3 and 6 in Coshocton counties; Straitsville, Moxhala or Upper Sunday creek districts in Perry county, and the Lower Sunday creek and Nelsonville districts, Athens county, forming the Hocking valley field, and working the "great seam," or "Nelsonville seam," 11 to 13 feet thick; Fultonville and Short creek valley, and Rush run, in Jefferson county (coal No. 8, or "Pittsburgh seam"); "Wheeling" or "Bellair" seam on Wheeling creek, Belmont county; "Cambridge seam" in southern part of Guernsey county; Jefferson township mine, Noble county; "Pomeroy seam" in Homer and Marion townships, Morgan county; besides very many other groups and districts.
	Fire-clay	Dover and Mineral Point, Tuscarawas county, a flint clay, in Coal Measures, used at Dover, Mineral Point, and Akron; Springfield, Summit county, largely mined for ware; Holmes county, in Coal Measures; New Lisbon, Liverpool, Smith's Ferry, on Ohio river, Achor, Carbon Hill mines, near Palestine, Leetonia, in Columbiana county, mostly from beneath coal seams Nos. 3 and 5, and furnishing material for potteries at East Liverpool and Wellsville; along Yellow creek valley, at Elliottsville, Croxon's run, and Sloan's Station, in Jefferson county, largely used in manufacture of firebrick; Symmes creek, Muskingum county; Holmes county, thick beds, undeveloped; Atwater township, Portage county; and at many other localities in Coal Measures territory. The fire-clay bed under seam No. 3 is usually thick and of excellent quality.
	Flagging stone	Berea, Cuyahoga county, the "blue stone" of Cleveland; Thompson, Geauga county; Amherst, Lorain county; Lima, Allen county (from Water-lime group); Eaton, Preble county; Belle Centre, Logan county; Greenfield, Highland county (curbstones and crosswalks from limestone of Helderberg group); Waverly sandstone of Scioto valley; Greene and Clarke counties (the "Springfield stone"), a magnesian limestone.
	Grindstones and whetstones.	Berea and Independence, Cuyahoga county, extensive quarries; Amherst quarries, Lorain county, producing the "American Wickersley stone"; Mesopotamia, Trumbull county (scythe-stones); Warren and Dunham townships, on Ohio river, Washington county (Coal Measures sandstones); Massillon, Stark county; Manchester, Summit county (whetstones).

OHIO—Continued.

Mineralogical name.	Common name.	Remarks.
Gypsum	Gypsum	Plaster Bed peninsula, Put-in Bay, Lake Erie, Ottawa county (in Water-lime group); West Sister island, Lucas county; Poland and Canfield, Mahoning county; Sandusky, Erie county. (?)
Halite	Common salt, brines	Salt is made from brines obtained in borings in Meigs, Athens, Perry, Morgan, Muskingum, Noble, and Guernsey counties. Formerly made in Scioto and Jackson counties. Brines come mainly from Waverly sandstone (Carboniferous). Salt works on Ohio river, in Meigs county; on Hocking and Monday creek, Perry county; on Muskingum, in Morgan and Muskingum counties; Scott works, Guernsey county, and in Olive township, Noble county. Brines are also found in Aurelius township, Washington county; Canal Dover, Sugar creek, and Goshen, in Tuscarawas county; Salineville and Little Beaver valley, Columbiana county; along Ohio river, East Liverpool to Wellsville, in Jefferson county.
	Hydraulic limestone, cement-rock.	South point of Put-in Bay, Lake Erie; Belle Centre, Logan county; Wayne township, Fayette county; Concord township, Ross county; Genoa, Ottawa county, and Fremont, Sandusky county (Magnesian limestones), extensively used, even to east; New Lisbon, Columbiana county; Defiance, "black slate" of Huron shales, making the well-known "Auglaize cement"; Barnesville, Belmont county, from bed overlying coal seam No. 9.
	Limestone	Building stone is obtained from the widespread limestone areas of the State at very many localities. The Corniferous limestone is quarried at Sandusky, Erie county; Marblehead, Ottawa county, and Kelley's island, in Lake Erie. It is known as "Sandusky stone," and is used in Toledo, Sandusky city, and Cleveland. Same rock is quarried at Bucyrus, Crawford county, and at Charloe, Paulding county. The Water-lime group affords limestone at Lima, Allen county, and at Tiffin, Seneca county. The Niagara limestone, also, is quarried in Bellevue and Fremont, in Sandusky county. In Thompson and Bloom townships, Seneca county; Marion, Marion county; White House, Sylvania, Providence, Lucas county, and Columbus, Franklin county, there are quarries in the Upper Corniferous. The Cincinnati group furnishes good stone in many southwestern counties. There are quarries in it, at Cincinnati; at Point Pleasant, Clermont county; in Montgomery county (many localities), and in Preble and Warren counties. The Springfield quarries, Clarke county, are in the Niagara, as is also the Piqua stone, Miami county, and the celebrated "Dayton stone," quarried in vicinity of Dayton, and in the Miami valley, and at Xenia and along Mossie creek, in Greene county. The Helderberg group is worked extensively at Greenfield and near Lexington, in Highland county.
Limonite	Brown hematite	Occurs in Coal Measures as result of oxidation of the carbonate (siderite). In southeast part of State, from Ohio river north to Hocking valley. Mined in Perry, Athens, Muskingum, and other counties, with the carbonate ore.
	Millstone, buhrstone	Richland and Clinton, Jackson county; Muskingum, Licking county; and Elk, Athens county.
	Ochers [paints]	Near Germantown, Montgomery county; Idaho and Grassy fork, Pike county (ochery travertines and small deposits); Springfield, Clarke county; Miamisburg, Montgomery county; these are properly clay beds, but worked for paint.
Petroleum	Petroleum	Grafton, Lorain county, also in Liverpool, Oil creek, and Elyria, in same county, springs and wells in first and second sand rocks; East Cleveland, Cuyahoga county; along outcrop of Cleveland shales in Medina, Summit and Trumbull counties, producing wells at Mecca in Trumbull county (superior lubricating oil); Preble county, springs at base of Clinton limestone; wells not successful. Tar spring, Pike county, springs out of Waverly sandstone; Bluerock township, Muskingum county, wells; Buck run, Morgan county, several wells; Kokosing district, Knox and Coshocton counties, gas and oil wells; Duck creek valley and Cow run, Washington and Noble counties, many productive wells; Newport on Ohio river, wells; eastern part of Adams and western Scioto counties, oil springs in black slates.

OHIO—Continued.

Mineralogical name.	Common name.	Remarks.
Quartz	Sand for glass manufacture.	Near Fulton, Stark county, a sand rock, used at Pittsburgh, Pa.; Sylvania, Lucas county; Chester, Geauga county, friable sandrock.
	Sandstone	"Berea sandstone"; noted quarries at Berea, Independence, Chagrin Falls, and Gates' Mills in Cuyahoga county; large quarries at Peninsula, Summit county; Windsor Mills, Ashtabula county, and in Munson and Thompson township in Geauga county. "Amherst sandstone," or "Ohio sandstone"; also from the Berea grit. "Blue Amherst," from base of this grit. Very large quarries at Amherst and Elyria, in Lorain county; also quarried at Columbia, La Grange, Pittsfield, and French creek, in Lorain county; in southeast part of Crawford county; Iberia, Mount Gilead, and Cardington in Morrow county; Sanbury and eastern part of Delaware county; Black lick, in Franklin county. Waverly sandstone in southern Ohio, in Scioto valley. Quarries at Waverly and Jasper, Pike county, and along Scioto river, in Ross county. The "Buena Vista" stone is from Waverly group, also (above the black shale and Waverly quarry stone), Pike county, along the Scioto river, northeast of Waverly. A sandstone (Waverly?) is quarried at Sugar grove and Lithopolis, in Fairfield county. The Massillon sandstone is quarried in Massillon, Fulton, and Bridgeport, Stark county (from Coal Measures). In Warren and Dunham townships, Washington county, sandstone (Carboniferous) is quarried, which is known as "Constitution stone." Sandstone quarries at Plymouth, Huron county; Mansfield, Richland county, and Grand rapids, Wood county (last named is Oriskany). The Carboniferous conglomerate is quarried at Akron and at Cuyahoga falls, Summit county; and at Russell and Newbury townships, Geauga county. Waverly conglomerate at Ashland, Ashland county.
Siderite	Carbonate of iron, clay ironstone; var. "limestone ore."	In Coal Measures of eastern Ohio; Baird ore, on Monday creek, below the "great seam" or Nelsonville coal; also between Monday creek and Hocking river, on Upper Sunday creek; Shawnee and Moxhala; all these localities in Perry county. At Bessemer, Athens county; other localities in Muskingum, Hocking, Vinton, Jackson, Scioto, and Lawrence counties. Hanging Rock region ores are carbonates mainly; limited outcrops observed in Washington, Jefferson, Holmes, Summit, and other counties in eastern part of State.
Siderite (2)	Black band ore	Tuscarawas valley, Tuscarawas, Stark, and Carroll counties. Occurs above coal No. 7, with "limestone ore" and "kidney ore" at some localities. Mines at New Cumberland, Canal Dover to Fairfield, Zoar, Clover Hill, Junkin, Auburn, and Salem, in Tuscarawas county; Osnaburg and Paris in Stark county, and in northern part of Muskingum county; other localities of occurrence in Coal Measures area of State.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

	Alum	Copperas mountain, Bainbridge, Ross county.
Celestite	Sulphate of strontia	Green or Strontian island, Put-in Bay, Lake Erie, in fine crystals and in large masses, filling fissures in the Water-lime rock; with calcite, White House, Lucas county; West Sister island, Lucas county, with gypsum.
	Copperas	Copperas mountain, Bainbridge, Ross county.
Galenite	Galena	Coshocton county, in Waverly rocks, in small quantity.
Gold	Gold	Belleville, Knox county; near Brownsville and near Newark, Licking county; Warren and Clermont counties. In drift clays, sands, and gravels very sparingly.
Hematite	Fossil ore, dyestone ore.	Sinking Springs, Adams county; most important deposit of this ore in the State; Todd's ford, near Wilmington, Clinton county; near Zanesville, Muskingum county.

OHIO—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite	Brown hematite	Vicinity of Zanesville, Muskingum county; near Maxville, Perry county, in Coal Measures; Plymouth township, Richland county, a large bed with calcareous tufa; Licking county, siliceous ores.
Limonite (2)	Bog-iron ore	Northwestern part of State, in small deposits, Amanda, Hancock county; Putnam county; Tiffin and Seneca, Seneca county; Palmer township, Washington county; a large body, ore manganiferous; Lorain county.
	Marls	Calcareous shell marls occur in lakes and marshes in Hudson and Northampton, in Summit county; in Brighton and Camden, Lorain county; in marshes in Williams and Fulton counties; in Rush Creek lake, Logan county. At Sinking Spring, Highland county, there is a marly magnesian limestone, and in Ashtabula county calcareous tufa occurs in Erie shales.
	Peat	Summit county, large deposits; Bloomfield township, Trumbull county, several thousand acres in extent; near Painesville, Lake county; Brighton and Camden. Lorain county; Williams and Fulton counties. Many other smaller deposits in northern part of State.

PENNSYLVANIA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Asbestus	Asbestus	Rockdale, Delaware county, worked to slight extent; Mineral hill and other localities in same county; in West Nottingham, East Nottingham, East Bradford, and Goshen townships, Chester county; near Lafayette, Montgomery county, with steatite; Chestnut hill near Easton, long opened and worked; and at Gap mine, Lancaster county.
Azurite	Blue carbonate of copper.	Cornwall, Lebanon county, with chalcopyrite and malachite in magnetic iron ore; Fritz island, near Reading, sparingly; Jones's mine, near Springfield, Berks county, with copper ores and magnetic iron ore; Perkiomen mine, near Shannonville, Montgomery county.
Calamine	Silicate of zinc	Friedensville, Saucon valley, Lehigh county, with blende in limestone; Espy, Northumberland county; Sinking valley, Blair county; Lancaster zinc mines. In small quantities, excepting Friedensville locality.
Cerussite	Carbonate of lead, white lead ore.	Silver-lead mines of Chester county, and Ecton mine, Montgomery county; in small quantities at Phœnixville lead mines, Pequea mine, and Lancaster zinc mines, in Lancaster county.
Chalcopyrite	Copper pyrites, pyritous copper ore.	Jones's mine, Berks county; Cornwall, Lebanon county; Fritz island mine, near Reading; mines near Knauretown, Chester county, with other ores of copper in irregular seams in magnetite; Gap (nickel) mine, Lancaster county; Chester, Delaware county; in gneiss at Frankfort and Wissahickon, Philadelphia county; near Lafayette, Montgomery county; Wheatley mine, Chester county, and in small quantities at copper mines in triassic sandstone. Collected with other copper ores at Cornwall; elsewhere unimportant as an ore.
Chromite	Chromic iron ore.	Wood's mine. Little Britain township, Lancaster, an old and famous mine, country rock serpentine; Low's, Linepit, and Jenkin mines in Fulton township, Lancaster county; Elk, East Nottingham, and West Nottingham townships, Chester county; Middletown and Marple townships, Delaware county; nearly all abandoned. Occurs in lenticular deposits in serpentine, and in form of "sand" in gravel.

PENNSYLVANIA—Continued.

Mineralogical name.	Common name.	Remarks.
Coal. [Mineral coal.]	Anthracite coal	1. Northern or Third coal field, Wyoming valley. The principal collieries are at Carbondale, Archibald, Oliphant, in Dunsmore, Scranton, Lackawanna township, in Lackawanna county; and Pittston, West Pittston, Plainsville, Wilkes-Barre, Kingston, Ashley, Sugar notch, Plymouth and Nanticoke, in Luzerne county. 2. Eastern middle coal field, or Lehigh coal basins, in southern part of Luzerne and adjoining parts of Carbon, Schuylkill, and Columbia counties. The localities of larger collieries are: Upper Lehigh, Drifton, Jeddo, Eckley, Harleigh, Milnesville, Ebervale, Hazleton, Buck mountain, Beaver Meadows, and Audenried. 3. Western middle coal field, or Second coal field, in Schuylkill, Columbia, and Northumberland counties. In it are, among others, the following localities: Mahanoy city, Shenandoah, Girardville, West Mahanoy township, Gilberton, Ashland, in Schuylkill county; Centralia, in Columbia county; and Mount Carmel and Shamokin, in Northumberland county. 4. Southern or First coal field, mostly in Schuylkill county. The more prominent localities are: Nesquehoning, at the northeast, in Carbon county; Coaldale, Tamaqua, Pottsville, Minersville, Tremont, and Lykens Valley, in Schuylkill county; and a few collieries in southwest extension of the field, in Dauphin county.
Coal (2)	Anthracite coal (?)	Loyalsock basin or coal field, Sullivan county. (Semi-anthracite?)
Coal (3). [Semi-bituminous.]	Bituminous coal	Towanda or Barclay district, in Bradford county; Little Pine creek and McIntyre basins in Lycoming county; Blossburg region in Tioga county, opened largely at Fall Brook, Morris run, and Blossburg; Gaines basin, western part of Tioga county; Snowshoe basin, in western part of Centre county; Phillipsburg coal field, in the counties of Centre and Clearfield, on the Moshannon creek and its tributaries; Johnstown field, Cambria county; Broad Top mountain coal region, partly in Bedford and partly in Huntingdon counties.
Coal (4). [Bituminous.]	Bituminous coal	In the portion of the State lying west of the Alleghanies, including twenty-seven counties in whole or in part, and having an area of about 12,000 square miles. The Upper Coal Measures are confined to southwestern part of State, having Alleghany, Beaver, Armstrong, and Indiana counties for their northern limit. Seams A–I, inclusive, are worked besides thin seams in the Upper Barren group in Washington and Greene counties. The Pittsburgh seam (H) is the most widely developed and most productive. It is the seam in the Connellsville coke region. Another important bed is known as the Sharon bed (a block coal) in Mercer county.
Corundum	Corundum, emery	Near Unionville, Newlin township, Chester county; a large bed, opened and worked up at Kennet Square; in vicinity of Media and in Aston township, Delaware county, in small quantity. Other occurrences in Chester, Delaware, and Lancaster counties, very sparingly.
	Feldspar	[See under Albite and Orthoclase].
	Fire-clay	Sandy Ridge, Centre county; Clearfield, Blue Ball station, Woodland, in Clearfield county; Johnstown, Cambria county; Indiana county, many localities; Brookville and Bellport, Jefferson county; near Kittanning, Armstrong county; Big Beaver township, Beaver county; Bolivar, Salina and Ligonier, Westmoreland county; Londonderry township, Somerset county; Springhill township, Fayette county; Benezette, Elk county; Queen's run and Farrandsville in Clinton county, are some of more important localities of general occurrence in Coal Measures in central and western parts of State. Quarried at these and other localities.
	Flagging stone	Numerous quarries in grits and sandstones of Hamilton group in Shohola, Lackawaxen, Greene, and Westfall townships, near Delaware river and Lackawaxen creek, in Pike county; also in Barrett, Price, and Paradise townships, Monroe county; Nicholson, Wyoming county; Auburn, Susquehanna county. In northwestern and western counties the sub-Carboniferous and Carboniferous formations yield a flagstone for local uses.

PENNSYLVANIA—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite	Galena	Phœnixville mines, Chester county; mines near Shannonville, Montgomery county; Pequea mine, Lancaster county (argentiferous); New Britain, Bucks county; Sinking valley, Blair county, accompanying zinc ores; with pyrite in sandstone, Bradford county; and, near Pottsville, mines of Chester and Montgomery counties have been long worked.
	Granite	Granitić, gneissic, and mica schist rocks are quarried in the eastern part of the State. The South Mountain range, from Delaware river to Lebanon county, and the gneissic rock region of the southeastern part of the State in Bucks, Philadelphia, Montgomery, Chester, Delaware, and Lancaster counties afford many outcrops. These stones are quarried in many places for building material.
Halite	Common salt, brines	Salt wells, Saltzburg, Indiana county; along Kiskiminetas river, Armstrong county; Bayard Salt Works, Long run, on Sewickley creek, Westmoreland county; on Youghiogheny, Fayette county; Tarentum, Allegheny county; Brighton and Industry, Beaver county; Boyd's Hill, Pittsburgh, and in Bradford county, in oil district. Manufactured on small scale at several of these places and for local uses only. Salt water in lower sands in oil region.
Hematite	Fossil ore, dyestone ore.	In the Clinton group, from Bloomsburg and Danville, Montour county, traceable through Northumberland, Snyder, Mifflin, Centre, Juniata, Fulton, and Huntingdon counties, of middle Pennsylvania, and thence through Bedford to the State line on the south. Fossil ores of the Chemung formation are mined in the north, in Bradford and Tioga counties, also in Lycoming county.
Hematite (2)	Specular iron ore, red hematite.	Not nearly so abundant as the fossil ore. Near Durham, Bucks county; near Hanover, at Dillsburg and Wellsville, the Codorus region, York county (micaceous hematite); with magnetic iron ores in Lebanon and Chester counties.
	Hydraulic limestone	Coplay, Lehigh county—manufactured into Portland cement; Hokendaqua creek, Northampton county, and near Siegfried's bridge (horizon of Trenton limestone); Johnstown, Cambria county; Putneyville, Armstrong county.
Kaolinite	Kaolin	Common in southeast part of State. Dug in Concord and Birmingham townships in Delaware county, and in New Garden, Kennett, and East Nottingham, in Chester county. Near Douglassville, Berks county.
	Limestone	The Siluro-Cambrian limestone of the Great valley, and of the valleys included between the ranges northwest of it, is quarried at very many localities and extensively. It affords building stone in Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland, and Franklin counties. The Lancaster and York county limestones furnish some quarry stone. In the central part of the State the Lower Helderberg and Upper Helderberg outcrops are quarried at a few localities. To the west and northwest the limestones in the Coal Measures occur at many localities.
Limonite	Brown hematite	Very extensively developed in the Great valley from the Delaware to the Maryland line. Many scattered ore banks in Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland, and Franklin counties, associated with the Siluro-Cambrian formation. Also in Montgomery and Chesteg counties, in a narrow belt crossing the Schuylkill at Sprinr Mill on southern margin of Limestone valley. In Lancaster county the noted Chestnut hill and other ore banks, in limestone (Formation II.). York county ore banks, west of Susquehanna. In Kishcoquillas, Nittany, Sinking, Canoe, and Morrison's Cove valleys in middle Pennsylvania. The Oriskany and Lower Helderberg formations carry limonites in Huntingdon, Blair, and Perry counties. In the Juniata region, in Mifflin and Huntingdon and Bedford counties, resulting from alteration of carbonate ores. The Marcellus shale is ore-bearing in Yellow creek district, in Blair county, and on the affluents of the Juniata in Juniata and Perry counties. Brown hematites abound in the Coal Measures also, and particularly along the outcrop of the "ferriferous limestone." They occur in western Indiana county, in northern Armstrong, in Clarion, Jefferson, Butler, Lawrence, and Beaver counties, in large deposits. Other localities are worked in Centre, Clearfield, and the Coal Measures territory of southwestern part of State.

PENNSYLVANIA—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite	Bog iron ore	Widely distributed; in small deposits generally. Mercersburg and other localities in Franklin county extensively developed and worked.
Magnetite	Magnetic iron ore	In the South mountain belt; large mines at Durham, Northampton county; Topton, near Reading; Fritz Island, near Springfield, Boyertown; Jones mine, near Morgantown, in Berks county; Cornwall iron mountain, in Lebanon county; Dillsburg, in York county; near Knauertown and the Warwick mines, in Chester county. Many additional localities of mines and of occurrences, in small quantities, could be given.
Malachite	Green carbonate of copper.	Cornwall iron mines, Lebanon county; Jones mine, near Morgantown, Berks county; Fritz mine, near Reading; mines near Knauertown, Chester county; Millerstown to Maryland line, Adams county. Not mined alone as an ore, but with other copper compounds.
	Marl	Harmonsburg, Crawford county; Greencastle, Franklin county.
	Marble	Large quarries along the Schuylkill, near Conshohocken; King of Prussia and Henderson station, in Montgomery county. Marbles occur in Chester and Lancaster counties to limited extent.
Millerite	Capillary pyrites, sulphide of nickel.	Gap nickel mine, Lancaster county, with copper-bearing pyrrhotite, copper pyrites, &c.
Orthoclose	Feldspar	Concord township, Lower Providence township, Ridley township, near Chester; near Upland, Delaware county; Pennsbury township, near Unionville, Newlin township, Poor Ho, quarries in West Bradford township (chesterlite), in Chester county; Mineral hill, Middletown, and Upper Providence, Delaware county; near Feisterville, Bucks county; Seissholzville, near Alburtis, Lehigh county; and many other places. Common as rock constituent. A few localities worked.
Petroleum	Petroleum	Pennsylvania oil region is comprised within the limits of McKean, Warren, Crawford, Venango, Mercer, Clarion, Butler, Lawrence, Beaver, Allegheny, and Washington counties. Some of the more important oil centers are Tidioute, West Hickory, Titusville, Shamburg, Pithole, Petroleum Centre, Oil City, Bradford; in southwestern part of State, on Dunkard's creek, Greene county. Oil is found in small quantities in Fayette and Westmoreland, and probably in other counties in western part of State.
Quartz	Quartz	Of general occurrence.
Quartz (2)	Sand	For glass manufacture, near Lewistown, Mifflin county; Hamilton township, Monroe county; Belvernon, on Monongahela river; Godfrey's ridge, near Stroudsburg, Monroe county.
	Sandstone	The Red Sandstone of the Triassic age affords a building stone at a few points in the belt crossing the State from the Delaware to Harrisburg, and thence to the Maryland line. The more extensive outcrops of the Silurian, Devonian, and Carboniferous sandstones in the Appalachian and Trans-Appalachian regions are much more largely used, and very many localities obtain stone for construction from the various members of these geological series. At the southeast the primal sandstone (of Rogers) is quarried at a very few places.
Serpentine	Serpentine	Southeast part of State, quarries near Springfield and Lafayette, Montgomery county; West Nottingham, Chester county; Media, Delaware county; used for building. Precious serpentine near Easton; East Goshen township, Chester county; Fritz island, near Reading, Berks county; near Yellow springs, Radnor township, Delaware county. Other localities of serpentine in Lancaster, York, Montgomery, and Lebanon counties.

PENNSYLVANIA—Continued.

Mineralogical name.	Common name.	Remarks.
Siderite	Carbonate of iron, carbonate ore, clay ironstone.	In eastern Pennsylvania, in Siluro-Cambrian formations, with limonites. In the Devonian (Formation VIII.) in Huntingdon, Bedford, and Fulton counties. In the Mauch Chunk red shale (XI.) carbonate ores occur in the Lackawanna valley and at Scranton; Ralston, Lycoming county; in Clearfield, Cambria, Huntingdon, Somerset, and Fayette counties. The Coal Measures carbonates are found in all the counties of the anthracite and bituminous coal basins.
Siderite (2)	Black band ore	In Coal Measures at Pottsville; Snow Shoe basin, Center county.
	Slate	Bangor (Chapman's quarries) in Northampton county, Slatington in Lehigh county, are centers of large quarrying operations for roofing slate. Peach Bottom slate district, York county, chiefly about Slate Hill post-office, and Hanover, York county. In Lancaster county slate is quarried near Peters's Creek Station.
Sphalerite	Zincblende	Friedensville zinc mines, Saucon valley, with blende and smithsonite in limestone; Lancaster zinc mines and Peque mine, Lancaster county, with galenite; Sinking valley, Blair county, with galenite and (in places) smithsonite in limestone, mines worked irregularly; New Britain, Bucks county, with galena; Espy, Columbia county, in limestone; Phœnixville mines, Chester county, with lead ores and in considerable quantity; Ecton mine, near Shannonville, Montgomery county.
Talc	Steatite, soapstone	Quarries near Lafayette, Montgomery county; West Goshen township, near Unionville, West Nottingham township, Chester county; near Texas, Lancaster county; near Easton, besides many other localities, in serpentine belts of southeast part of state.

Ores, minerals, and mineral substances of industrial importance and known occurrence, which are not at present mined.

Albite	Feldspar	Chester, Delaware county; Mineral hill, near Media, East Bradford and Unionville, Delaware county.
Amethyst	Amethyst	East Bradford and Pocopson, Delaware county; Sadsbury, Providence, Aston, Middletown, and Birmingham, Chester county. Occasionally stones suitable for gems.
Apatite	Phosphate of lime	Numerous localities in Berks, Montgomery, Philadelphia, Chester, and Delaware counties, but not to workable extent.
Asbolite	Earthy cobalt	Near Albertis, Lehigh county; in drift, opposite Fairmount, Philadelphia.
Barite	Barytes, heavy spar	West of New Hope, Bucks county, several old mine holes; at Phœnixville mines, Chester county; Jug Hollow mine, Montgomery county, and other localities in southeastern part of State. Fort Littleton, Fulton county, mined to some extent; Waynesboro, Franklin county; Sinking Valley, Blair county.
Bornite	Purple copper ore	In Triassic rocks, York county, largest deposit in State, but not to workable extent. Other localities in Montgomery, Chester, Adams, and (in Devonian rocks) in the northern central counties.
Celestite	Sulphate of strontia	Near Frankstown, Huntingdon county; in thin seams.
Chalcolite	Copper glance, vitreous copper.	Phœnixville, Chester county; Woods' mine, Lancaster county; with bornite in northern counties, sparingly.
Chrysocolla	Silicate of copper	Cornwall mines, Lebanon county; Jones mine, Morgantown, Berks county; Phœnixville, Chester county; Perkiomen mine, Montgomery county; Frankford, and on Wissahickon; nowhere in quantity to be considered as an ore.
Copper	Copper	Cornwall mines, Lebanon county; Jones iron mine, Berks county; Knauertown, Chester county; Gap (nickel) mine, Lancaster county; copper mines, South mountain, Millerstown to Maryland line, Adams county. At no one of these localities, of itself, in workable quantities.

PENNSYLVANIA—Continued.

Mineralogical name.	Common name.	Remarks.
Cuprite........	Red oxide of copper..	Cornwall, Lebanon county (a considerable percentage of the copper ores here separated from iron ore); Chestnut hill, near Easton; Perkiomen mine; copper mines in Adams county, near Maryland line.
Fluorite	Fluorspar............	Newlin, Chester county; in gneiss, Frankford; near Delaware water gap, very small quantities at all localities.
Garnet	Garnet................	Darby creek and Concord township, Delaware county; near Unionville, Chester county, and other localities in southeast part of State. Some suitable for cutting as gems.
Gold...........	Gold..................	Franconia, Montgomery county, sparingly in quartz and pyrite; in copper pyrites, Phœnixville; Gap mine; Chester county; sands of Delaware river and clays of Philadelphia scarcely traces. None of economic importance.
Graphite.......	Plumbago, black lead.	Bustleton, Bucks county, mine worked for nearly 100 years; Chestnut hill, near Easton; Robinson's hill, on Schuylkill, near Philadelphia; Pughtown, South Coventry, Chester county; near Jones's mine, Berks county; and other localities in gneissic and metamorphic rocks of Lehigh, Northampton, and Chester counties—generally sparsely disseminated in rock.
Greenockite ...	Sulphide of cadmium.	Friedensville zinc mines, Lehigh county, incrustation upon blende.
Hydrozincite ..	Carbonate of zinc	Friedensville, with zincblende.
Magnesite	Carbonate of magnesia	Magnesia quarries, Goat hill, West Nottingham, Chester county, formerly worked. Large deposits at Low's chrome mine in Lancaster county and at Scott's mines in Chester county. Other localities in Delaware, Chester, and Lancaster counties, of occurrence in small masses.
Melaconite	Black oxide of copper	Perkiomen mine, Montgomery county; silver lead mines, near Phœnixville, Chester county.
Molybdenite...	Sulphide of molybdenum.	Frankford, in gneiss; Chester, Delaware county; Alsace township, near Reading; sparingly.
Muscovite.....	Mica..................	Pennsbury township, Unionville, Newlin township, Chester county; Leiperville, Delaware county, and many localities in southeast part of State.
Psilomelane ...	Oxide of manganese..	Occurs with limonite in ore banks, Kittatinny valley, and in small quantities in gneiss, near Bustleton, Bucks county.
Pyrite	Iron pyrites	Gap mine, Lancaster county (nickeliferous); Cornwall, Lebanon county, cupriferous, and also cobaltiferous. Many localities; not mined except when bearing valuable metals, or for paint manufacture, *e. g.*, Jamestown, Mercer county.
Pyrolusite	Gray oxide of manganese, manganese ore.	Edge Hill and near Spring Mill, Montgomery county; with limonite frequently, especially in Saucon and Williams townships, Northampton county.
Pyrrhotite.....	Magnetic pyrites	Gap mine, Lancaster county, nickeliferous; also in Alsace township near Reading, Berks county; in small quantities at several other localities.
Silver (native).	Silver................	Wheatley mine, near Phœnixville, Chester county; Pequea mines, Lancaster county.
Smithsonite ...	Carbonate of zinc, "dry-bone."	Friedensville zinc mines, with calamine and blende; Sinking valley, Blair county; Lancaster zinc mines. Not worked alone as an ore.
Wad...........	Bog manganese	With limonite, Northampton, Lehigh, Berks, and other counties.
Wulfenite	Molybdate of lead	Lead mines near Shannonville, Montgomery county; Wheatley lead mines, Phœnixville, Chester county; Pequea mines, Lancaster county.
Zaratite	Emerald nickel	Wood's mine, near Texas, Lancaster county, with chromite, in considerable quantity.

RHODE ISLAND.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Mineralogical name.	Common name.	Remarks.
Coal	Coal, anthracite coal	Coal Measures extend from south to north across State; Newport, Kent, and Providence counties; Portsmouth mines; Cranston, mines worked; Newport neck, Newport county, seams one to three feet thick; Quaker hill, Newport county, mine opened years ago. Several beds, varying from 2 to 23 feet thick, but irregular. Some of coal graphitic. Production limited to local use mainly.
	Granite	Nipmuck granite quarried in South Scituate, Providence county; Kingston, Washington county, a porphyritic granite; Beacon pole hill, in Cumberland, a syenitic granite; large quarries at Westerly, worked for paving stone.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Agate	Agate	Diamond hill, Cumberland.
Arsenopyrite	Mispickel	Uxbridge, Providence county, occurs with galenite in thin vein.
Chalcedony	Chalcedony	Diamond hill, Cumberland.
Chalcopyrite	Copper pyrites	Near Sneech pond, Cumberland.
	Clay	Newport neck, Newport county, suitable for pottery; Block Island.
	Flagging stone, sandstone.	Pawtucket.
Galenite	Galena	Uxbridge, Providence county (argentiferous), small vein in crystalline rocks (granitic).
Graphite	Plumbago, black lead.	Tower Hill, Kingston, Washington county.
Hematite	Hematite	Cranston, Providence county.
Limonite	Bog iron ore	Foster, Providence county, small deposits.
Magnetite	Magnetic iron ore	Cumberland iron hill, 12 miles from Providence and near Massachusetts line; ore lean, but free from sulphur and phosphorus; deposits large; a porphyritic, magnetic iron ore. Gloucester, in chlorite.
Molybdenite	Sulphide of molybdenum.	Sneech Hill, in Cumberland county, in manganese ore.
Serpentine	Serpentine	Newport; Smithfield.
Sphalerite	Blende	Uxbridge, Providence county, in narrow vein with galenite.
Talc	Steatite, soapstone	On Mohassuc, Smithfield, Providence county, delicate green and white.
Wad	Bog manganese	Sneech pond, Cumberland, thick bed with iron ore.
	Whetstone	Woonsocket, in Providence county, micaceous sandstone worked for scythe-stones and grindstones. Smithfield, mica slate, long worked.

SOUTH CAROLINA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Mineralogical name.	Common name.	Remarks.
	Fire-clay	Wells' place, Kings mountain, York district, clays in Kaolin district in central belt of State. (?)
Gold	Gold	The gold belt extends from the North Carolina border, southwest across the counties of York, Lancaster, Chesterfield, Kershaw, Fairfield, Chester, Union, Spartanburg, Greenville, Pickens, and Abbeville. The principal mines at work are: Brewer mine in Chesterfield; Haile mine in Lancaster; Magnolia in York, and Lockhart in Spartanburg. Many old mines in the gold belt abandoned; auriferous gravels are found at many localities, but chiefly in York, Union, and Spartanburg counties.
	Granite	In Abbeville, Fairfield, Lexington, and Newberry districts. Union C. H., Union district (several quarries opened).
Itacolumite	Flexible sandstone	Grindstone ridge, in Spartanburg district (for grindstones mainly).
Kaolin	Porcelain clay	Near C. H., Chester district; Chesterville, Chester district (used for teeth); northwestern parts of York district; chalk hills, Hamburg, Edgefield district; Aiken, Barnwell district; Graniteville, Edgefield district; Congaree creek, Lexington district, C. H., Abbeville. Some of localities worked for paper clay.
	Limestone (marble in part).	Spartanburg district; Laurens district; localities Limestone springs in northeastern part of Spartanburg district.
	Marl	Post-pliocene—Wadmalew, Colleton district; St. Thomas, Charleston district; Edisto Island, Colleton district; along Santee, Ashley, Cooper, Edisto, and Savannah rivers. Belt along shore.
		Pliocene—Waccamaw, in Horry district; Darlington, Sumter, and Marlborough districts also contain deposits of these calcareous marls.
	Phosphate rock	Wando river, Charleston district; Cooper river, Eastern branch, Charleston district; Black river—Stono river tract (Ashley river), Charleston land tracts in this district. Edisto river deposits in Colleton district; Coosaw river and Bull river deposits in Beaufort; Chrisholm Island, St. Helena sound, Broad river, Beaufort river, all in Beaufort district; Coosawatchie river.
	Sandstone	Sandstone in Buhrstone formation. Little Horse creek, Edgefield district; Platte springs.
		Sandstone—new Red: Hornsborough, Chesterfield County.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asbestus	Asbestus	Near Glenn springs, Spartanburg district; near Cedar springs, Spartanburg; associated with steatite, in dike formation.
Bismuthite	Bismuth ocher	Brewer mine, northern part of Chesterfield district (in small quantity only).
Chalcopyrite	Copper pyrites	Darwin's mine, northern part of Union district; Mary mine, York district; Dickey place, Tiger river, northeastern part of Greenville district; Cherokee mine, northwestern part of Pickens district.
Cuprite	Red oxide of copper	Mary mine, York district.
Feldspar	Feldspar	Veins in gneiss near Pickensville, Pickens district, associated with bluish quartz; in large crystalline matter.

SOUTH CAROLINA—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite	Galena	Parson's mountain (in gold mines), Abbeville district; Cherokee valley, Laurens district; Cameron mine, two miles south of Limestone springs, in Spartanburg; in mica slate, argentiferous; Cherokee (gold) mine, in thin vein (argentiferous), in northwestern part of Pickens district.
Graphite	Plumbago, black lead.	Northeast corner of Spartanburg (near Cowpens furnace); Paris mountain, Greenville (thin vein, not worked).
Hematite	Red hematite, specular iron ore.	Whitaker's mountain, northwestern part of York district (Harding bank, Bird bank); northern slope of King's mountain, York district to Gelkey's mountain, in Union; Heady hill bank, near Cooperville, Spartanburg; Jackson bank; near Cowpens furnace, northeastern part of Spartanburg district; near Greenville C. H., Greenville district; thin superficial deposits, formerly worked. [See under Itabiryte.]
Itabiryte (*a*)	Specular schist	"Red ore"—Critses, Cooperville, Union district; Ellen furnance, near Union line, in Spartanburg district; Bird's mine, York district; Silver mountain, York district; Gibson's mine, Spartanburg. Ores in a narrow and short belt—York, Union, and Spartanburg districts. Occurrence in itacolumite.
Lignite	Brown coal	Whortleberry branch, north of Cheraw, Chesterfield district; near Mount Craghan, Marlborough, same district; Savannah river, Edgefield district.
Limonite	Brown hematite	Nanny's mountain, York district (northeast of Yorkville); Pacolet iron works, Spartanburg district; near Cowpens, Spartanburg district; Cherokee ford, Spartanburg district; McCord's mountain in Greenville district; Abbeville district; Ruff's mountain, Lexington; Crooked creek, Pickens district; also in Chesterfield district. [But mainly confined to mica slate of Spartanburg and Pickens districts.]
Magnetite	Magnetic "gray ore," iron ore.	Lee and Parker bank, northwestern part of York district; Swedish Iron Manufacturing Company's mine, corner of Union district; Hardin's bank, Whitaker's mountain, York district; Hogue bank, York district; Fields, Susan furnace; Blockley, in Spartanburg. Ore occurs in itacolumite and talcose slate rocks, in a belt stretching from northeast to southwest through York, Union, and Spartanburg districts. [Some of these iron ore banks may be working.]
Malachite	Carbonate of copper	Cameron mine, near Limestone springs, Spartanburg district.
	Manganese	[See Pyrolusite.]
	Ocher	Yellow, at Lang-Syne, Orangeburg; also in Chesterfield district.
Pyrite	Iron pyrites	Nilson mine, seven miles northeast of Yorkville, York district; Sutton mine, northeast corner of York district; Hagin mine, Bellair, Lancaster district; Brewer and Edgeworth mines near Hornsboro', Chesterfield district; abundant in Spartanburg and York districts.
Pyrolusite	Oxide of manganese	Hard Labor creek, Edgefield district.
Pyromorphite	Phosphate of lead	Cameron (copper) mine, Limestone spring, Spartanburg district.
	Sand	For glass—near Aiken, Barnwell.
Siderite	Specular iron ore	Bird bank, King's mountain, York district.
Silver	Silver	In galena, Cameron mine, two miles south of Limestone springs, Spartanburg, district; Cherokee mine, northwest part of Pickens district.
Talc	Steatite, soapstone	On Wateree creek, Lexington; Sandy river, Chester (worked to a limited extent); in Abbeville district, several beds; Anderson district, Cedar springs, in Spartanburg; near Glenn springs, Spartanburg; western part of Union district; Salubrity post-office, Pickens district.
	Whetstone	In Abbeville district; Turkey creek, Edgefield district.

a Itabiryte contains both magnetite and hematite.

TENNESSEE.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Mineralogical name.	Common name.	Remarks.
Azurite	Blue carbonate of copper.	Ducktown copper mines, Polk county.
Barite	Barytes, heavy spar	Mulherrin creek, Smith county, gangue of lead vein; gangue of lead vein near Haysborough, Davidson county, associated with blende and galena; twelve miles from Greenville, Greene county, in veins in Knox dolomite; Whetwell near Mouse creek, McMinn county, a large deposit; many other localities in small quantities.
Calamine	Silicate of zinc	Stiner's zinc mine, Powell's river, Union county, with smithsonite in irregular veins in the Knox dolomite; Mossy creek, Jefferson county, associated with smithsonite and blende in the Knox dolomite; other localities in Jefferson, Knox, and Cocke counties in valley of east Tennessee.
Chalcocite	Copper glance	Ducktown copper mines, Polk county.
Chalcopyrite	Copper pyrites	Ducktown mines, Polk county, most abundant ore at mines excepting black and red ores.
	Clay	Potters' clay; Sulphur fork of Beaver dam Hickman county, and many places in Hickman, Perry, and other counties along Tennessee river. Cumberland iron works, Stewart county, 4 miles southwest of Cumberland City, Stewart county. These have been worked for local uses; McMinnville, Warren county.
Cuprite	Red oxide of copper	Ducktown copper mines, Polk county, the rich ore of 2nd zone at mines, associated with black oxide of copper.
Coal	Coal, bituminous coal.	Bituminous Coal Measures coëxtensive with Cumberland table land, area 5,100 square miles extending across the State, including counties of Scott, Morgan, Fentress, Van Buren, Bledsoe, Sequatchee, Marion, Claiborne, Campbell, Anderson, Rhea, Hamilton, Overton, Putnam, White, Franklin, Warren, Coffee. 1. Sewanee division, or southern division; Sewanee coal banks near Tracy city, in Marion county; the main Sewanee seam varies from three feet to seven feet thick; there are several beds, thickness very irregular, but aggregate of coal large. 2. Walden's ridge and Raccoon mountain division; Ætna mines, in Marion county; main Ætna vein 18 inches to 7 feet or more thick, of good quality, cokable, not highly bituminous; above it are "Kelly coal," "Slate vein," and "Walker coal," each two to six feet thick. 3. Northern division, at Scarborough's mill, on Caney fork, seam four to six feet thick; principal mining localities, Tracy city, Marion county; Victoria mines; Coal creek mines, in Anderson county; Rockwood mines, Roane county; Sodden mines; mines near Chattanooga; Careyville, Campbell county.
	Flagging stone	Near Montgomery, Morgan county; near Knoxville, Knox county, blue flags (limestone); Lebanon, Wilson county. Sandstone of the mountain limestone, Overton and White counties.
Galenite	Galena	In iron ore, Bompass cove, Washington county; Carter furnace, Carter county; with copper ores at Ducktown mines, Polk county (small quantities); Caldwell's mine, on Powell's hill, Union county; occurs in scattered grains and lumps in Knox dolomite, and as vein, filling a vertical fissure, worked; Hambright's mine, Chatata valley, Bradley county, in Knox dolomite; Carter mine, 3 miles east of Sweetwater, Monroe county; Montgomery mine two miles northeast of Cartertown. Galenite occurs at many localities in Knox dolomite in East Tennessee valley, but not in workable quantities as opened. In limited quantities, Melherrin creek, Smith county, and elsewhere in central basin of Trenton in Tennessee and Nashville series (Trenton and Hudson).
Gold	Gold	Coca creek, Monroe county, Whippoorwill Mining Company. Gold-bearing quartz vein in semi-talcose clay slate; Coca creek, Monroe county, in sandstone gravels, worked a little every year; east of Montvale springs, Blount county; in water of Citico creek, Monroe county; in bed of Cane creek, Monroe county; headwaters of Tellico creek, Monroe county; Polk county also; veins of gold-bearing quartz in Ocoee group of slates.

TENNESSEE—Continued.

Mineralogical name.	Common name.	Remarks.
Hematite	Solid or hard ore, red hematite.	Cannon bank, seven miles from Elizabethtown, Carter county, massive bed in Knox sandstone, worked; Crockett bank, one mile west of Holston river and in eastern part of Sullivan county; Sharp bank, near Sullivan county; a bed in Knox dolomite; Thomson bank southeast of Bristol, Sullivan county.
Hematite (2)	"Drystoneore," "block ore."	Hills bank, eastern part of McMinn county, stratified large bed in Trenton series. This ore occurs on eastern border of Cumberland table land in counties Hancock, Claiborne, Grainger, Campbell, Anderson, Roane, Rhea, Meigs, and Hamilton. Used by furnaces in valley of East Tennessee. Occurs in ridges or ranges. 1. Mountain range almost continuous from Virginia to Georgia, 160 miles, and of average thickness of 20 inches; usually more than one ore bed. 2. Lookout Dyestone ridge, near Chattanooga, Hamilton county, extending north to Rhea county. 3. Half-moon Island range, in Roane, Rhea, and Meigs counties; excellent and extensive beds of ore. 4. Big valley and White Oak mountain ranges—a broken range extending across the State east of above ranges. 5. Powell's and Lone mountain ranges, in Hancock and Claiborne counties. 6. Elk fork, northwest of Campbell county, and Sequatchee valleys, in Bledsoe, Sequatchee, and Marion counties. A range northwest of above mentioned. Ore abundant; used on a small scale. In 1880, 71,657 tons were mined. Ore used at South Pittsburg, Chattanooga, Rockwood, and Oakdale furnaces. Largest and most productive mines are, Stringer's hill, north of Chattanooga and Shin Bone ridge, in Hamilton and Rhea counties, and near the Tennessee river and from Rockwood to Emory gap, in Morgan county, also Ooltewah and White Oak mountain, in Hamilton, James, and Bradley counties; Iron hill, Red Cloud mine, and Half-moon island mine, all in Rhea county; Ironton, Roane county.
	Limestone	Knox dolomite. Chattanooga, Hamilton county; Trenton (Carter's creek) limestone, Maury county; Nashville series, blue and dove-colored limestones, Nashville, Davidson county; Caryville, Campbell county.
Limonite	Brown hematite	Eastern iron ore region across State from Virginia to Georgia, in counties Johnson, Carter, Washington, Sullivan, Greene, Cocke, Sevier, Blount, Monroe, and Polk. They occur in banks or deposits in matrix of clay, sand, chert, and débris of disintegrated rocks of Knox group (Potsdam) mostly in Knox dolomite; 1880—8,630 tons of ore mined in this belt. At Crockett bank, eastern part of Sullivan county, with hematite, also other localities of the hematite in Sullivan county; Crockett's, Sharp's, and other banks, Johnson county, south foot of Holston mountain; Laurel creek valley and Butler furnace banks; Carter county, Dove river cove banks; Washington county, deposits in Bompass cove, Greasy cove; Greene county, several banks manganiferous ore near Unaka furnace; Cocke county, Whitehall, Peck's mountain, and others; Sevier county, almost inaccessible; Blount and Monroe counties, almost inaccessible; McMinn county, Tellico plains, several deposits; Ducktown copper mines in "gossan," Polk county. Western iron region: A belt 50 miles wide, crossing the State in counties of Lawrence, Wayne, Hardin, Lewis, Perry, Decatur, Hickman, Humphrey, Benton, Dickson, Montgomery, and Stewart. Occurs in irregular lumps or hollow concretions, called "pots," also "honeycomb" and "pipe," in the sandy matrix. "Ore region gravel" of Safford [alluvium], Hickman county, has several noteworthy localities, *e. g.*, at Ætna furnace (two square miles of ore ground, 10 feet to 100 feet deep); next come Dickson and Stewart counties, *e. g.*, beds of Cumberland iron works, in Stewart county, Bear spring, Morgan banks owned by it. Steele's bank, Montgomery county. These ores of excellent quality, but not fully developed as yet. Same ores on east side of Highland river in Warren, Coffee, White, and other counties. Knox ore is under various local names, according to structure, "Pipe," "Pot," "Blackjack," "Honeycomb," "Shot," "Bog" [30,000 tons of ore raised in 1880].
	Lithographic stone	Quarry in Clay county; also in Jefferson and McMinn counties.

TENNESSEE—Continued.

Mineralogical name.	Common name.	Remarks.
Magnetite	Magnetic iron ore	Crab orchard, Carter county, not a well defined vein, but with sahlite, in metamorphic group. Worked at a bloomary. An extension of Cranberry range of North Carolina; eastern part of Johnson county, far from transportation.
Malachite	Green carbonate of copper.	Ducktown copper mines, Polk county, in "gossan."
	Marble	Variegated marbles are quarried extensively at Knoxville, Concord, and other localities in Knox county; at the National quarry and Rogersville, in Hawkins county. The quarries are in the Trenton limestone, and the stone is known as "Tennessee marble." Other localities are: near Athens, McMinn county; on Tellico river, Monroe county; near Charleston, Bradley county; Morristown, Hamblen county; Jefferson county; Loudon county. In western part of State quarries are opened on Big Sandy river, in Henry county; Rockport, in Benton county; Bon Air, in White county; in Decatur county; in White county. The "Chattanooga marble" comes from the upper part of the Knox dolomite and from East Tennessee valley. Black marbles are found in the Knox group, in Sevier, Polk, and McMinn counties. Brecciated and conglomerate marbles have been quarried on the Little Tennessee, in Monroe and Blount counties; and occur in Knox and Ococe groups in Greene, Cocke, Sevier, and Unaka counties.
	Marl, greensand marl.	Western Tennessee; McNairy and Hardin counties.
Melaconite	Black copper	Ducktown copper mines, Polk county.
	Millstone	Chert of Knox dolomite localities, Big Spring, Claiborne county; also of other rocks for local uses.
	Sandstone	Chilohowee sandstones of East Tennessee. Freestones of the Coal Measures.
Siderite	Clay ironstone, carbonate of iron.	In shales of the sub-Carboniferous formation. Willey's bank on Coal creek, Anderson county, Coal creek and Careyville.
Siderite (2)		Beersheba springs, Grundy county; Coal creek, Anderson county; Careyville, Campbell county; and other Coal Measures localities.
Smithsonite	"Dry bone," carbonate of zinc.	Stiner's mine, on Powell's river, Union county, associated with calamine, in irregular veins in Knox dolomite; Mossy creek, Jefferson county, with calamine, ore abundant. Other localities in valley of east Tennessee.
Sphalerite	Zincblende, "black-jack."	In small quantities at Ducktown copper mines, Polk county; Stiner zinc mine on Powell's river, Union county; Mossy creek, in Jefferson county, occurs with smithsonite and calamine, ore abundant. Mines lately reopened. Other localities in Jefferson county, Knox county, and Cocke county, in valley of East Tennessee; also in Central Tennessee, with galena. [See Galenite and Barite.] Bald Hill mine, Union county; Claiburne county. Straight Creek mines actively worked.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Alum	Alum	In the Black shale formation under the Coal Measures; Alum cove, Sevier county, in shales.
Bitumen	Asphalt	Perry's, on fork of Blue buck creek, Hickman county, in seams (vertical), in limestone.
Cerussite	Carbonate of lead	Occurs with galenite at several localities of latter mineral.
Epsomite	Sulphate of magnesia.	Alum cove, Sevier county, in Ococe shales.
	Fire-clay	Under beds of coal beds in many localities; Aetna, Marion county; Chattanooga, Hamilton county.
	Granite	Occurs in east Tennessee.

TENNESSEE—Continued.

Mineralogical name.	Common name.	Remarks.
Gypsum	Gypsum	Gray's cave, north part of Sumner county, and many other localities; not anywhere workable amount.
Halite	Common salt	Brine wells; salt works, three miles from Sparta, White county; Anderson county, eastern base of Cumberland table land, well 1,000 feet deep; Obey river, Overton county, establishment here. Brine has been found in most of borings for petroleum in middle Tennessee, in Warren, Van Buren, Overton, and Jackson counties.
	Hydraulic limestone	Brown shale of Trenton and Nashville series, east of Knoxville, Knox county, have been used; Horse creek, east of Savanoa, Hardin county; Saltillo ledge, Hardin county; occurrences of hydraulic rock in Ortties bed of Nashville series, near Clifton, Wayne county, worked before war.
Lignite	Brown coal	Quite common in Bluff lignite formation (Tertiary), in western part of State, near Mississippi river, usually 3 feet to 4 feet thick, rarely 5 feet to 6 feet; few miles north of Elizabethtown, Carter county, occurring with clay, lignite of no value; not in demand; once worked. Raleigh, Shelby county; Old Fulton, Lauderdale county.
	Manganese, black oxide of manganese (?).	Jones's valley, Cocke county; Boatman's ridge, between Morristown and Beau's ridge, Cocke county; occurs in considerable masses; mines in Johnson county, worked for a time; Carter county, extensive beds.
Niter	Niter, saltpeter	Many caves in limestone formations, and especially in Cumberland table land; not of much account.
Petroleum	Petroleum, rock oil	Oil spring, Liepers creek, Maury county; Mill creek, near Cumberland river, Jackson county; several points on Obey's river, Overton county; Montgomery's mills, Piney river; Spring creek, southern part of Overton county, several wells bored near the last locality yielded oil; Jones's creek, Dickson county, several wells bored, unproductive; Eagle creek, Overton county, three wells, some oil; wells in Fentress county, no longer pumped.
Pyrite	Iron pyrites	At Ducktown mines (copper), Polk county, abundant with pyrrhotite (magnetic pyrites); near Greeneville, Greene county; in shaly (Knox) limestone, and other localities in Knox group of rocks.
Quartz	Glass sand	Knoxville, Knox county, once used; in counties west of Tennessee river.
	Slates	In eastern part of State, but undeveloped.

TEXAS.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

	Clay	Tom Green county; Concho county southwest to Rio Grande; Brazos county.
Coal	Coal, bituminous coal.	Bituminous (Carboniferous formation) extends from Llano county northward, to Red river, in Wichita county, many outcrops; Honey creek cove, Llano county, bed two feet thick; northeast part of Concho county; southwest part of Coleman county, three feet thick, of good quality; on east of Rio Grande, 60 miles below Presidio; Fort Belknap, Young county; along Whisky creek, north of Fort Belknap; on Coal creek, north part of Young county, bed five to six feet thick, mined for local use; Graham, opposite falls of the Salt fork; Clear fork of Brazos, northern part of Stephens county, local use only; Hubbard's creek, Stephens county; two and a half miles southeast of Henrietta, Clay county; on Sandy creek, southwest corner of Montague county, outcrops; Home creek, Coleman county; near the Colorado, Coleman county; Little Bull creek and Santa Anna mountain, Coleman county; north of San Saba river.

TEXAS—Continued.

Mineralogical name.	Common name.	Remarks.
Coal (continued).	Coal, bituminous coal.	in San Saba county; near Liberty hill, Williamson county, thin seam in cretaceous limestones; Clear fork, northern part of Stephens county; Fort Belknap, Young county, upper (Belknap coal bed), two and a half to four feet thick; lower (Brazos coal bed), four to six feet, extensively prospected. Brazos coal field extends south to Colorado river, coals high in ash and sulphur, not thoroughly tested; cannel coal on Nueces river, Kinney county, several beds three to four feet thick.
Halite	Common salt, brines, rock salt.	Along Upper Pecos river; Salt lake, near Horsehead, on Pecos river; water of lagoons west of Corpus Christi, towards Brownsville; Jordan's or Grand Saline, Van Zandt county, salt wells at work (in Tertiary); Graham, south part of Young county, wells for salt water; salt worked; salt made in south part of Wise county; Swenson's saline, west part Lampasas county; rock salt in Red river country.
Kaolinite		(See Clay.)
Lignite	Brown coal	Robertson county, used at Dallas; Bastrop, Bastrop county (almost continuous outcrops of coal from Little river, in Milam county, northeast to Herndon, on the Brazos). Two beds: upper, four to six feet thick; lower, six to eight feet thick (Tertiary). Barclay's, eight miles east of Bremond; Head's prairie, Limestone county, outcrops similar to Brazos bed; Bear Grass, Leon county, bed nine feet thick; seven miles west of Centerville, Leon county; on bank of Trinity river, Leon county; northern part of Anderson county; four miles northeast of Henderson, Rusk county; 30 miles south of Marshall, on Sabine river, at Coal ferry, Panoba county; Sulphur creek bluffs, Cass county, proved to be good; near Jourdan salines, Van Zandt county; northwest part of Grayson county, near Whitesboro; Burleson county. Tertiary coal beds extend from near Rio Grande, southwest of San Antonio, southeast to Bowie county, near northeast boundary of State; larger beds are near boundary of Cretaceous. Tertiary lignites in Rusk, Harrison, Cass, Grayson, Bastrop, Fayette, Caldwell, and Guadalupe counties.
	Limestone	Austin, Travis county; used at Austin, Paris, Sherman, etc.
	Sandstone	Northeast part of San Saba county, used for grindstones; eight miles west of Weatherford, Parker county, manufactured into grindstones and monuments; Milam, Robertson, and Cherokee counties, reddish brown sandrock, used for railroad construction, fine-grained and compact.
Silver	Silver	Padre mine, in Franklin, El Paso county, vein a fissure in Carboniferous limestone, ore argentiferous galena; Spencer mine, argentiferous galena in fissure in vein Chinati mountains in Presidio county; Mason, Mason county, calcite vein a galena; Llano county, argentiferous copper ore in a fissure vein, bornite-erubescite; Presidio county, recent discoveries of horn silver.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Agate	Agate	Near Van Horn's well, with carnelian and chalcedony.
	Alum shales	Copperas branch, four miles north of Whitesborough, Grayson county.
Amethyst	Amethyst	Llano county; Burnet county, in granite.
Asbestus	Asbestus	Near Sandys, Llano county, not in abundance to be worked.
Asphaltum	Bitumen	North of Austin and in Travis county; near Burnet, Burnet county, of no commercial value; Gordon mountain, Montague county, small beds in Cretaceous limestone.
	Bismuth ore	Near Little Wichita, Archer county, specimens.
Chalcedony	Chalcedony	Near Van Horn's well.

TEXAS—Continued.

Mineralogical name.	Common name.	Remarks.
Chalcocite	Sulphite of copper, vitreous copper.	Northwestern part of State.
Feldspar	Feldspar	Near Packsaddle mountain, Llano county, two to four feet thick; near Anderson copper mine, Chinati mountains, southeast part of Presidio county, extensive beds 20 to 50 feet thick.
	Fire-clay	(See clay.)
Galenite	Galena	(See Lead and Silver.)
Garnet	Garnet	Near Sandys, Llano county, in mica schists.
Gold	Gold	Headwaters Little Llano, eight miles south of Fort Mason, Llano county, specimens; Sandy creek, Llano county, found in washing sands; same county, in vein of copper ore, specimens only.
	Granite	Burnet, Llano, and San Saba counties.
Gypsum	Gypsum	Between Fort Quitman and Hot Springs, on the Rio Grande; eastern part of El Paso county; northern part of Presidio county; gypseous formation extends for hundreds of miles on headwaters of Red river.
Ilmenite	Titanic iron	Occurs in Llano county.
Jasper	Jasper	Near Fort Davis, Bexar county, Barilla springs.
	Lead ore	Near Blufton, Burnet county, in Potsdam, mine abandoned, ore disseminated in rock; old mine, abandoned, near Honey creek cove, Llano county, both lead and silver; specimens from Silurian rocks of Llano and San Saba counties.
Limonite	Brown hematite	Five miles east of Calvert, Robertson county, appear to be in large beds; Milam county, opposite coal of Herndon, Robertson county; Young's iron works, Cherokee county, both brown and red hematites, abundant; eight miles south of Rusk, Cherokee county, ore inexhaustible; near McLain's works, north part of Nacogdoches county; Nash's mine, at works, Cass county; Kelley's iron works, five miles north of Jefferson, Cass county; three miles south of Palestine, Anderson county, extensive bed; Whitesborough, Grayson county; Mount Enterprise, Rusk county; Jacksonville to Rusk, in Cherokee county. Iron ores occur in nearly every county in State where older Tertiary rocks prevail.
Magnetite	Magnetic iron ore	Burnet, Burnet county, thence southwest extend into Llano county, occurring in thick beds in granites, largest bed 12 miles west of Llano, Llano county; another large body eight miles northwest of latter; none of these deposits developed to any extent.
	Marble	White, black, flesh-colored, clouded, in Lower Silurian rocks of Burnet, Llano, and San Saba county.
	Molybdenum	Llano county, Burnet county, in gneissoid rocks.
Niter	Niter	In caves in Burnet, San Saba, and other counties to west of them.
	Obsidian	Near Muerto springs, Presidio county, in large veins.
	Ochers	Near Young's works, north part of Cherokee county, in clays, tried for local use.
	Opals	Near Van Horn's well, abundant; also, in igneous rocks of west.
Petroleum	Petroleum	Oil springs, six miles south of Melrose, Nacogdoches county, at base of Tertiary sandstones; springs western part of Bell county, not abundant; springs near Sabine pass, Jefferson county; Sour lake, few miles north of last locality.
Pyrite	Iron pyrites	On Copperas branch, four miles north of Whitesborough, Grayson county, in alum shales. Copperas and alum formerly made here.

TEXAS—Continued.

Mineralogical name.	Common name.	Remarks.
Pyrolusite	Oxide of manganese	Spiller mine, eastern part of Mason county, vein ten inches thick.
	Slate	Near base of Packsaddle mountain, Llano county, outcrops; Chinati mountains, southeast part of Presidio county.
Talc	Steatite	On the Hondo, Llano county; on the Sandys, Llano county, in large quantities, massive and light-colored.
	Tourmaline	Llano county, in granite.

VERMONT.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Chalcopyrite	Copper pyrites	Strafford, Orange county, in pockets in mica schist, with pyrite; Vershire, large deposit, with pyrite in mica schist, very extensively worked; Corinth, with pyrite in mica schist, extensively worked; Shrewsbury, Cuttingsville, at copperas mine; Wolcott, Lamoille county; Brighton and Concord, Essex county.
Copper (native)	Copper	Vershire and Strafford, Orange county, with copper ores; Bridgewater, in small quantity.
Granite	Granite	Barre, Coble hill, and Millstone hill quarries, fine-grained, used in State houses; Black mountain, Dummerston, Windham county; Ascutney mountain, Chester, Cavendish, Pomfret, and Berlin. Extensively quarried at Brunswick, Essex county, known as "Nulhegan granite"; Ryegate, Caledonia county, "Blue mountain granite"; Victory, Essex county; Brownington and Derby, Orleans county; and Woodbury, Washington county.
Kaolin	Clay	Pownal, Bennington county, Bennington, associated with iron ore, used for ware. Shaftsbury, Bennington county; Brandon, Rutland county, a large deposit used for fire-brick and paper. Wallingford, Rutland county; Monkton, Addison county, a large deposit. Plymouth, Windsor county, and Chittenden, Rutland county, kaolin or clay of State associated with limonite.
Limonite	Brown hematite	Henry mine, near North Bennington, large deposit of rich ore; Bennington mine, near Bennington, rich and manganiferous ore; Plymouth, Windsor county, in connection with ocher and kaolin.
Malachite	Green carbonate of copper.	Vershire, Orange county, copper mines.
	Marble	I. Vermont marble; extensive quarries on western side of Green mountains, in Addison, Bennington, and Rutland counties. Most noted quarries in towns of Middlebury, Sudbury, Brandon, Pittsford (several quarries), Rutland (a dozen or more quarries), (a) Clarendon, Wallingford, Tinmouth, Danby, Dorset, and Arlington—a belt 65 miles long, north to south. These are white saccharoidal marbles. Vermont Italian marble from Dorset. Most extensive quarries in Rutland, Shelburne, Addison county; at Swanton, Franklin county, dove-colored marbles. II. Winooski marble, worked to a limited extent in northwest part of State—Addison, Chittenden, and Franklin counties; also, localities at Mallett's bay, Colchester, near Burlington, and in Swanton. III. Plymouth marble, Plymouth, Windsor county, a variegated marble. IV. Isle la Motte marble, Isle la Motte, Lake Champlain; and in Champlain valley, a black marble.
Pyrite	Iron pyrites	Strafford (Copperas Hill mine), Orange county, a very large deposit interstratified with mica schist, associated with chalcopyrite; Cuttingsville, Rutland county, with chalcopyrite in gneiss; Vershire, Orange county, large bed with chalcopyrite; Corinth, with chalcopyrite; Brighton, Baltimore, and Brookfield, Orange county.

a Product, in 1882, valued at $2,000,000.

VERMONT—Continued.

Mineralogical name.	Common name.	Remarks.
Serpentine	Verd antique marble	Cavendish, Windsor county, for ornamental work; Roxbury, Washington county, quarries formerly worked; many other and large mountain masses in and near the talcose schist belt from Massachusetts to Canada—others in the gneiss; Newfane, Windham county; Plymouth, Windsor county; Troy and Westfield, Orleans county.
	Slate	Three ranges of roofing slate: I. Eastern, clay slate near Connecticut river, from Massachusetts line to Essex county; found in Guilford, Windham county; Thetford, Orange county; Waterford, Caledonia county, and other localities and small quarries. II. Middle range of clay slate extends from Memphremagog lake to Barnard slate quarries in Northfield, Montpelier, and elsewhere of uniform shade and black. III. Western, Vermont slate quarried largely in Castleton; also in Fairhaven, Poultney, Wells, and Pawlet, Rutland county; generally of a dark purple color, with occasional blotches of green; very compact and fissile. Large quarries near West Castleton, Hydeville, Scotch hill, and Fairhaven.
Talc	Steatite, soapstone	Abundant mostly on east side of Green mountains, near talcose slate, and found in a belt whole length of State. Marlborough, Windham county, known as "chalkstone;" Newfane, Chester, Grafton, and Athens, large quarries; also in Bridgewater, Plymouth, Cavendish, Weathersfield, Bethel, and Rochester, Windsor county, thence north in Washington, Lamoille, Franklin, and Orleans counties.
	Whetstone, oilstone, scythestone.	"Magog oilstone" (novaculite), near Canada line; Lake Memphremagog, Fitch's island quarry, honestones; Northfield, Washington county, talcose schist, scythestones; Ludlow, Rutland county, and Stockbridge, Windsor county, scythestones.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asbestus	Asbestus	Lowell, Troy, Jay, Cavendish, Roxbury, and Mount Holly.
Arsenopyrite	Mispickel	Brookfield, Waterbury, Stockbridge, and in Vershire, with pyrite and chalcopyrite.
Braunite	Manganese ore	Brandon, Bennington, Plymouth, and Chittenden in small quantities.
Chalcopyrite	Copper pyrites	Wolcott, Lamoille county; Brighton and Concord, Essex county.
Chromite	Chromic iron ore	Jay, Troy, Westfield, and Newfane, in several narrow veins in serpentine.
Feldspar	Feldspar	Corinth, Strafford, Norwich, Chester, Newfane, and Saxton's river.
	Flagging stone	Cavendish (gneiss); between Hartford and Rockingham, Windsor county, small quarries, in clay slate.
Galenite	Galena	Thetford, Orange county, old mine in vein of quartz, calcite, etc., in talcose slate (argentiferous); Norwich, Windsor county, small vein in talcose slate; Morristown, Lamoille county; Bridgewater and Plymouth, Windsor county, and Chittenden, Rutland county, occurrences only.
Gold	Gold	Bridgewater, Windsor county, sparingly in quartz veins in talcose slate at lead mine; Plymouth, Windsor county, in drift; Newfane, Windham county. Some of these localities may be worked a little (?).
Graphite	Plumbago, black lead	Brandon, Halifax, Hancock, Huntington, Newbury, Norwich, Pittsford, and Swanton.
Hematite	Red oxide of iron	Milton, near Lake Champlain, worked to slight extent; Fairfield, of small extent; Weathersfield, Windsor county.
	Infusorial earth	Peacham, Caledonia county.

VERMONT—Continued.

Mineralogical name.	Common name.	Remarks.
Lignite	Brown coal	Brandon, in and upon clay beds; Tertiary age.
Magnetite	Magnetic iron ore	Rochester, sparingly in chlorite slate; Plymouth and Ludlow, sparingly; Somerset, worked several years ago; Troy, Orleans county, a titaniferous ore in small beds; Bridgewater, Windsor county, and Chittenden.
	Marl	Abounds in most of towns bordering Lake Champlain; also in Windsor and Orange counties.
	Ocher	Brandon, Rutland county, limonite ores and ochers for yellows, browns, reds, and umbers; Bennington, red and yellow ocher; North Dorset, a vein between walls of calcareous quartz, manufactured into paint; and Watsfield.
	Peat, muck	Numerous localities, especially in Champlain valley.
Psilomelane	Black manganese ore, black hematite.	Brandon, with pyrolusite; Bennington, Chittenden, Bristol, Colchester, Plymouth, Pittsford, Stamford, Wallingford, and Irasburg.
Pyrolusite	Gray oxide of manganese.	Brandon, with limonite and psilomelane; Bennington, Bristol, Chittenden, Colchester, Plymouth, Pittsford, Stamford, Wallingford, and Irasburg.
Quartz	Sand rock	East Dorset, Bennington county, disintegrated quartz rock, once used for glass; Plymouth, Windsor county, associated with kaolin; elsewhere in western Vermont.
Siderite	Spathic iron ore, carbonate of iron.	Plymouth, in talcose slate, with magnetite and pyrite.
Silver	Silver	Traces in galenite at Thetford mine.
Sphalerite	Zincblende	In lead mine, Thetford, Orange county; Norwich and Morristown, sparingly, with galenite; Bridgewater, Windsor county, contains cadmium.
Zaratite	Emerald nickel	South Troy, Orleans county, very sparingly.

VIRGINIA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Asbestus	Asbestus	Bartons, Floyd county; Signers', Floyd county; near northern copper lode, Grayson county, and on Little river, below Hampton mine; lead and zinc mines, Painter's branch, Wythe county; Barnet's mills, Fauquier county; Pittsylvania county; Goochland county; Willis mountain, Buckingham county; Chula, Amelia county; near Appomattox river to Amelia county, near Franklin C. H.
Barite	Barytes, heavy spar	Frye's marble quarry, Wythesville, Wythe county, in small quantities; Brown hill, Wythe county, near lead and zinc ore deposits, in large masses; near Marion, Smyth county, mined, in Silurian limestone; Cavitt's creek and Baptist valleys, Tazewell county; and Russell county, along Clinch river; Lee county; Eldridge's gold mine, Buckingham county; near Lexington, Rockbridge county; several localities near Lynchburg, Bedford county; Beaver creek, Campbell county, bed of fine granular variety; near Saint Stephen's and in lower Fauquier county, several mines, no longer worked; between Marshallville and Upperville, Fauquier county, undeveloped; Prince William county, mines worked out.
Calamine	Silicate of zinc	Wythe county, lead mines with galena, blende, etc.
Cerussite	White lead ore, carbonate of lead.	Wythe lead mines, Austinville, Wythe county, with galena, blende, etc., in magnesian limestone, in small quantities; Crusinbury and Kitchen mine, Wythe county.
Chalcocite	Copper glance, sulphuret of copper.	Near Max meadows, Wythe county; Mount Airy, Smythe county; Toncray mine, Floyd county, with magnetite and pyrite, not worked; copper ranges or lodes in Carroll county, opened at several localities, west and northwest of Hillsville; occurs in upper part of deposits with melaconite and chalcopyrite.

VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Chalcopyrite...	Copper pyrites, yellow copper ore.	Toncray mine, Floyd county, with chalcocite, pyrite, and magnetite; northeast part of Floyd county; on north fork of Roanoke, with pyrrhotite; Peach Bottom copper lode, or range, Carroll county; northern copper range, at Great outburst; Chestnut creek, Copperas hill, Cranberry plains, and other localities. Continued southwest into Grayson county. Too far from cheap transportation. Several mines opened. Common at many localities in the "gold belt." Phœnix copper mine, Fauquier county; Ford's mine, Buckingham county; gangue in gold mine; mine near Herndon, Fairfax county; Madison county; Fairfax gap; head of Naked run, Greene county. Three veins traceable for long distance. Conway river, Greene county; Guilford, Loudon county; Richards' mine, Page county.
Coal	Coal, bituminous coal.	Coal Measures in Buchanan, Dickenson, Wise, Scott, Lee, Russell, and Tazwell, in southwest angle of State; in edge of Cumberland mountain range; sub-Carboniferous or Great Conglomerate coal group, in Wythe, Montgomery, Pulaski, Augusta, and Botetourt, on west side of the Great valley. Upper New river Coal Series opened in mines near Blacksburg, Brush mountain, and on Price mountain, Montgomery county; near Martin's, in Pulaski county, and in Little Walker mountain, in Wythe and Pulaski counties. A semi-bituminous coal is opened at Max meadow and Clark Summit line, in Pulaski; in Bland county, mines on south foot of Brushy mountain; in Tazewell county, at Middle creek, Horse Pen cove, and Abb's valley; in Buchanan county, on Connoway creek; in Wise county, near Big Stone gap; and on headwaters of Powell's river, Green river, and Pond run, bituminous, splint, and cannel coals.
Coal (2)........	Bituminous coal	Jura-Triassic coals. Richmond coal basin, 189 square miles, in Chesterfield, Powhatan, and Henrico counties, with mine centers at Midlothian, National, Clover hill, Carbon hill, and Dover. Three workable seams, and 50 to 60 feet of coal. Farmville coal basin, on the Appomattox river, and in Cumberland and Prince Edward counties, 25 square miles; mines at Farmville. Dan River basin, Pittsylvania and Henry counties, crossing into North Carolina. Several thin seams exploited.
Cuprite........	Red oxide of copper...	Linden, Warren county, with melaconite and native copper.
	Flagging stone........	Slate quarried on Hunt's creek, Buckingham county.
Galenite	Galena, sulphide of lead.	Wythe county lead mines: Occurs with blende, smithsonite, and calamine in magnesian limestone; worked for a century; Bertha zinc mine, eastern part of Wythe county, with blende; Little Reed island creek (Sayers), Wythe county; Forney mine, Wythe county, with blende; New river, near mouth of Reed Island creek, Pulaski county, galena and blende, with other lead and zinc minerals; Tract mountain and Big Walker mountain, Pulaski county; Sugar Grove, South Fork valley, Rich valley, Bear creek, localities in Smith county; Giles county, in Lower Helderberg rock, in small quantities; near Sharon, Bland county, also in Garden and Flat Top mountains; on Clinch river near mouth of Maiden Spring fork, Russell county; Floyd county, at McAlexander's, on Little river and this range with quartz and pyrites, argentiferous; Peach Bottom copper lode, Carroll county and Grayson county, argentiferous; Stafford, Nelson, and Franklin counties, argentiferous.
Gold...........	Gold.................	Brush creek, Montgomery county, in gravel; Little river, Floyd county; "gold belt" of Virginia from Potomac to Halifax county, 200 miles long and 15-25 miles wide, gold-bearing quartz in crystalline rocks, many mines opened, principally in Fauquier, Stafford, Culpeper, Spottsylvania, Orange, Louisa, Fluvanna, and Buckingham counties; Booker ford, Buckingham county, Rappahannock mine, Randolph mine, Whitehall mines, Pocahontas mine at Andrews, in Spottsylvania county; Louisa county mines; Chicago and Virginia Gold Mining Company, Orange county; Snead mine, Fluvanna county; Tellurian gold mine, Goochland and Fluvanna counties; eastern part of Culpeper county, several working localities; Culpeper gold mine, Culpeper

VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Gold (continued.)	Gold	county; Eagle mine, Stafford county; Franklin, Liberty, and other mines in Fauquier county, southern part lately reopened and worked very little, gold in sulphurets lost in roasting.
	Granite	Richmond, Petersburg, Fredericksburg, gray granites; Richmond, Henrico county; Tuckahoe district, Henrico county; Westham granite quarries, Manchester, old dominion quarry at Granite, Chesterfield county; Naurozine district, Dinwiddie county; Lynchburg, Campbell county; Columbia, on James river (a gneiss), Fluvanna county; Willis mountain, Buckingham county (a pink gneiss); Cumberland county, quarries in gneiss; Boorman, on Cedar run, Fauquier county, quarry worked for Washington city supply; also near Delaplaine, Fauquier county.
	Gypsum	Buena Vista plaster beds, Buchanan's plaster cove, and other localities on north fork of Holston valley, Smyth county and Washington county; extensive beds, associated in places with rock salt.
Halite	Common salt	I. Rock salt—Saltville, Smyth county, valley of north fork of Holston river, a large deposit; II. Brines—Saltville, Smyth county and Washington county; on Clinch river, southwest part of Lee county.
Hematite	Red hematite, specular iron ore.	In lower slates of Potsdam in Warren, Augusta, Rockbridge, Botetourt, Bedford, Wythe, and Smyth counties. Beds opened at Overall station, Warren county; Arcadia furnace, Botetourt county; Pollard cut, same county; specular ore at Cundiff creek, in Bedford county, and on Clinch mountain range, Washington county; also on south slope of Iron mountain, Grayson county. On James river, below Lynchburg. Traceable through Nelson, Amherst, Appomattox, Buckingham, Albemarle, Orange, and Culpeper counties; several mines opened near James river. Loudon county; Stafford county; east foot of Bull Run mountain, Prince William county.
Hematite (2)	Fossil ore, dyestone ore.	South flank Big Walker mountain, Wythe county; same range and also on Poor Valley ridge and Clinch mountain; in Flat Top, Buckhorn, and East river mountains, in Giles county; same ranges in Bland county, and also at Wolf creek and Round mountain; in Tazewell county; Russell county; Powell's mountain and south face of Clinch mountain, Scott county; Poor Valley ridge, Waldin's ridge, and Powell mountain, in Lee and Wise counties. Numerous ore banks in red hematite worked in Great valley of Virginia from Augusta to Smyth county.
	Hydraulic limestone	Balcony falls, James river, Bedford county. A gray magnesian stone, noted "Balcony Falls cement;" Madison run, Orange county, undeveloped.
	Limestone	Valley of Virginia and Piedmont district. Outcrops at many localities; for local uses mainly. Fauquier county; local use.
Limonite	Brown hematite	Occurs in Potsdam sandstone, in Page, Rockingham, Augusta, Rockbridge, Botetourt, Montgomery, Pulaski, Wythe, and Smyth counties; many deposits along western foot of Blue ridge. In magnesian limestone of Great valley in counties above enumerated; also in Oriskany sandstone, mainly in Pulaski and Giles counties. Ore banks at many localities in this valley quite to the Tennessee line. Limonite in extensive beds opened in Oriskany and Upper Helderberg formations, in Paint Lick mountain, Rich mountain, Nye's cove, and other localities in Tazewell county; in Clinch mountain and Kent's ridge, in Russell county; in Powell's mountain, Clinch mountain, Fossil and Big ridges, in Scott county; Bowling Green forge, Lee county. Large deposits with belts of magnetite and specular ore occur in a range near James river in Nelson, Amherst, Campbell, Appomattox, Buckingham, thence northeast into Fluvanna, Orange, and Culpeper, and terminating in Fauquier. Many openings on this range.

VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite (2) ...	Bog iron ore	In tidewater part of State, in Tertiary formation; ores generally lean.
Magnetite	Magnetic iron ore....	In Great valley of Virginia, at Ripplemead mine, near Pearisburgh; also near Newport, and other localities, Giles county; Wytheville, Wythe county, with hematite; near Abingdon, Washington county; Toncray mine, Hylton mine, and Bear beds, in Floyd county; Carroll county; Billings mine, near Independence, thence to New river, in Grayson county; several localities. James river belt: Mount Athos, Riverville, Appomattox county, with belts of specular and limonite ores; also in Buckingham, Culpeper; near Paris and Markham, in Fauquier and Spottsylvania counties; Stewart's knob, Patrick county; Rocky mountain, Franklin county; Albemarle county; in Chesterfield coal basin, at Tarbue's.
	Marl, greensand marl.	In Lower Tertiary or Eocene near head of tidal waters (average 16 miles wide). Greensand marls, principally in Prince George, Henrico, Hanover, and King William counties.
	Calcareous marls	In Middle Tertiary or Miocene, of tidewater area of State. Localities: Gloucester county; New Kent county; on Acquia creek, Strafford county.
Melaconite	Black oxide of copper.	In upper portions of copper lodes, Carroll county, with chalcocite and chalcopyrite, and malachite. Worked for a time; also Floyd and Grayson counties; Linden, Warren county.
	Millstone	Price's Mills, Montgomery county; southern part of Carroll county, granites used for millstones; Campbell county, syenitic rock used for millstone.
Malachite	Green copper ore, carbonate of copper.	Peach bottom copper range, Carroll county; northern copper lode or range, Carroll county, with limonite and ores of copper; near Overall's station, Warren county, with gray sulphide; near Catlett's station, Fauquier county; old mine near Linden, in Fauquier county, formerly worked.
	Marble	Near Wytheville, Wythe county; Frye's hill, southwest of Wytheville, Wythe county, quarries at these localities; Craigsville, Augusta county, "encrinal marble" and black marble from Lower Helderberg formation extensively quarried, Campbell county; near Marion, Smyth county; valley of north fork of Holston river, Washington county; Giles county (Rye hollow), etc.; Estillville, Scott county; near Greenwich, Rockbridge county; in Blue ridge, Fauquier county; Toddsburg, near Madison run, Orange county. Brecciated or Potomac marble, quarried near Leesburg, Loudon county, also in Fauquier county.
	Ocher..................	Keezletown, Rockingham county; Massanutton mountain; near Alma and Marksville, Warren county; Bermuda Hundred, on Appomattox river; Bon Air, Chesterfield county; hematites near Madison run, Orange county.
Psilomelane ...	Manganese ore	Cremona, with pyrolusite. Worked.
Pyrite	Iron pyrites	Common in many localities. Graham's, New river, Wythe county, with brown hematite outcrop; disseminated in proto-Carboniferous slates, Smyth county; Brush creek, Montgomery county; Floyd county, Toncray mine with copper sulphurets; southern copper lode, northern or Dalton lode, in Carroll county, immense deposits of pyrite, pyrrhotite, arsenopyrite, and chalcopyrite, underlying gossan and the deposits of melaconite and chalcocite; Grayson county—southeast corner of county in copper lodes with pyrrhotite and chalcopyrite. Western part of Grayson county in east slope of Balsam and White Top mountains. Many localities in "gold belt" and often auriferous, particularly in Amherst and Buckingham counties. Large deposit at Tolersville, Louisa county, occurs in chloritic slates.

VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Pyrolusite.....	Black oxide of manganese.	Crimona manganese mine, Augusta county, extensive deposit and worked steadily; Iron mountain, Wythe county; Glade ore bank near Max meadow, Wythe county, associated with iron ore Lick and Draper's mountain ranges, Wythe county; Flat Top mountain near Bland county line, Salt Pond mountain, Big Stony creek, Giles county; mountains western part of Bland county; Whitelow's and Shooting creek, Floyd county; near Vesuvius furnace, Rockbridge county; on James river, in Campbell and Appomattox counties; Cabell mine; Pittsylvania county, mined largely; Tolersville, Louisa county; Midway mills (Dan's mine), Nelson county.
	Sandstone, "brown stone."	Quarries in Triassic sandstone areas of middle Virginia; freestone quarries near mouth of Acquia creek; near Manassas, Williams county, a brownstone of Triassic extensively used in Washington and Alexandria and elsewhere; Thoroughfare gap, Prince William county, a quartzite.
Serpentine.....	....	Between Difficult creek and Stillhouse creek, near the Potomac, Fairfax county, heavy beds and containing chrome ore and talc and magnetite.
	Slate..................	For roofing: On Hunt's creek, Buckingham county, several quarries actively worked, and for a long time; Albemarle county; Baldwin quarry, Amherst county; near James river, Bedford county, and near Balcony falls, near Staunton, Augusta county; Newcastle, Craig county, opened; Keswick, Albemarle county, near Rappahannock river; near White Sulphur springs, Fauquier county, abandoned.
Smithsonite....	Carbonate of zinc, "dry bone."	Wythe county, lead and zinc mines with blende, galena, etc.
Sphalerite.....	Zincblende, black-jack.	Austinville, Wythe county, lead and zinc mines; occurs with galena and other ores of lead and zinc, in dolomite; has been long and largely worked; Bertha mine, Wythe county; Falling cliff mine, Wythe county, and Forney, Wythe county; on New river, near mouth of Red island creek, Pulaski county, with galena; near Sharon and on Garden and Flat Top mountains, Bland county, scattered in dolomite.
Talc...........	Steatite, soapstone....	Barton's, Floyd county; near Toncray mine, Floyd county; near Peach Bottom mountains, on north, Grayson county, in great masses. Wytheville, Wythe county, two miles west of Lynchburg. Campbell county, belt traceable for miles; near Amelia C. H., Amelia county; Spencer's store, Henry county, fine quarries; Vallena, Fluvanna county; Madison county, northwest base of Buffalo ridge, Amherst county, and Nelson county, small quarries opened; near Cartersville, Cumberland county, opened; Drainsville, near Potomac, Fairfax county, with serpentine.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Arsenopyrite ..	Mispickel, arsenical iron pyrites.	Purgatory, Floyd county, large vein, argentiferous; southern copper lode in Carroll and Grayson counties.
Bornite	Purple copper ore.....	Near Leesburg, Loudon county.
Carbonite	Natural coke..........	Chesterfield coal basin, Chesterfield county (Triassic).
Chromite.......	Chrome iron ore	In serpentine, Drainesville, near the Potomac, in Fairfax county.
Copper, native	Copper	Toncray mine, Floyd county; native copper lode, Carroll county, near Hillsville, etc.; near Linden, Warren county, with cuprite and melanconite.
	Feldspar...............	Common in "Middle Virginia."
	Fire-clay	Under coal seams in southwest angle of State, undeveloped. Lick mountain, Wythe county; Bon Air, Chesterfield county; near Court House, Powhatan county; also in counties of Cumberland, Buckingham, and Appomattox; near mouth of North river, Rockbridge county; Madison run, Orange county.

VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Graphite	Plumbago, black lead.	Winterham, Amelia county; Halifax county and Goochland county.
Kaolin	Clay	Augusta county; Prince Edward county; near Cumberland court house, Cumberland county, a belt of clay; kaolin or Sherando station, Augusta county; near Warrenton, Fauquier county, undeveloped; Strafford county; Lick mountain, Wythe county, in large quantities; near Rye valley, Smyth county.
Muscovite	Mica	Hanover county; near Court House, Goochland county; Louisa county; near New London, Bedford county; near Amelia court house, Amelia county.
Massicot	Lead ocher	Austin mines, Wythe county, in small quantities with galena and other lead ores.
Pyrrhotite	Magnetic pyrites	Northeast part of Floyd county, with chalcopyrite; a thick bed; Southern copper lode, and Northern or Dalton copper lode, Carroll county. Deposits of great extent, with pyrite, chalcopyrite, and arsenopyrite. Opened at Clifton mine, near Chestnut creek, Cranberry plains, etc., Carroll county. Extends southwest into Grayson county. Distant from transportation.
Quartz	Quartz, sand	Quartzite near Leesville, Bedford county; Thoroughfare gap, Prince William's county. Sand, for glass making, near Greenville, Augusta county.
Silver	Silver	See under Galenite and Arsenopyrite. Occurs alloyed with gold in gold bearing rocks of central part of State.
Sulphur	Sulphur	On Potomac, 25 miles above Washington, in small masses in limestone.
Tetradymite	Tellur-bismuth	Whitehall gold mines, Spottsylvania county; Monroe mine, Stafford county; Tellurium mine, Fluvanna county; Stafford county.
Tripolite	Infusorial earth	An extensive deposit traceable from the Patuxent river, in Maryland, to the Meherrin in Virginia. Exposed at Richmond and other points.
	Umber	Overall station, Warren county.

WEST VIRGINIA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Coal	Bituminous coal	Carboniferous formation has an area of 16,000 square miles. Lower Coal Measures and sub-conglomerate seams are worked in the southern part of State; in northeast the upper Coal Measures afford the working seams. Potomac basin, opened in Mineral and Grant counties; Preston county basin worked at Newburg, Austin, and Decker's creek, Monongalia county. Blue Stone Flat Top coal field, extensively worked in places, extends into Mercer, Raleigh, and Summers counties. In Randolph, Upshur, and Marion counties the Upper Freeport seam is thick, and worked in last named largely. The Great Kanawha basin is noted for its various seams of bituminous, splint, and cannel coals. Nowhere are the Lower Coal Measures better developed than in it. Cannelton, Fayette county, Peytonia, Boone county, afford "cannel splint." The "splint" coals are found in Braxton, Webster, Clay, Nichols, Fayette, Kanawha, Boone, Logan, Lincoln, and Wayne counties, often with more or less bituminous coals. Mines of splint coal at Coalburgh, East Bank, and Paint creek, in Kanawha county. Principal mining districts are along the Ohio river, Valley of Kanawha, and along lines of Baltimore and Ohio railroad, from Preston county west to Ohio.
Coal (2)	Anthracite coal	Berkeley county, thin seams worked for local use only.

WEST VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
	Fire-clay	Nuzum's mills in Marion county. Used for firebrick. Lost run, Taylor county; Tunnelton, Preston county; near Morgantown, Monongalia county; on Two-mile creek of Elk river, Kanawha county, worked; near Cassville in Wayne county; near Savageville, in Braxton county; Hancock county. Several firms make firebrick. Other localities in Coal Measures.
Halite	Common salt, brines	Brine wells. Principal points are: Charlestown, Kanawha county; West Columbia to Hartford, on Ohio river, Mason county; Bulltown, on Little Kanawha, Braxton county; Louisa, on Big Sandy river, Wayne county; New river, Mercer county; Birch, on Elk creek; mouth of Otter creek, on Elk river, Clay county; Cheat river, Decker's creek, and Scott's run, Monongalia county, in borings for oil. Mason County Salt Works most extensive, and make nearly all of State product.
Hematite	Fossil ore	North slope of East River mountain, Bluestone river on Black Oak mountains, and Flat Top mountains, Mercer county; Little mountain, Monroe county; Anthony's creek and Howard creek, Greenbrier county, both fossil and black ore; South Fork mountains, Pendleton county; middle, and also on north mountain ranges, Hardy county, large bodies developed; vicinity of Greenland gap, Grant county, five feet thick, parallel seams.
Hydraulic limestone.	Water-lime	Near Shepherdstown, Jefferson county, quarry in bluff on Potomac.
Limonite	Brown hematite	Near court-house, Raleigh county; Peter's mountain, Monroe county; South Fork mountains, and near Franklin, Pendleton county, with fossil ores; Salt Spring Run knob, Cunningham tract, south of Moorfield, Hardy county, large deposits; North or Capon mountain, Hardy county, have long been mined, associated with red hematites; Walker's ridge and Knobly mountain, Grant county; Bloomary, Capon mountains, Hampshire county, long worked; Sandy ridge, Morgan county; Martinsburg, Berkeley county; along Potomac, opposite Antietam creek, Jefferson county; near Bolivar heights, Harper's ferry; Maltby's ore bank, Jefferson county. Some of these localities are not now worked.
Niter	Saltpeter, "peter-dirt."	Caves in Greenbrier county; Monroe and Pocahontas counties.
Petroleum	Petroleum	Horse neck, Pleasants county; Cow creek and French creek, Pleasants county; Oil rock and California house, Ritchie county; Volcano and Sand hill, "heavy oils"; Burning springs, Wirt county; near Morgantown, Monongalia county, and at points on a line thence to Charlestown, Kanawha county.
Quartz	Sand	Sandy ridge, at Alpines, Morgan county, large deposits of white sand, worked for glass manufacture in Philadelphia.
	Sandstone	Near Morgantown, Monongalia county (Mahoning), sandstone is quarried; Grafton sandstone is quarried in Taylor county; Weston, Lewis county; Ranceverte, Greenbrier county; Charlestown, Kanawha county, Mahoning sandstone is extensively quarried for local use; Upper Kanawha, sandstones of Coal Measures are quarried; Hansford, on Kanawha river, Kanawha county; near Kanawha, on Elk river, Kanawha county; East Wheeling, Ohio county.
Siderite	Carbonate of iron, clay iron stone.	Mineral county and Grant county, thin seams at several localities; Three forks creek, Reedsville, Tunnelton, and Muddy creek, Preston county; Decker's creek, Scott run, Booth creek, and Cheat river, east part of Monongalia county; Fairmount, Marion county; near mouth of Last run, Taylor county; near Phillipi, Barbour county; Standing Rock run, worked by Elk Railroad Iron Company; Clay county, Braxton county; near Charlestown, Kanawha county; on Big Sandy river, at Cassville, Wayne county, eight seams one to three feet thick. Workable beds in Lower Coal Measures and Lower Barren Measures.

WEST VIRGINIA—Continued.

Mineralogical name.	Common name.	Remarks.
Siderite (2).....	Black band ore	Black band iron ore, near Big Sandy river, Wayne county; Davis and Briar creeks, Kanawha county; Bell creek, Fayette county; Little Elk run, Nicholas county; Little Sycamore creek of Elk river, Clay county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Barite	Barytes, heavy spar ..	Jefferson county; Mercer county, on north slope of East river mountain.
	Calcareous tufa, travertine, calcareous marl.	Patterson's creek, Grant county; Hardy county, Hampshire county, and other counties in large deposits; Jefferson county.
Dufrenite......	Phosphate of iron	South mountain, ten miles east of Lexington, Stockbridge county.
Fluorite	Fluorspar....	Shepherdstown, Jefferson county.
Grahamite.....	Asphalt	Filling fissures in sandstone (Carboniferous) near Cairo, in Ritchie county. Has been worked.
	Limestone	Jefferson and Berkeley counties.
	Manganese ore	Anthony's creek, Greenbrier county.
	Ocher.................	Yellow ocher, near Weston, Lewis county; South branch valley, Hardy county; Lost river, near Harper's Ferry, Jefferson county; near Shepherdstown, Jefferson county; Cline's cross roads, Pendleton county; on Guyandotte river, Cabell county; near Ceredo, Wayne county.
Quartz.........	Sand..................	Blue gap, Short mountain, Hampshire county, cliffs of white sand rock; near Morgantown, Monongalia county, very soft sandstone; Sir John's Run, in Morgan county.

WISCONSIN.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOHN C. SMOCK.]

Azurite........	Blue carbonate of copper.	Mineral Point copper mines, Iowa county, with chalcopyrite.
Chalcopyrite...	Copper pyrites........	Common in the lead region, ore at Mineral Point mines, Iowa county, Richland and Vernon counties, in Potsdam sandstone sparingly.
Copper, native .	Copper	Openings on Montreal and Bad rivers, Ashland county; Brule, Amnicon, and Black rivers, in Douglas county. Occurring in veins and scattered through spidotic; in boulders in eastern part of State; common.
Galenite	Galena................	That part of Wisconsin in the upper Mississippi lead district; in counties of La Fayette, Grant, Iowa, and Green. Principal districts or groups of mines are: Butown, T. 4, R. 4 W., Grant county; Potosi, T. 3, R. 3 W., Grant county; Fairplay, T. 1, R. 2 W., Grant county; Hazel Green district, in Grant and La Fayette counties; Shullsburg, La Fayette county; Benton and vicinity, La Fayette county; Plattville district, Grant county; Mifflin, Iowa county; Highland and vicinity, Linden, Mineral Point district, Dodgeville, Iowa county; Calamine and Vista, in La Fayette county; Monroe, Green county. Galena occurs in vertical crevices and in flat sheets in Galena limestone and in blue and buff limestones of Trenton group. With it are often found blende, pyrite, chalcopyrite, and other compounds of lead, zinc, and copper. Ores worked in some mines for both lead and zinc.

WISCONSIN—Continued.

Mineralogical name.	Common name.	Remarks.
	Granite	Near Dexter, on Yellow river, Wood county; several quarries opened in this county. Localities too numerous to mention—undeveloped.
Hematite	Specular iron ore, red hematite.	I. Specular iron ore. Menominee range. The western extension of this ore range is worked extensively at Commonwealth and Florence mines in T. 40, R. 18 E., in Florence county. Beds of great thickness in Huronian schistose rocks. Specular ore accompanied by some limonite. [Product 1882, 276,017 tons. Penokee range. Ashland and Bayfield counties, associated with magnetite in quartzite and slate of Huronian; great extent of lean ores; opened and worked at Penokee gap. Baraboo region, Sauk county, veins in white quartz (Huronian), not in workable amount; Westfield, Sauk county, and in western part of Sauk county, near Ironton; Cazenovia, Richland county, with limonite in Potsdam sandstone. Mines supply local furnaces. On Black river, Jackson county, also along Chippewa river, very lean ores. II. Clinton, or "fossil ore." Iron ridge, Hubbard, Dodge county; Maryville, Hubbard, Dodge county, in thick beds of great extent and largely worked.
	Hydraulic limestone, water-lime, cement rock.	Near and north of Milwaukee, on Lake Michigan, an impure dolomite of Hamilton formation. Extensively quarried and made into "Milwaukee cement rock." Ripon, limestone; Poygan, Winnebago county.
Kaolinite	Kaolin, porcelain clay, and fire-clay.	In a belt of Laurentian rocks 50 miles long and 15 miles wide, stretching from Black river, Jackson county, to the Wisconsin, in Wood county. Well exposed at Grand Rapids, Wood county, and worked for firebrick manufacture.
	Limestone	Many localities in southern and central parts of State. Westport, Dane county, a cream-colored limestone; near Madison, quarries in the Mendota limestone, a yellow, fine-grained rock; Boscobel, Grant county; Wauwatosa; Waukesha, Waukesha county (Niagara group); Cedarsburg, Genesee, Manitowoc; near Fond du Lac (Niagara).
Limonite	Brown hematite	Accompanies specular ore at Commonwealth and Florence mines, Florence county; Westfield and Ironton, Sauk county, and Cazenovia, Richland county, with hematite in Potsdam sandstone. Worked for local supply to furnaces.
Limonite (2)	Bog iron ore	Near Necedah, Juneau county; Grand Rapids, Wood county; other localities in marshes of central and northern parts of State.
Magnetite	Magnetic iron ore	Penokee range, Ashland and Bayfield counties. Ores occur in quartzites and slate rocks of the Huronian. Specular ore also common, with magnetite. Much of ore of this range is lean, but of excellent quality. Mined at Penokee gap, along Chippewa, Chippewa county, and Black river. Very lean; mixed magnetic and hematite ores (ferruginous schists).
Malachite	Green carbonate of copper.	Mineral Point copper mines, Iowa county, with other copper ores.
	Ocher, red and yellow.	Clintonville, Iowa county.
	Sandstone	Basswood island, Lake Superior, Ashland county, a large quarry. "Lake Superior brown sandstone"; Houghton point, Ashland county; Baraboo, Sauk county; Packwaukee, Marquette county; Wautoma, Waushara county; near Grand Rapids, Wood county; Black river falls, Jackson county; Stevens Point, Portage county. These are Potsdam rocks.
Smithsonite	Carbonate of zinc, "dry bone."	In lead district of southwest Wisconsin, with blende. More abundant in northern and central parts of district. Mines in Iowa county; generally contain both lead and zinc ores, and worked for both ores.
Sphalerite	Zincblende, "black jack."	Common in the lead district, as associate vein material with galena. Principally in northern and central parts of district. Mifflin, Centreville, Highland, and Linden, all in Iowa county, and east of Dodgeville, Iowa county; Mineral Point mines, Iowa county; worked for zinc.

WISCONSIN—Continued.

Mineralogical name.	Common name.	Remarks.
	Whetstones and grindstones.	Woodland, Sauk county, quarry.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Asphaltum	Bitumen	In Devonian limestone, near Milwaukee; in shales in lead region.
Barite	Barytes, heavy spar ..	In lead region abundant.
Cerussite	Carbonate of lead.....	Rarely, in lead district.
Chalcocite	Vitreous copper ore, copper glance.	Mineral Point copper mines, with chalcopyrite and carbonates.
Garnet.........	Garnet.................	Lac du Flambeau.
Gold...........	Gold..................	Northwest of Fond du Lac, in quartz; opened; Maxwell mines, Stockbridge, lately opened; Bumschwiller and Silver creek, near Ashland.
	Peat..................	Underlying many of bogs and swamps. Used for fuel.
Phlogopite.....	Mica...................	Eau Claire river, in large plates.
Pyrite	Iron pyrites	Lead district, southwest part of State. Common as vein material, with galena and blende.
Quartz.........	Sand for glass manufacture.	Saint Peter's sandstone at many localities; Waukau, Winnebago county.
Silver, native ..	Silver..................	Montreal river; sandstones; carry traces only.

DIVISION OF THE ROCKY MOUNTAINS.

Mr. Whitman Cross, to whom was assigned the compilation of the mineral occurrences in the Rocky Mountain region, explains in the accompanying letter the method which he has followed in the preparation of the lists:

DENVER, COLO., *May* 21, 1883.

Mr. ALBERT WILLIAMS, JR.,
United States Geologist, Washington, D. C.:

SIR: I have the honor to transmit herewith the lists of minerals and mineral substances of industrial importance occurring in Colorado, Dakota, Montana, New Mexico, and Wyoming, compiled in accordance with your directions.

As the value of such lists depends almost entirely upon the methods employed in their preparation, I wish to state the main principle which has guided me in the present case. I have inserted nothing in these lists for which I did not have what has seemed to me satisfactory authority. According to newspaper reports and statements of so-called "mining experts," scarcely any mineral is more abundant in many mining regions of the West than ruby silver, silver glance, "chlorides," etc., while for many such cases no foundation in fact exists at all, and for others the evidence obtainable is very unsatisfactory. I have therefore omitted from these lists many things of common report, some of them no doubt of actual occurrence, concerning which I could find no trustworthy information. The lists are therefore incomplete in regard to minerals which may have been publicly announced. I have chosen to err in this particular rather than by inserting occurrences which would necessarily be stricken from subsequent lists. Particularly for the tables of substances not at present mined it has been extremely difficult to obtain reliable data.

For aid in preparing these lists I am particularly indebted to Messrs. Richard C. Hill, of Denver, for information concerning New Mexico and southern Colorado; Richard Pearce, metallurgist of the Boston and Colorado Smelting Works at Argo, near Denver; Ernest Le Neve Foster, State Geologist of Colorado, Georgetown; and to G. E. Bailey, Territorial Geologist of Wyoming, Cheyenne. The data on iron ores are almost wholly derived from Mr. Bayard T. Putnam, special expert of the Tenth Census, and are condensed from the tables to be published by him in the forthcoming volume, "Iron in the United States," by Prof. Raphael Pumpelly, to be issued by the Geological Survey in connection with the Census.

Very respectfully, your obedient servant,

WHITMAN CROSS,
Assistant Geologist.

COLORADO.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by WHITMAN CROSS.]

Mineralogical name.	Common name.	Remarks.
Alaskaite,[a] $(Ag_2 Pl Cu_2) S + Bi_2 S_3$.	....	San Juan county, Poughkeepsie gulch, Alaska mine. Occurs in quantity as massive mineral with tetrahedrite, chalcopyrite, barite, and quartz.
Altaite $Pl Te$..	"Telluride"..........	Boulder county, Gold Hill district. Argentiferous and auriferous.
Anglesite, $Pl SO_4$.	Sulphate of lead	Clear Creek county, and adjacent parts of Summit county. A frequent surface ore of galena veins. Usually argentiferous, and mined for both lead and silver. Lake county, frequently associated with cerussite in the "sand carbonate" ores near Leadville. (See Cerussite.) Is undoubtedly a common decomposition product of galena, though seldom worthy of special notice.
Argentite, $Ag_2 S$.	Silver glance..........	Clear Creek county, near Georgetown. In small quantities with other silver minerals. Not uncommon. San Miguel county, Marshall creek. In quartz veins with tetrahedrite, galena, sphalerite, and some silver. Occasional.
Arsenopyrite..	Mispickel, arsenical pyrites.	Gilpin county. Of frequent occurrence, sometimes highly argentiferous. Occasionally auriferous.

[a] This mineral was described by König, Am. Phil. Soc., Philadelphia, 1881, p. 472; and in Groth's Zeitschrift für Krystallographie, vi., p. 42.

COLORADO—Continued.

Mineralogical name.	Common name.	Remarks.
Arsenopyrite—Continued.	Mispickel, arsenical pyrites.	Gunnison county, near Ruby camp. With proustite. Argentiferous. San Miguel county, Mount Wilson. Argentiferous; associated with tetrahedrite.
Bornite, $3 Cu_2 S + Fe_2 S_3$.	Peacock ore	Clear Creek county. Spanish Bar district. Fremont county. In small quantity with niccolite at Gem mine, Grape creek cañon; argentiferous.
Cerargyrite Ag Cl.	Horn silver, "chloride"	Lake county, near Leadville; particularly on Fryer hill. Not common. Summit county, near Breckenridge. On fissure planes of a quartzite. Illinois mine, Schanck hill. Custer county, near Silver Cliff. In small quantities impregnating a rhyolitic rock.
Cerussite Pl CO_3. (Argentiferous.)	"Carbonate," "hard carbonate," "sand carbonate."	Occurs in greater or less quantity with nearly all galena ores, as in Summit county, Eagle county, Chaffee county, Gunnison county, Ouray county, San Miguel county, Dolores county, &c.; but in Lake county, near Leadville, it is worthy of special note. As a compact mineral, usually with some quartz, it is called "hard carbonate"; as a loose sand deposit, often quite extensive, it is termed "sand carbonate." In the latter form it is often accompanied by anglesite and pyromorphite, which are, however, seldom distinguished. The cerussite is usually argentiferous, and is mined for both silver and lead.
Chalcocite	Copper glance	Clear Creek county, near Idaho Springs. With siderite and small crystals of sphalerite. Argentiferous. San Miguel county. Occurs almost alone, in sandstone with matrix of calcite. Argentiferous.
Chalcopyrite	Copper pyrites, "yellow copper;" when iridescent and tarnished, "peacock ore."	Boulder county, particularly in Grand Island and Ward districts. Argentiferous, and in the latter also auriferous. Gilpin county. A very common and sometimes rich gold-ore. Also argentiferous in many places. Occurs in veins in gneiss, with pyrite, sphalerite, galena, and tetrahedrite. Clear Creek county. Also abundant here, but chiefly a silver ore. Summit county, in Snake river region. Similar in occurrence to that of Clear Creek county. Chaffee county. An argentiferous ore, associated with galena, etc. Huerfano, Hinsdale, San Juan, Ouray, and San Miguel counties. A common argentiferous ore, usually associated with galena, tetrahedrite, pyrite, etc.
Coal, var. anthracite.	Anthracite	Gunnison county, near Crested Butte. Of Cretaceous age, but said to possess the qualities of the best Carboniferous anthracite. The veins are now being extensively developed.
Coal, var. bituminous.	Lignite, soft coal	Bituminous coal from the Laramie group of the Cretaceous formation (post-Cretaceous according to some authors) is extensively mined at the eastern base of the Rocky mountains. In the northern part of the State the chief development is in Weld county (at Erie); Boulder county (at Canfield, Langford, Louisville, etc.); and in Jefferson county (at and near Golden). In El Paso county, at Franceville, on the Denver and New Orleans railroad, developments have been recently made. In Fremont county the coal fields southeast of Cañon city are extensively worked. In the southern part of the State the same coal beds are largely productive at Walsenburg in Huerfano county, and near El Moro and Trinidad, in Las Animas county. In Park county, near Como, in the South Park, coal of the Laramie group is worked. Cretaceous coals of a lower geological horizon than the Laramie are found in many places in the mountain districts of the State. In most instances the development is slight. Near Crested Butte, in Gunnison county, are large beds of a very fine bituminous coal, occurring near the anthracite, and which are now actively worked. This coal produces an excellent coke, and is also used in Denver, Leadville, etc., for gas manufacture. In La Plata county, near Durango, are several thick veins of Cretaceous coal, which are now mined. The same coal is said to appear in Conejos county, adjoining La Plata county on the east, but is not yet worked.

COLORADO—Continued.

Mineralogical name.	Common name.	Remarks.
Coal, var. bituminous.	Lignite, soft coal.....	Near Rico, in Dolores county, coal, also of Cretaceous age, is slightly mined for local use. In San Miguel, Ouray, and other counties, coal of unknown extent and quality has been found.
Embolite; Ag (Cl Br). (*a*.)	Chlorobromide of silver.	Lake county, near Leadville. Of frequent occurrence, particularly on Fryer and Carbonate hills. Occurs chiefly in a siliceous iron ore in cavities, and on fissure planes.
Enargite. $3 Cu_2 S + As_2 S_5$.	....	Gilpin county, Russell gulch; particularly in the Powers mine. Argentiferous; with pyrite and fluorite. Rio Grande county, Summit district. Both auriferous and argentiferous; often carries free gold. With pyrites only, in quartz matrix. San Juan county, Red mountain, (*b*) abundant. Argentiferous, with tetrahedrite and galena in quartz veins.
	Fire-clay	Jefferson county: seams in the sandstone of the Dakota Cretaceous. Extensively mined near Golden, and used in the manufacture of firebricks, muffles, etc., at Golden and Denver. Doubtless occurs in the same geological horizon at many places along the foothills. This clay is of the very finest quality.
Galenite, argentiferous.	Galena................	Boulder county, Grand Island district, with chalcopyrite, sphalerite, and smaller quantities of other minerals. Gilpin county, Clear Creek county. In these counties a very common ore, associated with one or more of the minerals pyrite, chalcopyrite, sphalerite, tetrahedrite. Summit county, Snake river district. Occurrence as in Clear Creek county, near Breckenridge, Ten-mile district. In limestone, with pyrite, sphalerite, &c. Eagle county, near Red cliff. In limestone, as above. Lake county, Leadville region. Very prominent ore occurs in limestone; often much altered into cerussite (see Cerussite); Homestake peak; in Archæan. Park county. Occurs on eastern slope of the Mosquito range; same manner as at Leadville. Chaffee county, several districts. Important ore. Custer county, near Silver cliff. Bull Domingo mine, and in small quantities elsewhere. Fremont county. Cotopaxi, in cañon of the Arkansas; limited. Gunnison, Saguache, Huerfano, Rio Grande, Hinsdale, San Juan, Ouray, San Miguel, Dolores, and La Plata counties. In all these counties galena is an abundant ore of silver. It is most frequently associated with tetrahedrite, which is also argentiferous; in many cases with chalcopyrite, and more rarely with various other minerals. Is usually mined and treated for lead as well as silver.
Gold, native...	Gold..................	Routt county. Placers in Hahn's Peak region; veins not yet opened. Not yet important. Boulder county. Placers limited; associated with telluride minerals in Magnolia, Sugar Loaf, Gold Hill, and Central districts. In quartz veins with pyrite, fluorite, and barite, near Jamestown. Gilpin county. Placers limited. Common in small quantities with auriferous minerals of region; *i. e.*, pyrite, chalcopyrite, and sphalerite. Clear Creek county. Sparingly in placers on Clear creek. Summit county. Placers in French, Fuller, and other gulches. Moderately productive near Breckenridge; also in dendritic coatings in fissure planes of a schistose rock; limited. Park county. Placers on the western and eastern borders; limited. Veins near Montgomery; little worked. Lake county. Placers on California gulch; about exhausted. In veins near Leadville, and very limited. Chaffee county. Placers very little worked at present. In quartz veins in Granite and Hope districts; limited. Saguache county. In veins, with pyrolusite; also associated with native silver on Carnero creek; limited. Costilla county. Placers near Placer; veins, Grayback gulch, south end of the Sangre de Cristo mountains. Rio Grande county, Summit district. In a ferruginous decomposition product of pyritiferous veins; also with enargite, same region. Ouray county, Uncompahgre district. Placers near mouth of Dallas creek; not now paying.

a. The proportions of chlorine and bromine are variable, and iodine sometimes appears.
b. Mineral not absolutely determined from Red mountain. Is impure; *probably* enargite.

COLORADO—Continued.

Mineralogical name.	Common name.	Remarks.
Gold, native ...	Gold	San Miguel county. Extensive placers; also in quartz veins. La Plata county. Placers on Rio La Plata and Rio de las Animas; veins near Parrott city.
Hematite	Specular iron	Lake county, Breece iron mine, Breece hill, near Leadville. Very pure ore; large, irregular deposits in porphyry.
Hessite, Ag_2Te	Telluride of silver ...	Boulder county, Gold Hill district. Important ore.
Hessite, var. petryite, $(Ag Au)_2 Te$.	"Telluride"	Boulder county. Not uncommon ore. Important; Gold Hill mines, especially. Hinsdale county, Hotchkiss mine. (This mineral seems to be a telluride of gold and silver, but is impure, and the species cannot be considered as determined.)
Limonite	Brown hematite, brown iron ore.	Saguache county, at Hot springs, western foothills of the Sangre de Cristo range, eight miles from Villa grove, large body interbedded with limestone nearly 100 feet thick in places; very pure ore; extensively worked by the Colorado Coal and Iron company.
Magnetite	Magnetic iron	Costilla county, Grayback gulch, five miles from Placer station, on Denver and Rio Grande railroad; interbedded with impure limestone; good ore. Worked by Colorado Coal and Iron company. Fremont county, Iron mountain, near Pine creek, a branch of Grape creek, 22 miles from Cañon city. Quite titaniferous; up to nearly 15 per cent. TiO_2. Worked by Colorado Coal and Iron company. Chaffee county, in Arkansas hills, nine miles from Salida (south Arkansas). Extensively worked by Colorado Coal and Iron company. Gunnison county, Cebolla creek, a pure ore in large quantity. Is to be used as a source of ore for iron works soon to be erected at Gunnison city.
Massicot	Oxide of lead	Dolores county, near Rico, with galena ores; argentiferous. San Miguel county, upper San Miguel region, with galena; argentiferous. In less quantities in many places as decomposition product of galena.
	Plastic clay...........	Common in the Laramie group; often intimately associated with the coal. mined in various places. Used in coarser pottery.
Polybasite (*a*), $9 Ag_2S+Sb_2S_3$.		Clear creek county.
Proustite, $3 Ag_2S, Sb_2S_3$.	Ruby silver (light) ...	Gunnison county, Ruby district, with arsenopyrite; small quantity.
Pyrargyrite, $3 Ag_2S, Sb_2S_3$.	Ruby silver (dark)....	Gilpin county, near Central city. A rare mineral. Clear Creek county. Frequently occurs in small quantity with stephanite, argentite, native silver, and the more common ores. Gunnison county, Ruby district. With tetrahedrite and native silver. Not uncommon. Hinsdale county, Galena district, associated with stephanite. Occasional occurrence. Ouray county, Sneffle's district, with sphalerite. Not uncommon. San Miguel county, Marshall creek basin. Occasional, with stephanite and sphalerite. Dolores county, near Rico. Not uncommon, with argentite. (?)
Pyrite (auriferous).	Iron pyrites	Boulder county, Ward district. Gilpin county. Abundant; in veins with chalcopyrite, sphalerite, &c. An important ore of gold. Clear Creek county, Empire district. Abundant, but low grade gold ore. Experiments as to treatment now in progress. Rio Grande county, Summit district. With enargite. Not uncommon. San Miguel and La Plata counties. Common.

a While not absolutely determined, it is thought probable by experienced persons that this mineral occurs frequently with pyrargyrite, argentite, and other silver minerals; *e. g.*, in the Terrible mine, near Georgetown.

COLORADO—Continued.

Mineralogical name.	Common name.	Remarks.
Pyromorphite (argentiferous).	....	Lake county, near Leadville. Associated with cerussite in the "sand carbonate." (See Cerussite.)
Pyrrhotite.....	Magnetic iron pyrites	San Juan county, Needle mountains. Limited quantity; auriferous.
Quartz.........	Common white quartz.	Jefferson county. Mined from veins in the foothills near Golden, and used in the manufacture of firebricks at Golden.
	As sandstone	Beds of white sandstone, said to be suitable for glass manufacture, occur all along the eastern base of the mountains, and in many places in the mountains.
	Moss agate, "silicified wood," and "smoky quartz."	Very common, and much used in the manufacture of jewelry, ornaments, etc. The smoky quartz occurs near Pike's Peak, and is known in trade as "smoky topaz" or "Cairngorm stone."
Schirmerite 3 $(Ag_2 Pb) S$, 2 $Bi_2 S_3$.	....	Boulder county. With telluride minerals in small quantity. (*a*) Clear Creek county, Geneva district. Summit county, Peru district. Sparingly. (*b*) San Miguel county, Howard's fork of San Miguel river. Santa Cruz mine, with bismuthinite, chalcopyrite, and galena.
Silver, native ..	Silver	Clear Creek county. Of frequent occurrence as companion of the argentiferous ores of the region. Usually in small quantity. Lake county. Rare; in a few mines of the Leadville region; Evening Star, Little Chief, etc. Gunnison county, Ruby district. Associated with pyrargyrite, tetrahedrite, etc.; not uncommon. Hinsdale county, Galena district. With galena and tetrahedrite; not common. San Miguel county. With stephanite, galena, and tetrahedrite; occasional.
Sphalerite	Zincblende	Gilpin county and Clear Creek county. A common mineral, usually argentiferous, sometimes highly so, and occurring associated with pyrite, chalcopyrite, galena, and tetrahedrite; mined for silver only. Hinsdale, San Juan, Ouray, San Miguel, Dolores, and La Plata counties. A very common, usually argentiferous, mineral; common associate galena; frequently together with chalcopyrite, tetrahedrite, or pyrargyrite.
Stephanite 5 $Ag_2 S, Sb_2 S_3$.	Brittle silver..........	Clear Creek county. Frequently associated in small quantity with other silver-bearing minerals of county. Hinsdale county, Galena district. Limited. San Juan county, Uncompahgre district. Occasional. Ouray county, Sneffle's and Uncompahgre districts. Occasional. San Miguel county. Not common.
Silvanite (Au Ag) Te_2.	"Telluride"..........	Boulder county, Gold Hill and other districts. La Plata county, Junction creek, and at head of the Rio La Plata. In quartz veins.
Tetrahedrite ...	Gray copper, fahlerz..	Gilpin and Clear Creek counties. Very abundant; argentiferous in both; auriferous in Gilpin; common associates pyrite, galena, sphalerite, and chalcopyrite. Summit county, adjoining Clear Creek county. Lake county, a few mines in the Sawatch range. Limited. Hinsdale, San Juan, Ouray, and San Miguel counties. A very abundant silver ore, associated with one or more of the minerals pyrite, chalcopyrite, sphalerite, galena, and occasionally with others; most prominent ore mineral of the San Juan region. Huerfano county. Rarely. Gunnison county, Ruby district. With pyrargyrite and native silver.
Uraninite	"Pitchblende".......	Gilpin county, near Central City. Discovered and worked for uranium by Richard Pearce, esq., of Denver; not at present productive; occurs with other uranium minerals, torbernite, etc.

a First described from Boulder county by Genth; Am. Phil. Soc., Philadelphia, XIV., p. 230, 1874.
b This mineral was first called schapbachite as occurring in these counties; and I am not aware that a quantitative analysis has ever been made.

COLORADO—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Chalcanthite. $Cu S O_4 + 5 H_2 O$.	Bluestone............	Clear Creek county, and adjacent parts of Summit county. In considerable quantities in veins, with tetrahedrite, galena, chalcopyrite, sphalerite, barite, etc. Prospective.
Chrysocolla....	Silicate of copper, blue copper.	Custer and Saguache counties; Sangre de Cristo mountains; undeveloped.
Cinnabar	Cinnabar	La Plata county. In sandstone; said to be rich; undeveloped.
Fluorite. CaF_2	Fluorspar............	Boulder and Jefferson counties. Veins in Archæan; said to be extensive; used in small quantities as a flux in smelting; San Juan county, Poughkeepsie gulch; in veins with quartz.
Graphite.......	Plumbago, black lead.	Gunnison county; 3½ miles north of Pitkin; branches of Quartz creek; impure; in quartz veins 2½ feet thick; no present value.
Gypsum	Gypsum	In the Jurassic and Triassic strata along the eastern base of the Rocky mountains. Often in pure state, and available for many purposes. Opened on the Cache la Poudre river, at Morrison, and near Cañon City. Also occurs in the South park, and at many other points where the Jurassic and Triassic strata are exposed.
Magnetite	Magnetic iron	Park county, near Hamilton. Said to occur in quantity, and of good quality; undeveloped; Boulder county, near Caribou; veins in Archæan; undeveloped.
Marble	Marble	Jefferson county, near Morrison. A brownish, mottled rock: Specimens polished at Exposition of 1882; not in use yet. Chaffee county; large beds of white and variegated marble said to have been recently discovered.
Molybdenite...	Sulphide of molybdenum.	Gunnison county, two miles from Pitkin. In quartz veins. Possible source of molybdenum.
Muscovite	Mica..................	Fremont county, Cotopaxi. Veins in Archæan; prospected somewhat; Jefferson county, Bear creek; scarcely explored as yet.
Niccolite.......	Kupfernickel (German).	Fremont county, Grape creek cañon, Gem mine. In dolomite, with bornite, and rarely native silver; not yet used as ore of nickel.
Serpentine.....	Serpentine...........	Park county, Buckskin gulch. A mottled rock, largely calcite, but deeply colored by true serpentine; prospective use as ornamental stone.
Smaltite	Gray cobalt ore.......	Gunnison county, near Gothic. In a vein with calcite gangue, associated with small quantities of erythrite and native silver; possible source of cobalt. Analysis by M. W. Iles, American Journal of Science, May, 1882.
Sphærosiderite (including the alteration products).	Nodular iron ore, carbonate ore, clay ironstone.	A thin seam of sphærosiderite occurs above the coal of the Laramie formation in many parts of Colorado and New Mexico. In some places it has weathered out in nodules, which are found upon the plains in great quantity. It is found near Trinidad and El Moro, in Las Animas county, Walsenburg, in Huerfano county, and Marshall, in Boulder county. The greater part is too impure for use.

DAKOTA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by WHITMAN CROSS.]

Mineralogical name.	Common name.	Remarks.
Galenite	Galena	Lawrence county, Bear Butte district, near Galena. Argentiferous, in limestone.
Gold	Native gold, free gold.	Lawrence county, Black Hills. Free in certain strata of the Archæan formation. Most commonly in lenticular masses of smoky quartz in a schist; but also in some peculiar amphibolitic or chloritic schists; rarely in a breccia. The placers have been extensively worked; are now paying but little. Pennington county and Custer county. Gold occurs in similar manner to that in Lawrence county, but much less important; placers in both counties.
Muscovite	Mica	Custer county, Custer district. In large veins in the Archæan. With milky quartz, labradorite, albite (var. clevelandite), beryl, and a yellow mica (sp. ?)
Pyrite (auriferous).	Iron pyrites; pyrites of iron.	Lawrence county, Bear Butte district. Limited occurrence; in fine particles disseminated through many Archæan schists of the Black Hills.

Ores, minerals, and mineral substances of industrial importance and of known occurrence, but which are not at present mined.

Coal (var. bituminous).	Brown coal, soft coal, etc.	Mandan county, on Hay creek, and other branches of the north fork of Cheyenne river. North of the Black Hills. Little developed.
Gypsum	Gypsum	Lawrence county, six miles northeast of Deadwood; and in other places on the north and northwest slopes of the Black Hills.

MONTANA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by WHITMAN CROSS.]

Argentite	Silver glance	Silver Bow county, Summit valley district, near Butte City. Small quantity, in few mines, with argentiferous pyrites, etc.
Arsenopyrite	Mispickel, arsenical pyrites.	Lewis and Clarke county, Ten-mile district. Auriferous; mined for gold contents.
Bornite	Peacock ore	Silver Bow county, Summit valley district, near Butte City. Massive ore occurs, with chalcopyrite, pyrite, and native silver. Mined chiefly for copper. Highly argentiferous in a few places only.
Cerargyrite	Horn silver, "chloride."	Silver Bow county, Summit valley district, near Butte City. Small particles in pyrolusite, malachite, and other surface minerals of many veins.
Chalcocite (Cu_2S).	Copper glance	Silver Bow county, Summit valley district, near Butte City. Massive; important as copper ore; also highly argentiferous in places.
Chalcopyrite	Copper pyrites	Silver Bow county, Summit valley district, near Butte City. Massive ore, with bornite, pyrite, native silver; argentiferous. Mined for silver and copper; abundant. Beaver Head county, Trapper district. Abundant, with galena. Mined for copper and silver.
Cuprite (Cu_2O).	Red copper	Silver Bow county, Summit valley district, near Butte City. Minor element in copper ores of region, but mined with the rest.

MONTANA—Continued.

Mineralogical name.	Common name.	Remarks.
Galenite (Pb S).	Galena	Lewis and Clarke county, Ten-mile and Ottawa districts. Argentiferous. Jefferson county, near Wickes. Argentiferous, with sphalerite and pyrite. Smelted at Wickes. Beaver Head county, Trapper district. Argentiferous; prominent lead and silver ore of region, with chalcopyrite and other copper minerals. Deer Lodge county, Flint creek district. Argentiferous, with sphalerite and tetrahedrite.
Gold, native	Gold	Missoula county, Cedar creek and other districts, in placers and veins. Not much developed; reason—country new. Deer Lodge county: Placers in many places; have been rich; still productive. At Cable city, in a vein associated with nagyagite (Atlantic Cable mine). Lewis and Clarke county, near Helena. Formerly rich; now moderately productive; other places; also in veins. Jefferson county. Placers; moderately productive. Cataract and other districts; near surface of pyritiferous veins. Gallatin county. Placers; little worked now. Madison county. Placers; near Virginia City, rich; also north and northeast of Virginia City. Veins; surface of pyritiferous veins. Meagher county. Placers; extensive; little worked; new country. Beaver Head county, near Bannack. Placers and quartz veins; neither much worked.
Malachite	"Green copper," green carbonate of copper, etc.	Silver Bow county, Summit Valley district, near Butte City. Surface mineral in veins, carrying chalcopyrite, bornite, etc., below. Usually carries silver. Used as copper and silver ores.
Nagyagite		*a* Deer Lodge county, Cable city. Atlantic Cable mine; with gold, pyrite, and chalcopyrite. *b* Beaver Head county. Small particles impregnating the wall rock of a pyritiferous vein. Not abundant.
Psilomelane	Manganese	Silver Bow county. See Pyrolusite; occurrence the same.
Pyrargyrite	Ruby silver	Deer Lodge county, Flint Creek district. With galena and sphalerite; limited.
Pyrite, auriferous.	Iron pyrites, "white iron."	Lewis and Clarke county, several districts. In veins with quartz. Jefferson county, Cataract, Elkhorn, Cedar Plains, and other districts. Common; also argentiferous in places. Madison county. Common; in veins with quartz. Deer Lodge county. Common; in veins with quartz. Silver Bow county, Summit Valley district, near Butte City. Also argentiferous; with small quantities of rhodocrosite, calcite, and siderite. Beaver Head county, Bannack district. Massive; in veins on contact of limestone and eruptive rock. Not very rich.
Pyrolusite	Manganese, black oxide of manganese.	Deer Lodge county, Flint Creek district. Surface ore in a few mines; carries silver, probably as chloride. Silver Bow county, Summit Valley district, near Butte City. Common surface ore in many veins, carrying rhodonite, etc., below. Usually contains silver, and is much sought for as flux for siliceous ores.
Rhodonite		Silver Bow county, Summit Valley district, near Butte City. In many veins at some depth, with rhodocrosite, pyrite, chalcopyrite, and native silver. Slightly argentiferous, and used as a flux.
Silver, native	Silver	Silver Bow county, neighborhood of Butte City, Summit Valley district. In veins; 1st type, associated with pyrite, sphalerite, rhodonite, and rhodocrosite; 2d type, with mass of pyrites, chalcopyrite, and bornite. Rich ore.
Sphalerite	Zincblende	Silver Bow county, Summit Valley district, near Butte City. Argentiferous; mined for silver contents. Veins with native silver, pyrite, rhodonite, and rhodocrosite; also in intimate association (chemical?) with Cu_2S, highly argentiferous; and, thirdly, with tetrahedrite.

a Species not definitely determined. Resembles nagyagite more than any other telluride. First noticed by Richard Pearce, Denver, Colorado.
b Also observed by Mr. Pearce.

MONTANA—Continued.

Mineralogical name.	Common name.	Remarks.
Sphalerite—Continued.	Zincblende	Deer Lodge county, Flint Creek district. Argentiferous, with tetrahedrite and galena.
Tetrahedrite	Gray copper, fahlerz	Deer Lodge county, Flint Creek district. With galena and sphalerite; argentiferous. Silver Bow county, Summit Valley district, near Butte City. With galena, pyrite, and argentite. Small quantity, but sometimes rich in silver.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Coal	Lignite, soft coal, brown coal.	Coal of the Laramie (Cretaceous) formation exists over a large area at the eastern base of the Rocky mountains, but is as yet almost wholly undeveloped. At Livingstone, on the Yellowstone river, the Northern Pacific Railroad Company has recently found workable veins of coal.

NEW MEXICO.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by WHITMAN CROSS.]

Argentite	Silver glance	Socorro county, Black range mountains, Chloride camp. Thin veins or films in quartz, with some cerargyrite. Grant county, near Silver city; a frequently occurring ore in small quantity.
Azurite	Blue carbonate of copper.	Grant county, Santa Rita (see malachite). In small quantities with the other copper ores of New Mexico.
Bornite	Peacock copper ore	Socorro county, Mogallon mountains; with chalcopyrite, chalcocite, and native silver in quartz matrix; argentiferous. Lincoln county, Nogal mountains. In quartz veins traversing slate; argentiferous.
Cerargyrite	Horn silver, "chloride."	Near Socorro. With barite, in small quantity. Grant county, Lake valley; a very rich and important ore. Pinos Altos, and near Silver city.
Cerussite (argentiferous).	"Carbonate," lead carbonate, etc.	Socorro county, Magdalena mountains.
Chalcocite (argentiferous).	Copper glance	Socorro county, Mogallon mountains. Occurs with chalcopyrite, bornite, and native silver; Black range mountains, Mineral creek district: argentiferous in varying degree. Grant county, Carlisle district, near Steeple rock. With chalcopyrite and malachite in quartz matrix; argentiferous.
Chalcopyrite	Copper pyrites	Santa Fé county, Santa Fé mountains. Argentiferous. Socorro county, Mogallon mountains. With chalcocite, bornite, and native silver: argentiferous. Grant county, Carlisle district; argentiferous.
Chrysocolla	Silicate of copper	Grant county, Burro mountains. Associated with malachite and cuprite; now used as copper ore. Socorro county, Oscura mountains, in large quantity; mining recently begun. Santa Fé county, Santa Fé mountains. Said to be argentiferous.
Chrysocolla (variety).	Tile ore	Socorro county. Under this head may be mentioned the "tile ore," "mahogany ore," or "coffee copper," which is a mixture of chrysocolla, cuprite, limonite, etc., and which is worked as a copper ore; is a fine smelting ore. Oscura mountains.

NEW MEXICO—Continued.

Mineralogical name.	Common name.	Remarks.
Coal (var. bituminous).	Lignite, soft coal	Colfax county, Raton hills. The continuation of the Trinidad (Colorado) coal fields; workable beds said to exist in nearly all the cañons as far south as Poñil cañon; extensively worked near the Colorado State line, near Atchison, Topeka, and Santa Fé railroad. Santa Fé county, Galisteo coal field, exposed on Galisteo creek westward for 15 miles from Galisteo; worked at Cerillos. Socorro county, western base of the Oscura mountains; recently opened. Taos county, adjoining the Colorado State line; extension of the coal fields of La Plata county, Colorado; not yet opened.
Copper (native)	Copper	Grant county, Santa Rita mines. In thin sheets, with cuprite, malachite, and azurite; worked with other copper minerals.
Cuprite	Ruby copper	Grant county, Santa Rita copper mines. With copper, malachite, etc.
Fluorite	Fluorspar	Grant county, near Silver City. In a vein; somewhat used as a flux.
Galenite (argentiferous).	Galena	Socorro county, Magdalena mountains, in quartz. Low grade silver ore. Grant county, near Silver City, with barite (argentiferous). Santa Fé county, Los Cerillos district, mined for lead and silver.
Gold	Gold	Taos county placers; not greatly developed. Colfax county, extensive and rich placers; lack of water prevents work in some places; veins near Old Baldy mountains. Santa Fé county, placers on east slope of Placer mountains; not much developed in the new localities, owing to lack of water; veins little opened. Doña Aña county, Hillsborough district, both placers and quartz veins; moderately productive. Lincoln county, White Oaks district, placers and quartz veins; both being opened at present. Grant county, Piños Altos, Georgetown, and Carlisle districts, placers and quartz veins; productive.
Halite	Salt	Santa Fé county, seven miles east of the Sandia mountains. In salt marsh; rather impure, but used locally for table salt.
Limonite	Hydrated iron oxide	Occurs in several places in too impure condition to serve as an ore of iron; used as a flux.
Malachite	Green copper carbonate.	Grant county, Santa Rita mines. With azurite, cuprite, and native copper; Burro mountains; not largely developed as yet.
Massicot	Oxide of lead	Socorro county, Magdalena mountains. Argentiferous, but of low grade. Less prominently in other places, associated with galena.
Pyrargyrite	Ruby silver	Grant county, Bullard's peak district. With sphalerite, argentite, and native silver.
Pyrite (auriferous).	Iron pyrites, pyrites of iron.	Grant county, Pinos Altos and Georgetown districts.
Silver, native	Silver	Socorro county, Mogallon mountains. With chalcopyrite, bornite, and chalcocite. Grant county, near Silver City; in an argillaceous shale, and in veins, with pyrargyrite, argentite, and sphalerite. Burro mountains, little developed.
Sphalerite (argentiferous).	Zincblende	Socorro county, Black Range mountains; Turkey creek district. Mined for silver contents. Grant county, near Georgetown, mined for silver.
Tetrahedrite	Gray copper, fahlerz (German).	Socorro county, near Pueblo springs. In quartz veins with chalcopyrite; highly argentiferous.
Turquois	Turquois	Santa Fé county, Los Cerillos, small veins in a trachytic rock; long mined by Indians and Mexicans; still productive, chiefly of inferior quality.

Ores, minerals, and mineral substances of industrial importance and known occurrence but which are not at present mined.

Bornite, $3Cu_2S+Fe_2S_3$.	Peacock ore	Rio Arriba county, Abiquiu district (see chalcocite).

NEW MEXICO—Continued.

Mineralogical name.	Common name.	Remarks.
Chalcocite, Cu_2S.	Copper glance	Rio Arriba county, Abiquiu district, with bornite. Both minerals formerly worked for copper by Mexicans; not argentiferous.
Chrysocolla	Silicate of copper	Santa Fé county, Santa Fé mountains. Not now worked; prospective.
Gypsum	Gypsum	Valencia county, Zuni mountains, as selenite. Used for window panes by Indians, also to make whitewash; extent unknown. Socorro county, ten miles west of Socorro. In beds sometimes 14 feet thick; mined and used as whitewash by Mexicans. San Miguel county, near Pecos. Said to occur in large beds, pure, near line of Atlantic and Pacific railroad.
Hematite	Hematite, red oxide of iron.	Santa Fé county, Placer mountains. Almost wholly undeveloped. Grant county, Santa Rita, near copper mines. Bed three feet thick; somewhat explored; not mined.
Magnetite	Magnetic iron	Santa Fé county, Placer mountains. Unknown extent; said to be of good quality; Los Cimarron mountains, 22 miles south of Santa Fé. Colfax county, near Cimarron, Cito creek; undeveloped in both places.
Muscovite	Mica	Rio Arriba county, near Abiquiu. In large sheets in pegmatitic veins; good quality, clear; undeveloped.
Niccolite, Ni As	Kupfernickel (German).	Grant county, Bullard's peak district, in Burro mountains. Recently discovered, with several cobalt and silver minerals.
Siderite, var. sphærosiderite.	Nodular iron ore, "clay ironstone."	Colfax county, nodules in Fort Pierre shales of Colorado Cretaceous, from Colorado State line south to Oscate creek. Santa Fé county, Galisteo region. Same formation as in Colfax county, but nodules less pure. Same substance, less pure, and in shales of Laramie group in both Colfax county and Santa Fé county. Some of this may be pure enough to serve as iron ore.

WYOMING.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by WHITMAN CROSS.]

Chalcocite	Copper glance	Laramie county. Said to occur with cuprite, malachite, and other copper minerals, at the Hartville mines, and to be argentiferous; in small quantity.
Chrysocolla	Silicate of copper, "blue copper."	Laramie county, near Hartville. Occurs with cuprite, etc.; chief ore of Michigan mine, Muskrat cañon; with it are other copper minerals in smaller quantity. (See Cuprite.)
Coal, var. bituminous.	Lignite, soft coal	Coal of the Laramie group is widely distributed in Wyoming. It is chiefly developed in the neighborhood of the Union Pacific railroad; Uinta county; at Twin creek, Evanston, Alma, etc.; Sweetwater county; Rock Springs; Carbon county, at Carbon.
Cuprite	Red oxide of copper	Laramie county, near Hartville. With chrysocolla and other copper minerals; lately discovered; now mined for cuprite.
Gold, native	Gold	Sweetwater county. Placers not rich, and little worked at present; free gold occurs sparingly as a result of the alteration of auriferous pyrite in certain metamorphic schists, and to a limited extent in veins; total gold production very small.
Hematite	Red oxide of iron	Associated with cuprite, etc., at Hartville copper mines.
Pyrite, auriferous.	Iron pyrites, pyrites of iron.	Sweetwater county, Sweetwater district. In metamorphic schists; low grade and little worked.

WYOMING—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Amphibolite, var. asbestus.	Asbestus	Carbon county, Seminole mountains. Said to occur in considerable quantity; little explored.
Graphite	Plumbago, "black lead."	Albany county, 18 miles east of Laramie City. In Archæan formation; undeveloped.
Gypsum	Gypsum	Extensive beds of gypsum occur in Laramie and Albany counties, chiefly in the Trias.
Halite	Salt	Laramie county. Undeveloped. Said to occur in large quantities.
Hematite	Hematite, red oxide of iron.	Carbon county, near Rawlins, on the Union Pacific railroad. Partly as "mineral paint" used by the Indians; prospective development.
Ilmenite	Titanic iron	Albany county, iron mountain 25 miles north of Laramie City. For description and analysis, see Vol. II., Exploration of the 40th Parallel; Descriptive Geology, pp. 14–16.
Muscovite	Mica	Laramie county, Whalen cañon, Ryer mine. Crook county, Belle Fourche district.
Petroleum	Petroleum	More or less distinct indications of petroleum are met with in Sweetwater, Carbon, Johnson, and Crook counties, particularly in Carbon county, on and near the Sweetwater river; the fluid found has the character of heavy lubricating oil, green or brownish when crude; but very little explored as yet.
Sulphur	Sulphur	Uinta county, Uinta mountains. Undeveloped; 30 miles southeast of Evanston.
Thenardite	Sulphate of soda	Albany county, 14 miles southwest of Laramie City. Deposit said to cover 56 acres, with thickness of 15 feet. Specimen at Denver Exposition, 1882, contains about 12 per cent. epsomite, and but little of other impurities. Other deposits said to exist in Albany and Sweetwater counties; as yet little developed.
Trona	Carbonate of soda	Sweetwater county, near Independence Rock. Under "trona" are here included numerous deposits in which the bicarbonate of soda is said to predominate, mixed with the simple carbonate, and varying quantities of halite, thenardite, epsomite, etc. Many deposits are said to exist, varying in area from 20 to 300 acres, and in depth to a maximum of 45 feet. As yet little explored.

PACIFIC DIVISION.(a)

ALASKA.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

[Reported by JOSEPH PERKINS.]

Mineralogical name.	Common name.	Remarks.
Calcite	Limestone	Near Sitka.
Chalcopyrite	Copper pyrites	Islands on the coast.
Graphite	Plumbago	Near Port Clarence.
Lignite	Coal	Coast of Arctic ocean.
Pyrite	Iron sulphurets	Near Sitka.

ARIZONA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined. (b)

[Reported by EDWARD STAHL and D. B. HUNTLEY.]

Anglesite	Sulphate of lead	In many lead mines. (H.)
	Antimonial lead ores	(H.)
Argentite	Silver glance	Associated with other ores of lead, zinc, and silver (S).
	Arsenical lead ores	(H.)
Arsenopyrite. (H.)	Mispickel, arsenical pyrites.	When associated with other gold and silver ores, it is mined along with these for the precious metals. (S.)
Atacamite	Chloride of copper	Occasionally found with other ores of copper. (S.)
Azurite. (H.)	Blue carbonate of copper; copper carbonate, often called "bromide of silver."	Abundant with other copper ores. (S.)
Barnhardite	Sulphide of copper and iron.	Abundant with other copper ores. (S.)
Berthierite	Sulphide of antimony and iron.	Associated with argentiferous ores. (S.)
	Bismuth ores	In small quantities with the gold and silver ores of Tombstone district and elsewhere. (H.)
Bornite. (H.)	Variegated copper ore.	With other ores of copper. (S.)
Brogniardite		Associated with other argentiferous ores. (S.)
Cerargyrite	Chloride of silver, horn silver, "chloride."	With other silver ores in many mines. (S. H.)
Cerussite. (H.)	Carbonate of lead, "carbonate."	Abundant. Mined for its lead for use in smelting argentiferous or auriferous ores, and for its silver contents. (S.) In many mines. (H.)
Chalcanthite	Bluestone	(H.)
Chalcocite. (H.)	Copper glance	Associated with other copper ores. (S.)
Chalcopyrite. (H.)	Copper pyrites	Abundant. When sufficiently argentiferous and auriferous it is mined for these metals; when associated with other copper ores, it is mined along with these for its copper. (S.)
Chrysocolla. (H.)	Silicate of copper	Occasionally found with other ores of copper. (S.)

a The territory reported on by Mr. Perkins (of the California State Mining Bureau) contains, in addition to the substances named, nearly all of the known ores of gold and silver.

b Many of the minerals in this list occur as accidental accompaniments of regular ore minerals, or are mined for the gold, silver, copper, or lead contents.

ARIZONA—Continued.

Mineralogical name.	Common name.	Remarks.
Copper (native) (H.)	Copper	Found often, in smaller or larger quantities, interspersed through other copper ores. (S.)
Cuprite. (H.)	Copper oxide, "red copper."	With other ores of copper. (S.)
Dioptase	Emerald copper	Occasionally found with other ores of copper. (S.)
Dolomite	Dolomite, magnesian limestone.	(H.)
Dyscrasite	Antimonide of silver.	Associated with other ores of lead and silver. (S.)
Embolite	Chlorobromide of silver.	Occasionally found with other silver ores. (S.)
Feldspar	Feldspar	(H.)
Fluorite	Fluorspar	(H.)
Freieslebenite	Antimonial sulphide of silver.	Rather abundant. Associated with other argentiferous ores. (S.)
Galenite. (H.)	Galena	Invariably argentiferous, and sometimes interspersed with gold in grains of size invisible to unaided eye, to as large as a pea. Mined for its contents of precious metals, as well as for its lead in smelting other silver and gold ores. Very abundant. (S.)
	Garnet rock. (H.)	
Gold	Gold	In alluvium in many ravines and water courses; also in very many veins associated with common pyrite, chalcopyrite, blende, galena, mispickel, serpentine, heavy spar, and many other ores and rocks. (S.) Quartz and placer mines. (H.)
Granite	Granite	(H.)
Graphite	Graphite, plumbago, black lead.	Small deposits occasionally met with. Used to a very small extent for fireproof material. (S.)
Hematite	Iron ore	Mined as ore and flux. (H.)
Leucopyrite	White pyrites	When associated with other gold and silver ores it is mined along with these for the precious metals. (S.)
Lignite	Bituminous coal	Prospected only. (H.) Extensive deposits in northeastern Arizona between 109° and 111° longitude and 35° and 37° latitude. Mined to a very small extent. (S.)
Limonite	Ocher	Mined as ore and flux. (H.)
Magnetite	Magnetic oxide of iron.	(H.)
Malachite	Green carbonate of copper, copper carbonate.	Abundant with other copper ores. (S.) Important source of copper. Principal localities Globe, Bisbee, and Clifton. (H.)
Melaconite	Black oxide of copper.	With other ores of copper. (S.)
Miargyrite. (H)		Rather abundant; associated with other argentiferous ores. (S.)
	Ocher. (H.)	
Polybasite		Found occasionally with other argentiferous ores. (S.) Fine large specimens at Silver King mine. (H.)
	"Porphyry"	(H.)
Proustite	Light ruby silver	Associated with other argentiferous ores. (S.)
Pyrargyrite	Dark ruby silver	Rather plentiful; associated with other argentiferous ores. (S.) Fine specimens at Tip-top mine. (H.)
Pyrite. (H.)	Pyrites, iron pyrites	Very abundant. When sufficiently auriferous in itself, or when associated with other silver or gold ores, it is mined for the precious metals. (S.)

ARIZONA—Continued.

Mineralogical name.	Common name.	Remarks.
Pyrolusite	Binoxide of manganese	(H.)
Pyrrhotite	Magnetic pyrites	Occasionally met with. Sometimes auriferous. (S.)
Quartz	Quartz	Gangue. (H.)
Siderite. (H.)	Brown spar, spathic iron ore.	Associated with silver ores. (S.)
Silver, native. (H.)	Silver	Occasionally found in other argentiferous ores. (S.)
Sphalerite	Blende, zincblende	Very abundant in many mines, especially below water level. (H.) Generally both argentiferous and auriferous to a smaller or larger extent; when associated with other argentiferous and auriferous ores, it is mined along with these for the precious metals. (S.)
Stephanite (H.)	Brittle silver	Abundant with other silver ores. (S.)
Sternbergite		Associated with other silver ores. (S.)
Stromeyerite		Associated with other cupriferous and argentiferous ores. (S.)
Talc	Talc, soapstone	(H.)
	Tellurium	Occurs in small quantities in Tombstone district; but the tellurium minerals have not been determined. (H.)
Tetrahedrite (H.)	Fahers, gray copper	When sufficiently argentiferous, it is mined for silver; rather abundant. (S.)
Wad	Wad, bog manganese	(H.)
Wulfenite	Lead spar, molybdate of lead.	Fine crystals at Castle Dome. (H.)
Zinkenite	Sulphide of antimony and lead.	When associated with argentiferous ores it is mined along with these for the precious metals. (S.)

Ores, minerals, and mineral substances of industrial importance and known occurrence, bu which are not at present mined. (*a*)

	Alabaster	Superstition mountains; near Pueblo Viego, Pima county; near sulphur springs; in La Gija range, and elsewhere.
	Alum	Found on Verde river. (S.)
Alunogen	Sulphate of alumina	Found on Verde river. (S.)
Anglesite	Sulphate of lead	Occurs with other lead ores. (S.)
Anhydrite	Anhydrous gypsum	On Verde river and many other places. (S.)
Asbestus	Asbestus	Some brought in from Tonto basin, and from the Great Colorado plateau. (S.)
Asphaltum	Asphaltum, bitumen	Found in sandstone on Great Colorado plateau. (S.)
Aurichalcite	Brass ore	Found with other ores of zinc. (S.)
Barytes	Heavy spar	Abundant; often gangue of argentiferous and auriferous ores. (S.)
Biotite	Brown mica	(H.)
Braunite	Manganese ore	Many deposits; not used because of no demand. (S.)
Breunerite	Brown spar	Often met with. (S.)
	Building stone	Of many kinds and of fine quality in great abundance. (S.)

a Many of the minerals here enumerated are to be found in the foregoing list also. They are repeated here, as they occur in many localities where they are not worked.

ARIZONA—Continued.

Mineralogical name.	Common name.	Remarks.
Calamine	Silicate of zinc	Several good-sized deposits or veins are known to exist. (S.)
Calcite	Carbonate of lime, calcspar.	Abundant. (S.)
Caledonite	Impure sulphate of lead.	Occurs with other lead ores. (S.)
Cervantite	Antimony ocher	Occurs in some abundance, associated with other antimony ores; not utilized because no reduction works, and transportation too expensive. (S.)
Chalcanthite	Blue vitriol, sulphate of copper.	Often found in ravines contiguous to copper mines. (S.)
Cinnabar	Cinnabar	Float only found. (H.)
Copperas	Green vitriol, sulphate of iron.	Occasionally found with pyrites. (S.)
Crednerite	Oxide of manganese and copper.	Many deposits. No demand. (S.)
Crocoite	Chromate of lead, red lead.	Occasionally met with in other lead ores. (S.)
Dechenite and descloizite.	Vanadate of lead	Occasionally met with in other lead ores. (S.)
Dolomite	Magnesian limestone	Abundant. (S.)
Epsomite	Epsom salt	Found on Verde river. (S.)
	Fire-clays and refractory stone.	Of excellent quality; found at various places. (S.)
Fluorspar	Fluorspar	Abundant on the Great Colorado plateau. Occasionally met with near Prescott. (S.)
Garnet	Garnet	Plentiful on Great Colorado plateau and other places. (S.)
Glauberite	Sulphate of soda and lime.	Occurs on Verde river. (S.)
Gold	Gold	Many deposits of alluvium and detritus, often quite rich in gold, exist, which are not mined owing to scarcity of water and for want of capital to construct reservoirs in which to retain the waters that run to waste in rainy seasons. Many excellent auriferous veins are not worked for want of proper reduction works. (S.)
Gypsum	Gypsum, plaster of Paris.	Abundant in Verde range and elsewhere. (H. and S.)
Halite	Common salt	Along Verde river, associated with gypsum, sulphate of magnesia, and sulphate of soda; used to a small extent for cattle; too impure for table use. (S.) Headwaters of Salt river and in Tonto basin, Gila county. (H.)
Hansmannite	Black manganese	Many deposits. (S.)
Hematite, micaceous iron, and itabiryte.	Iron ore	Many deposits. (S.)
Kaolinite	Kaolin	Several large deposits. (S.)
Leadhillite		Occurs with other lead ores. (S.)
Lignite	Coal	Prospected only. (H.)
Limonite	Iron ore	Many deposits. (S.)
Magnesite	Carbonate of magnesia	Abundant. (S.)
Magnetite	Magnetic iron ore	Several veins near Prescott. (S.)
Manganite	Manganese ore	Many deposits. (S.)
Mirabilite	Glauber salt	Occurs on Verde river. (S.)

ARIZONA—Continued.

Mineralogical name.	Common name.	Remarks.
Molybdenite...	Sulphide of molybdenum.	Argentiferous. (H.)
Muscovite	Mica..................	Several deposits, but as none of them have been developed their value is unknown. (S.)
Opal (varieties cacholong and hyalite).	....	Several localities in Yavapai county. (S.)
Phœnicochroite	Subsesquichromate of lead.	Occasionally met with in other lead ores. (S.)
Platinum	Platinum	Reported, but doubtful. (H.)
Psilomelane ...	Black manganese	Many occurrences. (S.)
Pyrolusite	Gray manganese......	Many deposits. (S.)
Pyromorphite..	Phosphate of lead	Occasionally found with other lead ores. (S.)
	Sandstone	Of excellent quality; in great abundance on Great Colorado plateau; also $2\frac{1}{2}$ miles northwest of Prescott. (S.)
	Silver ores............	Many argentiferous veins, of known richness, which are not mined for want of capital and proper reduction works. (S.)
Smithsonite....	Carbonate of zinc.....	Found with other ores of zinc. (S.)
Stibnite........	Sulphide of antimony.	Large veins of good quality of ore, which are not worked because of high rates for transportation to markets. (S.)
Talc	Talc	Frequent. (S.)
Thenardite	Commonly called Verde salt.	Large deposit of it on Verde river, about a mile from Camp Verde; sometimes quite pure, at other times mixed with gypsum, sulphate of magnesia, chloride of sodium, &c. A very little of it is used for cattle, which seem to like it. (S.)
Vanadinite	Vanadate of lead	Associated with other lead ores. (S.)
Vauquelinite ..	Chromate of lead and copper.	Occasionally met with in other lead ores. (S.)
Volborthite....	Vanadate of copper...	Occasionally met with in other copper and lead ores. (S.)
Volgerite	Antimony ocher	Occurs in some abundance, associated with other antimony ores. (S.)
Willemite......	Anhydrous silicate of zinc.	Several good-sized deposits or veins are known to exist. (S.)
Wulfenite	Molybdate of lead	Occasionally met with in other lead ores. (S.)

MINING DISTRICTS OF ARIZONA.

[Reported by D. B. HUNTLEY.]

Districts.	Character of ore.	Reduction works.
COCHISE COUNTY.		
California (Gayleville)		
Cochise	Silver	
Dos Cabezas	Gold, silver	One gold mill.
Huachuca Mountains	Lead, silver, copper	
Russell	Copper, silver, gold	One copper smelter.
Swisshelm	Silver	
Tombstone	Gold, silver, lead	One lead smelter, nine mills.
Turquois	Silver, lead	
Warren	Copper, silver, lead	Two copper smelters.
Winchester	Silver	
GILA COUNTY.		
Globe	Copper, silver, gold, lead	Six smelters, eleven mills.
Pioneer	Silver	Two mills.
GRAHAM COUNTY.		
Arivipai Cañon	Silver, lead	
Ash Spring Mountains		
Bunker Hill	Gold, silver	
Copper Mountain	Copper, gold, silver	Five smelters.
Greenlee Gold Mountain	Placer gold	
Lone Star		
Mayflower		
MARICOPA COUNTY. (a)		
Cave Creek	Gold, silver	
MOHAVE COUNTY.		
Aubrey	Silver	
Cedar	Silver (base)	Two mills.
Gold Basin	Gold, copper	
Hackberry	Silver	One mill.
Hualapais	Silver (free-milling), silver-lead	Four mills.
Maynard	Silver (base)	
Waba Yuma	Copper	
Williams Fork	do	
PIMA COUNTY.		
Amole	Silver (milling and smelting)	
Arivaca	Gold, silver (milling)	One mill or smelter.
Aztec		
Barbaquivira	Gold, silver	
Cababi	Silver, copper	
Calabasas	Gold, silver	
Cañon del Oro	Silver, gold, lead	
Chuvaca	Silver (milling)	
Empire	Silver (milling), lead	One mill.
Greaterville	Placer gold, gold quartz	
Harshaw	Silver	One mill.
Helvetia	Silver, copper	One smelter.
Myers	Silver, copper (milling and smelting)	One mill.
Old Hat	Copper, silver, gold, lead	One smelter.
Oro Blanco	Gold, silver (milling)	One mill.
Papago	Copper, silver	
Patagonia	Silver, lead, copper	
Pima	Silver, gold, copper	
Quijatoa	Silver, copper	
Red Rock	Gold, silver, copper, lead	
San Pedro	Gold, silver	
San Xavier	Copper, silver	
Santo Domingo	Silver	
Silver Bell	Copper	
Silver Hill	Lead	
Tucson	Gold, silver	
Tyndall	Silver	
Washington Camp	Silver, lead	One smelter.
Wright	Silver	
Wrightson	Silver	
Young America	Copper	

a Incomplete.

MINING DISTRICTS OF ARIZONA—Continued.

Districts.	Character of ore.	Reduction works.
PINAL COUNTY.		
Bunker Hill (*a*)	Gold, silver	
Casa Grande	Gold, silver, copper	
Halstead		
Mineral Creek	Copper, silver	One mill.
Mineral Hill	Gold, silver, copper, lead	One furnace.
Owl Head	Gold, silver, copper	One mill.
Pinal		
Pioneer	Silver, gold, copper, lead (milling and smelting).	Four mills, one smelter.
Ripsy	Gold, silver	
Riverside	Copper, silver	One furnace.
Rodgers	Silver, gold	
Saddle Mountain	Gold, silver	
Superstition Mountains	Silver	
YAVAPAI COUNTY.		
Antelope	Placer gold, gold quartz	
Big Bug	Silver, gold	
Black Hills	Gold, silver, copper, lead	
Bradshaw	Silver, gold	One mill.
Castle Creek	Copper, silver	
Copper Basin	do	
Hassayampa	Silver, placer gold, gold quartz	One mill.
Humbug	Gold, silver	Do.
Peck	Silver, gold	Do.
Pine Grove	do	Do.
Santa Maria	Gold, silver, copper	
Tiger	Silver, gold	One mill.
Tonto Basin	Gold, silver, copper	Do.
Turkey Creek	Silver, gold	Do.
Walker	do	One furnace, one mill.
Walnut Grove	Silver, copper, gold	
Weaver	Placer gold, gold quartz	
YUMA COUNTY.		
Alvarado	Copper, silver	
Castle Dome	Lead, silver (smelting)	
Centennial	Gold, copper	
Ellsworth	Gold	One mill.
Eureka	Silver, lead	
Gila City	Gold, copper	
Harcuabar	Silver, gold, copper	One smelter.
Laguna	Gold	
Montezuma	Gold, silver, copper	
Mohawk	Copper, silver	
Plumosa	Silver lead, placer gold	
Rawhide	Copper, gold	
Silver Camp	Silver, gold, lead	One mill, two smelters.

a See Graham county.

CALIFORNIA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOSEPH PERKINS.]

Mineralogical name.	Common name.	Remarks.
Aragonite	"Suisun marble"	Solano county. Used for mantels, pedestals, and smaller ornaments.
Asphaltum	Asphaltum	Los Angeles, San Luis Obispo, and Santa Barbara counties. Used extensively in paving, roofing, &c., and employs considerable capital and labor throughout the State.
Calcite	Limestone	Burnt for lime in Santa Cruz, Placer, San Luis Obispo, and Napa counties.
Calcite	Marble	Quarried for coping and building, in Calaveras and Tuolumne counties; for making lime, in Santa Cruz and Amador counties; as flux for iron works, in Placer county.
	Cement	Solano county.
	Chromic iron ore	San Luis Obispo, Tuolumne, and El Dorado counties. Shipped to the Eastern States in large quantities.
	Clay	Contra Costa, Placer, and El Dorado counties. Used for pottery, but no fine ware yet made.
Cinnabar	Cinnabar	Lake, Sonoma, Napa, Fresno, and Santa Clara counties.
	Copper ore	Calaveras, Nevada, and Fresno counties. Generally shipped to England.
Galenite	Galena, lead ore	Inyo county.
	Granite	Sacramento and Placer counties.
Halite	Salt	Alameda county; large investment for manufacturing salt from the water of the bay of San Francisco.
Hematite	Iron ore	Placer county.
Lignite	Coal	Contra Costa and Placer counties.
Magnetite	Iron ore	Placer county.
Mercury, native	Native quicksilver	In some of the cinnabar mines.
Petroleum	Petroleum, coal oil	Santa Clara, Santa Cruz, Los Angeles, Ventura, and Santa Barbara counties.
	Pumice stone	San Francisco county.
	Sandstone	Solano county.
Saponite	Rock soap	Ventura county.
Steatite	Soapstone	Placer county. Used as furnace lining; sawed into bricks for the market.
Thinolite, gay-lussite.		Mono county. Used for making lime.
Tincal	Borax	San Bernardino county.
	Tufa	Santa Cruz county. Used for making cement.
Ulexite	Borax, borate of lime.	San Bernardino and Inyo counties.

CALIFORNIA—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
	Alabaster	Alabaster cave, El Dorado county; also in Solano, Tuolumne, and Los Angeles counties.
Aragonite	Onyx marble	San Luis Obispo, Siskiyou, Placer, and Kern counties; found in small fragments not large enough to work.
	Arsenic ores	
Asbestus	Asbestus	Tulare, Yolo, and Mariposa counties; in small quantity, limited market.
Asphaltum	Asphaltum	Mendocino and Sonoma counties; in small quantity.
Azurite	Blue carbonate of copper.	Inyo, San Bernardino, and Shasta counties.
Barite	Barytes, sulphate of baryta.	
	Bismuth ores	
	Bitumen	Santa Clara county.
	Buhrstone	Inyo county.
Calcite	Marble	Monterey, Nevada, and Kern counties.
Calcite (2)	Limestone	San Bernardino, Mono, San Benito, Inyo, and Calaveras counties.
Cassiterite	Tin ore	San Bernardino county, Temescal district.
	Cement	Alameda, Amador, Santa Cruz, and Contra Costa counties.
	Chalk	Silver Mountain district, Alpine county.
	Chromic iron ore	Sonoma, Santa Clara, San Mateo, Napa, Fresno, Amador, Sacramento, Tulare, and Solano counties.
Cinnabar	Cinnabar	Many deposits in El Dorado, Fresno, Kern, Napa, Solano, San Luis Obispo, Yolo, Santa Barbara, and Tuolumne counties, which cannot be worked at a profit at the present price of quicksilver.
	Clay	Kern, Tuolumne, Amador, Mono, Marin, Lake, Inyo, Sonoma, and Mendocino counties.
Chrysocolla	Silicate of copper	Inyo and San Diego counties.
Corundum	Corundum	
Diamond	Diamond	In gold placers, Shasta, Butte, and other counties.
Erubescite	Vriegated copper ore.	
Erythrite	Red cobalt ore	Los Angeles county.
	Feldspar	Mariposa county.
Fluorite	Fluorspar	
Galenite	Galena	San Bernardino, Mono, and Amador counties.
Garnet	Garnet	
	Granite	Mariposa and Nevada counties.
Graphite	Plumbago	Calaveras county.
Halite	Salt	Inyo and San Bernardino counties.
Hematite	Iron ore	Amador, Inyo, Alameda, Del Norte, Alpine, Butte, and Nevada counties.
Iridosmine	Iridosmine	In gold placers.
Lignite	Coal	Is found in inferior quality or small quantity in the following counties, but in some cases further development will probably show better results: Amador, Monterey, Lake, San Benito, Los Angeles, Kern, San Bernardino, Fresno, Calaveras, San Francisco, and Lassen counties.

CALIFORNIA—Continued.

Mineralogical name.	Common name.	Remarks.
Limonite	Iron ore	Calaveras, Tulare, San Luis Obispo, Placer, and Santa Clara counties.
	Litharge	San Bernardino county.
	Lithographic stone	Kern county; quality fair; quantity not known.
Malachite	Green carbonate of copper.	San Diego, Colusa, Shasta, Tuolumne, Los Angeles, Amador, Tulare, Del Norte, Placer, Contra Costa, Mono, San Luis Obispo, Sonoma, Mariposa, and San Bernardino counties.
Magnetite	Magnetic iron ore	Shasta, Amador, Plumas, Butte, Yuba, El Dorado, San Benito, Mariposa, and San Diego counties.
	Marl	Various localities.
Muscovite	Mica	El Dorado and Mariposa counties.
	Nickel ore	San Benito and Kern counties.
Obsidian	Obsidian	
	Ocher, red and yellow.	Calaveras and Sonoma counties.
Petroleum	Petroleum, coal oil	San Luis Obispo and San Diego counties.
Platiniridium	Platinum	Mendocino and Trinity counties.
	Pumice stone	Mono and San Diego counties.
Pyrite	Iron sulphurets	Alpine, Amador, Placer, Lake, Inyo, Nevada, Shasta, Tuolumne, Mono, El Dorado, and San Luis Obispo counties.
Pyrolusite	Manganese ore	Sonoma, Tuolumne, Marin, Calaveras, Mariposa, and Alameda counties.
	Quartz sand	For glass making.
	Roofing slate	
	Sandstone	Santa Clara, Shasta, Tuolumne, San Mateo, and Napa counties.
Saponite	Rock soap	Santa Barbara county.
Selenite	Gypsum	Ventura, Los Angeles, Monterey, Kern, Lake, Santa Barbara, Tulare, and Lassen counties.
Sphalerite	Zincblende, "black jack."	Tulare and San Mateo counties; small deposits of no present value.
Steatite	Soapstone	Yuba, Tuolumne, Kern, Los Angeles, Nevada, Fresno, Amador, Marin, and Tulare counties.
Stibnite	Sulphide of antimony.	San Benito, Los Angeles, Tulare, Santa Clara, and Kern counties.
Strontianite	Carbonate of strontia.	
Sulphur	Sulphur	Lake and Napa counties.
	"Syenite"	San Mateo county.
Thenardite	Sulphate of soda	Inyo county.
Thinolite, gay-lussite.		Lassen county.
Trona	Carbonate of soda	Inyo county.
	Tufa	Kern, Shasta, Mono, and San Luis Obispo counties.
Ulexite	Borate of lime	Kern county.
	Umber	
Wolfram	Tungstate of iron	

IDAHO.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by ALBERT WILLIAMS, JR.]

Mineralogical name.	Common name.	Remarks.
Anglesite (argentiferous).	Sulphate of lead	Wood River county; in surface ores of some of the argentiferous lead mines.
Argentite	Silver glance	Silver City, Owyhee county; Tahoma mine, Atlanta, Alturas county; and elsewhere.
Arsenopyrite (auriferous).	Mispickel	Notably at Rocky Bar, Hardscrabble, Granite, Yuba, and Shaw's Mountain districts, but frequent in many other localities.
Azurite	Blue carbonate of copper.	Lemhi county, Alturas county.
Calcite	Limestone	Used as flux and burned for lime.
Cerargyrite	Horn silver, "chloride."	Many mines of Owyhee county; surface ore of Monarch lode, Atlanta, Alturas county.
Cervantite	Antimony ocher	Small quantities in surface lead ores of Wood River country.
Cerussite (argentiferous).	Carbonate of lead, "carbonate."	Wood River and neighboring districts.
Chalcopyrite (auriferous).	Copper pyrites	In many gold mines.
	Clay (common brick)	Boisé City.
	Clay (fire)	Of poor quality; refractory furnace linings commonly brought from Santa Cruz, California.
Dufrenoysite	Sulpharsenide of lead	Crown Point mine, Banner district.
Freibergite	Argentiferous tetrahedrite.	Columbia, Pilgrim, and other mines, Sawtooth district.
Galenite (argentiferous).	Galena	Important deposits in Wood River country, Alturas county, and in Lemhi county.
Gold, native	Gold	Deep placers in Boisé basin, Boisé county; placer gold is found along many of the streams throughout the Territory, and in the Snake river; hydraulic mining in many scattered districts; quartz gold in Yankee Fork, Mount Estes, Granite, Rocky Bar, Bonaparte, Atlanta, Red Warrior, Cañon creek, Shaw's mountain, Silver City, Florence, Warren's, Wagontown, and other districts; crystallized specimens from Gold Hill mine, Granite district, Boise county, particularly fine.
Hematite	Iron ore	Used as flux.
Limonite	Iron ore	Used as flux.
Malachite	Green carbonate of copper.	Lemhi county.
Marcasite	White pyrites	In some gold mines.
Proustite	Light ruby silver, arsenical ruby.	Notably in Monarch and Buffalo mines, Atlanta; associated with pyrargyrite in Sawtooth and other districts.
Pyrargyrite	Dark ruby silver, antimonial ruby.	Atlanta district, Monarch, Tahoma, Jessie Benton, Buffalo, and other mines; Sawtooth district; Smiley's basin.
Pyrite (auriferous).	Iron sulphurets	In many gold mines, notably in Granite and Yuba districts.
	Sandstone	Fine varieties of red and gray freestone near Boisé City.
Silver, native	Silver	Atlanta district.
Sphalerite	Zincblende	Auriferous at Bonaparte mine.
Stephanite	Brittle silver	Custer and Unknown mines, Yankee Fork; also in Queen's River district, and reported elsewhere.
Stibnite	Sulphide of antimony.	In argentiferous lead mines of Wood river.
Tetrahedrite	Fahlerz	Obscure, but probably frequent with antimonial and arsenical silver ores.

IDAHO—Continued.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Mineralogical name.	Common name.	Remarks.
Arsenopyrite (auriferous).	Mispickel	In many mines which are unproductive because of the absence of proper reduction works.
Azurite	Blue carbonate of copper.	With other copper ores in many unworked deposits, as in Lemhi, Custer, and Alturas counties.
Bismuthinite	Sulphate of bismuth.	Reported.
Calcite	Marble	Reported.
Cerargyrite	Horn silver	
Cerussite	Carbonate of lead	
Chalcopyrite	Copper pyrites	
	Clays	
Cuprite	Copper oxide	
	Dolomite	
Erubescite	Variegated copper ore.	
Galenite	Galena	Many unworked deposits.
Gold	Gold	Many unworked deposits.
	Granite	Principal country rock of central Idaho. Often a good building stone, but unused.
Halite	Salt	In southeastern Idaho.
Hematite	Iron ore	
Lignite	Coal	Owyhee, Ada, and Boisé counties.
Limonite	Iron ore	
Malachite	Green carbonate of copper.	Many localities.
Marcasite	White pyrites	(See Arsenopyrite.)
Molybdenite	Sulphide of molybdenum.	Reported.
Muscovite	Mica	Fine specimens of large sheets at Payette river and near Boisé City. Samples have been shipped.
Proustite	Light ruby silver	
Pyrargyrite	Dark ruby silver	
Pyrite (auriferous).	Iron sulphuret	
Pyrolusite	Manganese ore	Shaw's mountain.
	Sandstone	
Sphalerite	Zincblende, "black jack."	Never worked except as accidental component of precious-metal ores.
Stibnite	Sulphide of antimony.	(See remark on Sphalerite.)

NEVADA.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOSEPH PERKINS.]

Mineralogical name.	Common name.	Remarks.
Anglesite	Sulphate of lead	Eureka county.
Azurite	Carbonate of copper, "bromide of silver."	Esmeralda county.
Cerussite	"Carbonate," carbonate of lead.	Large deposits in Eureka county.
Cuprite	Copper oxide	Esmeralda county.
Galenite	Galena	In many counties. Principal occurrence Eureka district, Eureka county.
Halite	Salt	Lincoln and other counties.
Malachite	Carbonate of copper	Esmeralda county.
	Mineral soap	Elko county; used for mixing in manufacture of soap.
Sulphur	Sulphur	Humboldt county.
Thenardite	Sulphate of soda	Esmeralda county.
	"Trachyte"	Storey county; used as building stone.
Trona	Carbonate of soda	Esmeralda county.
Ulexite	Borate of lime	Esmeralda county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Azurite	Blue carbonate of copper.	Elko county.
Cinnabar	Cinnabar	Washoe county.
Galenite	Galena	Esmeralda, Lander, and White Pine counties.
Graphite	Plumbago	Ormsby county.
	Gypsum	Storey county.
Halite	Salt	Esmeralda county.
Hematite	Iron ore	Elko and Churchill counties.
Malachite	Green carbonate of copper.	Lander, Elko, and Humboldt counties.
	Nickel ore	Esmeralda county.
Pyrite	Iron sulphurets	Lander county.
Stibnite	Sulphide of antimony.	Humboldt county.
Sulhpur	Sulphur	Washoe county.
Thinolite		Humboldt county.
Trona	Carbonate of soda	Churchill county.
Ulexite	Borate of lime	Humboldt county.

OREGON.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOSEPH PERKINS.]

Mineralogical name.	Common name.	Remarks.
Lignite	Coal	Coos and Curry counties.
Magnetite	Magnetic iron ore	Josephine county.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

	Buhrstone	Bald Peter mountain.
	Jet	Clatsop county.
Lignite	Coal	Eagle mountain.
	Nickel ore	Baker county.
Priceite	Borate of lime	Curry county.

UTAH.

Ores, minerals, and mineral substances of industrial importance, which are at present mined. (a)

[Reported by D. B. HUNTLEY.]

Anglesite	Sulphate of lead	Mined for lead and silver.
Arsenopyrite	Mispickel	Mined for gold and silver contents.
Azurite	Copper carbonate, often called "bromide of silver."	Mined for copper and silver.
Barite	Heavy spar	Gangue of silver and lead at Horn Silver mine.
	Bismuth ore	Limited quantities in Tintic district.
	Bituminous coal	See lignite.
Calcite	Limestone	Gangue and flux.
Brown hematite.	Iron ore	Used as flux in lead smelting.
Cerargyrite	Horn silver, chloride	
Chalcopyrite	Copper pyrite	Mined for gold and silver contents.
Cerussite	Carbonate of lead, "crystalized lead."	Mined for silver, lead, and gold; the principal source of lead in Utah.
Chrysocolla	Silicate of copper	
	Clays	For common and firebrick.
	Coal	See lignite.
Cubanite		
Cuprite	Copper oxide	
Dolomite	Magnesian limestone	Wall rock of many silver-bearing veins.
Erubescite		
Galenite	Galena	Mined for lead and silver; common.

a In Utah, at present, everything is mined for silver, gold, lead, copper, antimony, or coal and salt. Many "accidental" minerals are found in the mines.

UTAH—Continued.

Mineralogical name.	Common name.	Remarks.
Gold	Gold	Free, and associated with complex minerals. Small placers in West Mountain district.
Granite	Granite	Building stone. For Mormon temple; 5,000 tons used per year.
Gypsum	Gypsum, plaster-of-paris.	
Halite	Rock salt and lake salt.	Mined as rock salt, and also collected by solar evaporation and boiling of water of salt springs. Principal source Salt lake.
Hematite	Iron ore	Flux in lead smelting.
Leadhillite		
Lignite	Coal	Mined largely for steam and domestic use.
Limonite	Ocher, often called "chloride."	For flux.
Malachite	Copper carbonate	Mined for copper and silver.
Molybdenite	Sulphide of molybdenum.	
Orpiment	Yellow sulphide of arsenic.	Limited quantity in one silver mine in Bingham cañon.
Polybasite		
	"Porphyry"	Sometimes used as building stone. (All rocks not called granite, limestone, sandstone, or slate are usually known as "porphyry.")
Pyrargyrite	Dark ruby silver	
Pyrite	Pyrite	Mined for gold and silver contents. Frequently accompanies other ores.
Pyrolusite	"Manganese," binoxide of manganese.	
Rhodocrosite	Carbonate of manganese.	
	Sandstone	Vast quantities. Sometimes used as building stone. Gangue of silver ores at Silver Reef.
Sphalerite	Blende, zincblende, "black jack."	Mined for silver contents.
Stibnite	"Antimony," sulphide of antimony.	Mined for antimony. Often associated with galena.
Tetrahedrite	Fahlerz, gray copper	Mined for silver.
	Tufa	Used as lining for lead furnaces.
Wulfenite	Molybdate of lead	Occurs with silver ores.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined. (*a*)

Biotite	Mica	
Calcite	Marble	
Cervantite, or stibconite.	Antimony ocher	Limited quantities.
Cinnabar	Cinnabar	
Geocerite (?) or ozocerite (?).	Mineral wax	Contains much paraffine; not much prospected.

a The names duplicated in this list from the foregoing list refer to important occurrences of the same mineral not mined.

UTAH—Continued.

Mineralogical name.	Common name.	Remarks.
Gypsum (1)....	Alabaster..............	
Gypsum (2)....	Gypsum, plaster-of-paris.	Abundant, but not developed because of lack of demand and want of transportation facilities.
Hematite.....	Iron ore..............	Large quantities; not worked for iron because of lack of capital and means of transportation.
Kalinite.......	Alum, potash alum...	
	Alum shales..........	
Kaolinite (1)...	Kaolin................	In Tintic district.
Kaolinite (2)...	"Gunnison paint"....	Near Gunnison.
Lignite........	Lignite, coal..........	Many beds not worked.
Magnetite.....	Iron ore..........	
Muscovite.....	Mica..................	
Niter..........	Saltpeter, nitrate of potash.	Near Fillmore and near Parowan.
Sulphur.......	Sulphur, brimstone...	Large quantities.
Tiemannite....	Selenide of mercury..	In Ohio district.

WASHINGTON.

Ores, minerals, and mineral substances of industrial importance, which are at present mined.

[Reported by JOSEPH PERKINS.]

Lignite........	Coal..................	King county, and neighborhood of Puget sound.

Ores, minerals, and mineral substances of industrial importance and known occurrence, but which are not at present mined.

Lignite........	Coal..................	Many known deposits not worked.
Limonite......	Iron ore..............	
	Plastic clay...........	Tacoma county.

APPENDIX.

THE NEW TARIFF.

At the close of the second session of the Forty-seventh Congress the tariff bill entitled "An act to reduce internal-revenue taxation, and for other purposes," was passed. It was approved by the President March 3, 1883, and is now in force. The following extracts show the present rates of import duties upon chemical products, metals, mineral products, etc., and substances having a more or less direct bearing upon the mineral industries of the country, together with the free list abridged on the same plan.

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SEC. 2502. There shall be levied, collected, and paid upon all articles imported from foreign countries, and mentioned in the schedules herein contained, the rates of duty which are, by the schedules, respectively prescribed, namely:

SCHEDULE A.—CHEMICAL PRODUCTS.

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Alumina, alum, patent alum, alum substitute, sulphate of alumina, and aluminous cake, and alum in crystals or ground, sixty cents per hundred pounds.

Ammonia, anhydrous, liquefied by pressure, twenty per centum ad valorem.

Ammonia aqua, or water of ammonia, twenty per centum ad valorem.

Ammonia, muriate of, or sal-ammoniac, ten per centum ad valorem.

Ammonia, carbonate of, twenty per centum ad valorem.

Ammonia, sulphate of, twenty per cent. ad valorem.

All imitations of natural mineral waters, and all artificial mineral waters, thirty per centum ad valorem.

Asbestus, manufactured, twenty-five per centum ad valorem.

Baryta, sulphate of, or barytes, unmanufactured, ten per centum ad valorem.

Baryta, sulphate of, or barytes, manufactured, one-fourth of one cent per pound.

Refined borax, five cents per pound.

Pure boracic acid, five cents per pound; commercial boracic acid, four cents per pound; borate of lime, three cents per pound; crude borax, three cents per pound.

Cement, Roman, Portland, and all others, twenty per centum ad valorem.

Whiting and Paris white, dry, one-half cent per pound; ground in oil, or putty, one cent per pound.

Prepared chalk, precipitated chalk, French chalk, red chalk, and all other chalk preparations which are not specially enumerated or provided for in this act, twenty per centum ad valorem.

Chromic acid, fifteen per centum ad valorem.

Chromate of potash, three cents per pound.

Bi-chromate of potash, three cents per pound.

Cobalt, oxide of, twenty per centum ad valorem.

Copper, sulphate of, or blue vitriol, three cents per pound.

Iron, sulphate of, or copperas, three-tenths of one cent per pound.

Acetate of lead, brown, four cents per pound.

Acetate of lead, white, six cents per pound.

White lead, when dry or in pulp, three cents per pound; when ground or mixed in oil, three cents per pound.

Litharge, three cents per pound.

Orange mineral, and red lead, three cents per pound.

Nitrate of lead, three cents per pound.

Magnesia, medicinal, carbonate of, five cents per pound.

Magnesia, calcined, ten cents per pound.

Magnesia, sulphate of, or Epsom salts, one-half of one cent per pound.

Potash:

Crude, carbonate of, or fused, and caustic potash, twenty per centum ad valorem.

Chlorate of, three cents per pound.

Hydriodate, iodide, and iodate of, fifty cents per pound.

Prussiate of, red, ten cents per pound.

Prussiate of, yellow, five cents per pound.

Nitrate of, or saltpeter, crude, one cent per pound.

Nitrate of, or refined saltpeter, one and one-half cents per pound.

Sulphate of, twenty per centum ad valorem.

Soda:

Soda-ash, one-quarter of one cent per pound.

Soda, sal, or soda crystals, one-quarter of one cent per pound.

Bi-carbonate of, or super-carbonate of, and saleratus, calcined or pearl ash, one and one-half cents per pound.

Hydrate or caustic, one cent per pound.

Sulphate, known as salt cake, crude or refined, or niter cake, crude or refined, and Glauber's salt, twenty per centum ad valorem.

Soda, silicate of, or other alkaline silicate, one-half of one cent per pound.

Sulphur:

Refined, in rolls, ten dollars per ton.

Sublimed, or flowers of, twenty dollars per ton.

Wood-tar, ten per centum ad valorem.

Coal-tar, crude, ten per centum ad valorem.

Coal-tar, products of, such as naphtha, benzine, benzole, dead oil, and pitch, twenty per centum ad valorem.

All coal-tar colors or dyes by whatever name known and not specially enumerated or provided for in this act, thirty-five per centum ad valorem.

All preparations of coal-tar, not colors or dye, not specially enumerated or provided for in this act, twenty per centum ad valorem.

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Ultramarine, five cents per pound.

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Colors and paints, including lakes, whether dry or mixed, or ground with water or oil, and not specially enumerated or provided for in this act, twenty-five per centum ad valorem.

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Ocher, and ochery earths, umber and umber earths, and sienna and sienna earths, when dry, one-half of one cent per pound; when ground in oil, one and one-half cents per pound.

Zinc, oxide of, when dry, one and one-fourth cent per pound.

Zinc, oxide of, when ground in oil, one and three-fourths cent per pound.

All preparations known as essential oils, expressed oils, distilled oils, rendered oils, alkalies, alkaloids, and all combinations of any of the foregoing, and all chemical compounds and salts, by whatever name known, and not specially enumerated or provided for in this act, twenty-five per centum ad valorem.

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All non-dutiable crude minerals, but which have been advanced in value or condition by refining or grinding, or by other process of manufacture, not specially enumerated or provided for in this act, ten per centum ad valorem.

All earths or clays, unwrought or unmanufactured, not specially enumerated or provided for in this act, one dollar and fifty cents per ton.

All earths or clays, wrought or manufactured, not specially enumerated or provided for in this act, three dollars per ton; china clay, or kaolin three dollars per ton.

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SCHEDULE B.—EARTHENWARE AND GLASSWARE.

Brown earthenware, common stoneware, gas-retorts, and stoneware not ornamented, twenty-five per centum ad valorem.

China, porcelain, parian, and bisque, earthen, stone, and crockery ware, including plaques, ornaments, charms, vases, and statuettes, painted, printed, or gilded, or otherwise decorated or ornamented in any manner, sixty per centum ad valorem.

China, porcelain, parian, and bisque ware, plain white, and not ornamented or decorated in any manner, fifty-five per centum ad valorem.

All other earthen, stone, and crockery ware, white, glazed, or edged, composed of earthy or mineral substances, not specially enumerated or provided for in this act, fifty-five per centum ad valorem.

Stoneware, above the capacity of ten gallons, twenty per centum ad valorem.

Encaustic tiles, thirty-five per centum ad valorem.

Brick, firebrick, and roofing and paving tile, not specially enumerated or provided for in this act, twenty per centum ad valorem.

Slates, slate pencils, slate chimney-pieces, mantels, slabs for tables, and all other manufactures of slate, thirty per centum ad valorem.

Roofing-slates, twenty-five per centum ad valorem.

Green and colored glass bottles, vials, demijohns and carboys (covered or uncovered), pickle or preserve jars, and other plain, molded, or pressed green and colored bottle glass, not cut, engraved, or painted, and not specially enumerated or provided for in this act, one cent per pound; if filled, and not otherwise in this act provided for, said articles shall pay thirty per centum ad valorem in addition to the duty on the contents.

Flint and lime glass bottles and vials, and other plain, molded, or pressed flint or lime glassware, not specially enumerated or provided for in this act, forty per centum ad valorem; if filled, and not otherwise in this act provided for, said articles shall pay, exclusive of contents, forty per centum ad valorem in addition to the duty on the contents.

Articles of glass, cut, engraved, painted, colored, printed, stained, silvered, or gilded, not including plate-glass, silvered, or looking-glass plates, forty-five per centum ad valorem.

All glass bottles, and decanters, and other like vessels of glass, shall, if filled, pay the same rates of duty, in addition to any duty chargeable on the contents, as if not filled, except as in this act otherwise specially provided for.

Cylinder and crown glass, polished, not exceeding ten by fifteen inches square, two and one-half cents per square foot; above that, and not exceeding sixteen by twenty-four inches square, four cents per square foot; above that, and not exceeding twenty-four by thirty inches square, six cents per square foot; above that, and not exceeding twenty-four by sixty inches square, twenty cents per square foot; all above that, forty cents per square foot.

Unpolished cylinder, crown, and common window glass, not exceeding ten by fifteen inches square, one and three-eighths cents per pound; above that, and not exceeding sixteen by twenty-four inches square, one and seven-eighths cents per pound; above that, and not exceeding twenty-four by thirty inches square, two and three-eighths cents per pound; all above that, two and seven-eighths cents per pound: *Provided*, That unpolished cylinder, crown, and common window glass, imported in boxes containing fifty square feet, as nearly as sizes will permit, now known and commercially designated as fifty feet of glass, single thick and weighing not to exceed fifty-five pounds of glass per box, shall be entered and computed as fifty pounds of glass only; and that said kinds of glass imported in boxes containing, as nearly as sizes will permit, fifty feet of glass, now known and commercially designated as fifty feet of glass, double thick and not exceeding ninety pounds in weight, shall be entered and computed as eighty pounds of glass only; but in all other cases the duty shall be computed according to the actual weight of glass.

Fluted, rolled, or rough plate glass, not including crown, cylinder, or common window-glass, not exceeding ten by fifteen inches square, seventy-five cents per one hundred square feet; above that, and not exceeding sixteen by twenty-four inches square, one cent per square foot; above that, and not exceeding twenty-four by thirty inches square, one cent and a half per square foot; all above that, two cents per square foot. And all fluted, rolled, or rough plate glass, weighing over one hundred pounds per one hundred square feet, shall pay an additional duty on the excess at the same rates herein imposed.

Cast polished plate glass, unsilvered, not exceeding ten by fifteen inches square, three cents per square foot; above that, and not exceeding sixteen by twenty-four inches square, five cents per square foot; above that, and not exceeding twenty-four by thirty inches square, eight cents per square foot; above that, and not exceeding twenty-four by sixty inches square, twenty-five cents per square foot; all above that, fifty cents per square foot.

Cast polished plate glass, silvered, or looking-glass plates, not exceeding ten by fifteen inches square, four cents per square foot; above that, and not exceeding sixteen by twenty-four inches square, six cents per square foot; above that, and not exceeding twenty-four by thirty inches square, ten cents per square foot; above that, and not exceeding twenty-four by sixty inches square, thirty-five cents per square foot; all above that, sixty cents per square foot.

But no looking-glass plates or plate glass, silvered, when framed, shall pay a less rate of duty than that imposed upon similar glass of like description not framed, but shall be liable to pay, in addition thereto, thirty per centum ad valorem upon such frames.

Porcelain and Bohemian glass, chemical glassware, painted glassware, stained glass, and all other manufactures of glass or of which glass shall be the component material of chief value, not specially enumerated or provided for in this act, forty-five per centum ad valorem.

Schedule C.—Metals.

Iron ore, including manganiferous iron ore, also the dross or residuum from burnt pyrites, seventy-five cents per ton. Sulphur ore, as pyrites, or sulphuret of iron in its natural state, containing not more than three and one-half per centum of copper, seventy-five cents per ton: *Provided*, That ore containing more than two per centum of copper shall pay, in addition thereto, two and one-half cents per pound for the copper contained therein.

Iron in pigs, iron kentledge, spiegeleisen, wrought and cast scrap-iron, and scrap-steel, three tenths of one cent per pound; but nothing shall be deemed scrap-iron or scrap-steel except waste or refuse iron or steel that has been in actual use and is fit only to be remanufactured.

Iron railway-bars, weighing more than twenty-five pounds to the yard, seven-tenths of one cent per pound.

Steel railway-bars and railway-bars made in part of steel, weighing more than twenty-five pounds to the yard, seventeen dollars per ton.

Bar-iron, rolled or hammered, comprising flats not less than one inch wide nor less than three-eighths of one inch thick, eight-tenths of one cent per pound; comprising round iron not less than three-fourths of one inch in diameter, and square iron not less than three-fourths of one inch square, one cent per pound; comprising flats less than one inch wide, or less than three-eighths of one inch thick; round iron less than three-fourths of one inch and not less than seven-sixteenths of one inch in diameter, and square iron less than three-fourths of one inch square, one and one-tenth of one cent per pound: *Provided*, That all iron in slabs, blooms, loops, or other forms less finished than iron in bars, and more advanced than pig-iron, except castings, shall be rated as iron in bars, and pay a duty accordingly; and none of the above iron shall pay a less rate of duty than thirty-five per centum ad valorem: *Provided further*, That all iron bars, blooms, billets, or sizes or shapes of any kind, in the manufacture of which charcoal is used as fuel, shall be subject to a duty of twenty-two dollars per ton.

Iron or steel tee rails, weighing not over twenty-five pounds to the yard, nine-tenths of one cent per pound; iron or steel flat rails, punched, eight-tenths of one cent per pound.

Round iron, in coils or rods, less than seven-sixteenths of one inch in diameter, and bars or shapes of rolled iron not specially enumerated or provided for in this act, one and two-tenths of one cent per pound.

Boiler or other plate iron, sheared or unsheared, skelp-iron, sheared or rolled in grooves, one and one-fourth cents per pound; sheet iron, common or black, thinner than one inch and one-half and not thinner than number twenty wire gauge, one and one-tenth of one cent per pound; thinner than number twenty wire gauge and not thinner than number twenty-five wire gauge, one and two-tenths of one cent per pound; thinner than number twenty-five wire gauge and not thinner than number twenty-nine wire gauge, one and five-tenths of one cent per pound; thinner than number twenty-nine wire gauge, and all iron commercially known as common or black taggers iron, whether put up in boxes or bundles or not, thirty per centum ad valorem: *And provided*, That on all such iron and steel sheets or plates aforesaid, excepting on what are known commercially as tin-plates, terne-plates, and taggers-tin, and hereafter provided for, when galvanized or coated with zinc or spelter, or other metals, or any alloy of those metals, three-fourths of one cent per pound additional.

Polished, planished, or glanced sheet-iron, or sheet-steel, by whatever name designated, two and one-half cents per pound: *Provided*, That plate or sheet or taggers iron, by whatever name designated, other than the polished, planished, or glanced herein provided for, which has been pickled or cleaned by acid, or by any other material or process, and which is cold rolled, shall pay one-quarter cent per pound more duty than the corresponding gauges of common or black sheet or taggers iron.

Iron or steel sheets, or plates, or taggers iron, coated with tin or lead, or with a mixture of which these metals is a component part, by the dipping or any other process, and commercially known as tin plates, terne plates, and taggers tin, one cent per pound; corrugated or crimped sheet iron or steel, one and four-tenths of one cent per pound.

Hoop, or band, or scroll, or other iron, eight inches or less in width, and not thinner than number ten wire gauge, one cent per pound; thinner than number ten wire gauge and not thinner than number twenty wire gauge, one and two-tenths of one cent per pound; thinner than number twenty wire gauge, one and four-tenths of one cent per pound: *Provided*, That all articles not specially enumerated or provided for in this act, whether wholly or partly manufactured, made from sheet, plate, hoop, band, or scroll iron herein provided for, or of which such sheet, plate, hoop, band, or scroll iron shall be the material of chief value, shall pay one-fourth of one cent per pound more duty than that imposed on the iron from which they are made, or which shall be such material of chief value.

Iron and steel cotton-ties, or hoops for baling purposes, not thinner than number twenty wire gauge, thirty-five per centum ad valorem.

Cast-iron pipe of every description, one cent per pound.

Cast-iron vessels, plates, stove-plates, andirons, sadirons, tailors' irons, hatters' irons, and castings of iron, not specially enumerated or provided for in this act, one and one-quarter of one cent per pound.

Cut nails and spikes, of iron or steel, one and one-quarter of one cent per pound.

Cut tacks, brads, or sprigs, not exceeding sixteen ounces to the thousand, two and one-half cents per thousand; exceeding sixteen ounces to the thousand, three cents per pound.

Iron or steel railway fish-plates, or splice-bars, one and one-fourth of one cent per pound.

Malleable iron castings, not specially enumerated or provided for in this act, two cents per pound.

Wrought iron or steel spikes, nuts, and washers, and horse, mule, or ox shoes, two cents per pound.

Anvils, anchors or parts thereof, mill-irons and mill-cranks, of wrought irons and wrought-iron for ships, and forgings of iron and steel, for vessels, steam-engines, and locomotives, or parts thereof, weighing each twenty-five pounds or more, two cents per pound.

Iron or steel rivets, bolts, with or without threads or nuts, or bolt-blanks, and finished hinges or hinge-blanks, two and one-half of one cent per pound.

Iron or steel blacksmiths' hammers and sledges, track-tools, wedges, and crowbars, two and one-half of one cent per pound.

Iron or steel axles, parts thereof, axle-bars, axle-blanks, or forgings for axles, without reference to the stage or state of manufacture, two and one-half of one cent per pound.

Forgings of iron and steel, or forged iron, of whatever shape, or in whatever stage of manufacture, not specially enumerated or provided for in this act, two and one-half cents per pound.

Horseshoe-nails, hob-nails, and wire-nails, and all other wrought-iron or steel nails, not specially enumerated or provided for in this act, four cents per pound.

Boiler tubes, or flues, or stays, of wrought-iron or steel, three cents per pound.

Other wrought iron or steel tubes or pipes, two and one-quarter cents per pound.

Chain or chains of all kinds, made of iron or steel, not less than three-fourths of one inch in diameter, one and three-quarter cents per pound; less than three-fourths of one inch and not less than three-eighths of one inch in diameter, two cents per pound; less than three-eighths of one inch in diameter, two and one-half cents per pound.

Cross-cut saws, eight cents per linear foot.

Mill, pit, and drag saws, not over nine inches wide, ten cents per linear foot; over nine inches wide, fifteen cents per linear foot.

Circular saws, thirty per centum ad valorem.

Hand, buck, and all other saws, not specially enumerated or provided for in this act, forty per centum ad valorem.

Files, file blanks, rasps, and floats of all cuts and kinds, four inches in length and under, thirty-five cents per dozen; over four inches in length and under nine inches, seventy-five cents per dozen; nine inches in length and under fourteen inches, one dollar and fifty cents per dozen; fourteen inches in length and over, two dollars and fifty cents per dozen.

Steel ingots, cogged ingots, blooms and slabs, by whatever process made; die blocks or blanks; billets and bars and tapered or beveled bars; bands, hoops, strips, and sheets of all gauges and widths; plates of all thicknesses and widths; steamer, crank, and other shafts; wrist or crank pins; connecting-rods and piston-rods; pressed, sheared, or stamped shapes, or blanks of sheet or plate steel, or combination of steel and iron, punched or not punched; hammer-molds or swaged steel; gun-molds, not in bars; alloys used as substitutes for steel tools; all descriptions and shapes of dry sand, loam, or iron-molded steel castings, all of the above classes of steel not otherwise specially provided for in this act, valued at four cents a pound or less, forty-five per centum ad valorem; above four cents a pound and not above seven cents per pound, two cents per pound; valued above seven cents and not above ten cents per pound, two and three-fourths cents per pound; valued at above ten cents per pound, three and one-fourth cents per pound: *Provided*, That on all iron or steel bars, rods, strips, or steel sheets, of whatever shape, and on all iron or steel bars of irregular shape or section, cold-rolled, cold-hammered, or polished in any way in addition to the ordinary process of hot-rolling or hammering, there shall be paid one-fourth cent per pound, in addition to the rates provided in this act; and on steel circular saw plates there shall be paid one cent per pound in addition to the rate provided in this act.

Iron or steel beams, girders, joists, angles, channels, car-truck channels, TT, columns and posts, or parts or sections of columns and posts, deck and bulb beams, and building forms, together with all other structural shapes of iron or steel, one and one-fourth of one cent per pound.

Steel wheels and steel-tired wheels for railway purposes, whether wholly or partly finished, and iron or steel locomotive, car, and other railway tires, or parts thereof, wholly or partly manufactured, two and one-half of one cent per pound; iron or steel ingots, cogged ingots, blooms or blanks for the same, without regard to the degree of manufacture, two cents per pound.

Iron or steel rivet, screw, nail, and fence, wire rods, round, in coils and loops, not lighter than number five wire gauge, valued at three and one-half cents or less per pound, six-tenths of one cent per pound. Iron or steel, flat with longitudinal ribs for the manufacture of fencing, six-tenths of a cent per pound.

Screws, commonly called wood screws, two inches or over in length, six cents per pound; one inch and less than two inches in length, eight cents per pound; over one-half inch and less than one inch in length, ten cents per pound; one-half inch and less in length, twelve cents per pound.

Iron or steel wire, smaller than number five and not smaller than number ten wire gauge, one and one-half cents per pound; smaller than number ten and not smaller than number sixteen wire gauge, two cents per pound; smaller than number sixteen and not smaller than number twenty-six wire gauge, two and one-half cents per pound; smaller than number twenty-six wire gauge, three cents per pound: *Provided*, That iron or steel wire covered with cotton, silk, or other material, and wire commonly known as crinoline, corset, and hat wire, shall pay four cents per pound in addition to the foregoing rates: *And provided further*, That no article made from iron or steel wire, or of which iron or steel wire is a component part of chief value, shall pay a less rate of duty than the iron or steel wire from which it is made either wholly or in part: *And provided further*, That iron or steel wire-cloths, and iron or steel wire-nattings, made in meshes of any form, shall pay a duty equal in amount to that imposed on iron or steel wire of the same gauge, and two cents per pound in addition thereto. There shall be paid on galvanized iron or steel wire (except fence wire), one half of one cent per pound in addition to the rate imposed on the wire of which it is made. On iron wire rope and wire strand, one cent per pound in addition to the rates imposed on the wire of which it is made. On steel wire rope and wire strand, two cents per pound in addition to the rates imposed on the wire of which it is made.

Steel, not specially enumerated or provided for in this act, forty-five per centum ad valorem: *Provided*, That all metal produced from iron or its ores, which is cast and malleable, of whatever description or form, without regard to the percentage of carbon contained therein, whether produced by cementation, or converted, cast, or made from iron or its ores, by the crucible, Bessemer, pneumatic, Thomas-Gilchrist, basic, Siemens-Martin, or open-hearth process, or by the equivalent of either, or by the combination of two or more of the processes, or their equivalents, or by any fusion or other process which produces from iron or its ores a metal either granular or fibrous in structure, which is cast and malleable, excepting what is known as malleable iron castings, shall be classed and denominated as steel.

No allowance or reduction of duties for partial loss or damage in consequence of rust or of discoloration shall be made upon any description of iron or steel, or upon any partly manufactured article of iron or steel, or upon any manufacture of iron and steel.

Argentine, albata, or German silver, unmanufactured, twenty-five per centum ad valorem.

Copper, imported in the form of ores, two and one-half cents on each pound of fine copper contained therein; regulus of and black or coarse copper, and copper cement, three and one-half cents on each pound of fine copper contained therein; old copper, fit only for remanufacture, clippings from new copper, and all composition metal of which copper is a component material of chief value, not specially enumerated or provided for in this act, three cents per pound; copper in plates, bars, ingots, Chili or other pigs, and in other forms, not manufactured, or enumerated in this act, four cents per pound; in rolled plates, called brazier's copper, sheets, rods, pipes, and copper bottoms, and all manufactures of copper, or of which copper shall be a component of chief value, not specially enumerated or provided for in this act, thirty-five per centum ad valorem.

Brass, in bars or pig, old brass, and clippings from brass or Dutch metal, one and one-half cent per pound.

Lead ore, and lead dross, one and one-half cent per pound.

Lead, in pigs and bars, molten and old refuse lead run into blocks and bars, and old scrap lead, fit only to be remanufactured, two cents per pound.

Lead, in sheets, pipes, or shot, three cents per pound.

Nickel, in ore, matte, or other crude form not ready for consumption in the arts, fifteen cents per pound on the nickel contained therein.

Nickel, nickel oxide, alloy of any kind in which nickel is the element of chief value, fifteen cents per pound.

Zinc, spelter, or tutenegue, in blocks or pigs, and old worn-out zinc, fit only to be remanufactured, one and one-half cent per pound; zinc, spelter, or tutenegue in sheets, two and one-half cents per pound.

Sheathing, or yellow metal, not wholly of copper, nor wholly nor in part of iron, ungalvanized, in sheets, forty-eight inches long and fourteen inches wide, and weighing from fourteen to thirty-four ounces per square foot, thirty-five per centum ad valorem.

Antimony, as regulus or metal, ten per centum ad valorem.

Bronze powder, fifteen per centum ad valorem.

Cutlery, not specially enumerated or provided for in this act, thirty-five per centum ad valorem.

Dutch or bronze metal, in leaf, ten per centum ad valorem.

Steel plates, engraved, stereotype plates, and new types, twenty-five per centum ad valorem.

Gold-leaf, one dollar and fifty cents per package of five hundred leaves.

Hollow-ware, coated, glazed, or tinned, three cents per pound.

Muskets, rifles, and other fire-arms, not specially enumerated or provided for in this act, twenty-five per centum ad valorem.

All sporting breech-loading shot-guns, and pistols of all kinds, thirty-five per centum ad valorem.

Forged shot-gun barrels, rough-bored, ten per centum ad valorem.

Needles for knitting or sewing machines, thirty-five per centum ad valorem.

Needles, sewing, darning, knitting, and all others not specially enumerated or provided for in this act, twenty-five per centum ad valorem.

Pen-knives, pocket-knives, of all kinds, and razors, fifty per centum ad valorem; swords, sword-blades, and side-arms, thirty-five per centum ad valorem.

Pens, metallic, twelve cents per gross; pen-holder-tips and pen-holders, or parts thereof, thirty per centum ad valorem.

Pins, solid-head or other, thirty per centum ad valorem.

Britannia ware, and plated and gilt articles and wares of all kinds, thirty-five per centum ad valorem.

Quicksilver, ten per centum ad valorem.

Silver leaf, seventy-five cents per package of five hundred leaves.

Type-metal, twenty per centum ad valorem.

Chromate of iron, or chromic ore, fifteen per centum ad valorem.

Mineral substances in a crude state and metals unwrought, not specially enumerated or provided for in this act, twenty per centum ad valorem.

Manufactures, articles, or wares, not specially enumerated or provided for in this act, composed wholly or in part of iron, steel, copper, lead, nickel, pewter, tin, zinc, gold, silver, platinum, or any other metal, and whether partly or wholly manufactured, forty-five per centum ad valorem.

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SCHEDULE N.—SUNDRIES.

Alabaster and spar statuary and ornaments, ten per centum ad valorem.

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Beads, and bead ornaments of all kinds, except amber, fifty per centum ad valorem.

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Bouillons, or cannetille, metal threads, filé, or gespinst, twenty-five per centum ad valorem.

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Burrstones, manufactured or bound up into millstones, twenty per centum ad valorem.

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Coal slack or culm, such as will pass through a half-inch screen, thirty cents per ton of twenty-eight bushels, eighty pounds to the bushel.

Coal, bituminous, and shale, seventy-five cents per ton of twenty-eight bushels, eighty pounds to the bushel. A drawback of seventy-five cents per ton shall be allowed on all bituminous coal imported into the United States which is afterwards used for fuel on board of vessels propelled by steam which are engaged in the coasting trade of the United States, or in the trade with foreign countries, to be allowed and paid under such regulations as the Secretary of the Treasury shall prescribe.

Coke, twenty per centum ad valorem.

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Compositions of glass or paste, when not set, ten per centum ad valorem.

Coral, cut, manufactured, or set, twenty-five per centum ad valorem.

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Crayons of all kinds, twenty per centum ad valorem.

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Emery grains and emery manufactured, ground, pulverized, or refined, one cent per pound.

Epaulets, galloons, laces, knots, stars, tassels, and wings, of gold, silver, or other metal, twenty-five per centum ad valorem.

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Finishing powder, twenty per centum ad valorem.

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Friction or lucifer matches of all descriptions, thirty-five per centum ad valorem.

Fulminates, fulminating powders, and all like articles, not specially enumerated or provided for in this act, thirty per centum ad valorem.

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Grindstones, finished or unfinished, one dollar and seventy-five cents per ton.

Gunpowder, and all explosive substances used for mining, blasting, artillery, or sporting purposes, when valued at twenty cents or less per pound, six cents per pound; valued above twenty cents per pound, ten cents per pound.

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Japanned ware of all kinds, not specially enumerated or provided for in this act, forty per centum ad valorem.

Jet, manufactures and imitations of, twenty-five per centum ad valorem.

Jewelry of all kinds, twenty-five per centum ad valorem.

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Lime, ten per centum, ad valorem.

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Marble of all kinds, in block, rough or squared, sixty-five cents per cubic foot; veined marble, sawed, dressed, or otherwise, including marble slabs and marble paving-tiles, one dollar and ten cents per cubic foot.

All manufactures of marble not specially enumerated or provided for in this act, fifty per centum ad valorem.

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Pencils of wood filled with lead or other material and pencils of lead, fifty cents per gross and thirty per centum ad valorem; pencil-leads, not in wood, ten per centum ad valorem.

Percussion caps, forty per centum ad valorem.

Philosophical apparatus and instruments, thirty-five per centum ad valorem.

Pipes, pipe-bowls, and all smokers' articles whatsoever, not specially enumerated or provided for in this act, seventy per centum ad valorem; all common pipes of clay, thirty-five per centum ad valorem.

Plaster of Paris, when ground or calcined, twenty per centum ad valorem.

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Polishing powders of every description, by whatever name known, including Frankfort black, and Berlin, Chinese, fig, and wash blue, twenty per centum ad valorem.

Precious stones of all kinds, ten per centum ad valorem.

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Salt, in bags, sacks, barrels, or other packages, twelve cents per one hundred pounds; in bulk, eight cents per one hundred pounds: *Provided*, That exporters of meats, whether packed or smoked, which have been cured in the United States with imported salt, shall, upon satisfactory proof, under such regulations as the Secretary of the Treasury shall prescribe, that such meats have been cured with imported salt, have refunded to them from the Treasury the duties paid on the salt so used in curing such exported meats, in amounts not less than one hundred dollars: *And provided further*, That imported salt in bond may be used in curing fish taken by vessels licensed to engage in the fisheries, and in curing fish on the shores of the navigable waters of the United States, under such regulations as the Secretary of the Treasury shall prescribe; and upon proof that the salt has been used for either of the purposes stated in this proviso, the duties on the same shall be remitted.

Scagliola, and composition tops for tables or for other articles of furniture, thirty-five per centum ad valorem.

Sealing-wax, twenty per centum ad valorem.

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Stones, unmanufactured or undressed, freestone, granite, sandstone, and all building or monumental stone, except marble, not specially enumerated or provided for in this act, one dollar per ton; and upon stones as above, hewn, dressed, or polished, twenty per centum ad valorem.

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THE FREE LIST.

SEC. 2503. The following articles when imported shall be exempt from duty:

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Guano, manures, and all substances expressly used for manure.

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Agates, unmanufactured.
Apatite.
Asbestus, unmanufactured.
Arsenic.
Antimony ore, crude sulphide of.
Arsenic, sulphide of, or orpiment.
Arseniate of aniline.
Baryta, carbonate or witherite.
Bauxite.
Aniline salts or black salts and black tares.
Bromine.
Cadmium.
Calamine.
Cerium.
Cobalt, as metallic arsenic.
Chalk and cliff-stone, unmanufactured.
Feldspar.
Cryolite or kryolith.
Iridium.
Kieserite.
Kyanite or cyanite, and kainite.

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Lime, chloride of, or bleaching powder.
Magnesium.
Magnesite, or native mineral carbonate of magnesia.
Manganese, oxide and ore of.
Mineral waters, all not artificial.
Osmium.
Palladium.
Paraffine.
Phosphates, crude or native, for fertilizing purposes.
Potash, muriate of.
Plaster of Paris or sulphate of lime, unground.

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Soda, nitrate of, or cubic nitrate.
Strontia, oxide of, and proto-oxide of strontian, and strontianite, or mineral carbonate of strontia.
Sulphur, or brimstone, not specially enumerated or provided for in this act.
Sulphur lac or precipitated.

Tripoli.

Uranium, oxide of, verdigris or subacetate of copper.

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Crude minerals, not advanced in value or condition by refining or grinding, or by other process of manufacture, not specially enumerated or provided for in this act.

SUNDRIES.

Aluminum.

Amber beads and gum.

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Asphaltum and bitumen, crude.

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Articles imported for the use of the United States, provided that the price of the same did not include the duty.

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Barrels of American manufacture, exported filled with domestic petroleum, and returned empty, under such regulations as the Secretary of the Treasury may prescribe, and without requiring the filling of a declaration at time of export of intent to return the same empty.

Articles the growth, produce, and manufacture of the United States, when returned in the same condition as exported. Casks, barrels, carboys, bags, and other vessels of American manufacture, exported filled with American products, or exported empty and returned filled with foreign products, including shooks when returned as barrels or boxes, but proof of the identity of such articles shall be made under regulations to be prescribed by the Secretary of the Treasury; and if any of such articles are subject to internal tax at the time of exportation, such tax shall be proved to have been paid before exportation and not refunded.

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Bells, broken, and bell metal broken and fit only to be remanufactured.

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Bismuth.

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Breccia, in blocks or slabs.

Brine.

Brazil pebbles for spectacles, and pebbles for spectacles rough.

Bullion, gold and silver.

Burgundy pitch.

Burrstone, in blocks, rough or unmanufactured, and not bound up in millstones.

Cabinets of coins, medals, and all other collections of antiquities.

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Coal, anthracite.

Coal-stores of American vessels, but none shall be unloaded.

Cobalt, ore of.

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Coins, gold, silver, and copper.

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Copper, old, taken from the bottom of American vessels compelled by marine disaster to repair in foreign ports.

Copper, when imported for the United States Mint.

Coral, marine, unmanufactured.

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Diamonds, rough or uncut, including glaziers' diamonds.

Diamond dust or bort.

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Emery ore.

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Flint, flints, and ground flint-stones.

Fossils.

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Glass, broken pieces, and old glass which cannot be cut for use, and fit only to be remanufactured.

Glass plate or disks, unwrought, for use in the manufacture of optical instruments.

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Hones and whetstones.

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Jet, unmanufactured.

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Junk, old.

Lava, unmanufactured.

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Lithographic stones, not engraved.

Loadstones.

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Magnets.

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Medals of gold, silver, or copper.

Meerschaum, crude or raw.

Mica and mica waste.

Models of inventions and other improvements in the arts; but no article or articles shall be deemed a model or improvements which can be fitted for use.

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Ores, of gold and silver.

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Pewter and britannia metal, old and fit only to be remanufactured.

Philosophical and scientific apparatus, instruments, and preparations, statuary, casts of marble, bronze, alabaster, or plaster of Paris, paintings, drawings, and etchings, specially imported in good faith for the use of any society or institution incorporated or established for religious, philosophical, educational, scientific, or literary purposes, or encouragement of the fine arts, and not intended for sale.

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Platina, unmanufactured.

Platinum, unmanufactured, and vases, retorts, and other apparatus, vessels, and parts thereof, for chemical uses.

Plumbago.

Polishing-stones.

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Pumice and pumice stone.

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Regalia and gems, statues, statuary, and specimens of sculpture, where specially imported in good faith for the use of any society incorporated or established for philosophical, literary, or religious purposes, or for the encouragement of the fine arts, or for the use or by order of any college, academy, school, seminary of learning, or public library in the United States.

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Rotten stone.

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Shingle-bolts and stave bolts, provided that heading bolts shall be held and construed to be included under the term stave bolts.

Handle-bolts.

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Sodium.

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Specimens of natural history, botany, and mineralogy, when imported for cabinets, or as objects of taste or science, and not for sale.

Spunk.

Spurs and stilts, used in the manufacture of earthen, stone, or crockery ware.

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Sweepings of silver and gold.

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Terra alba, aluminous.

Terra japonica.

Tin ore, bars, blocks, or pigs, grain or granulated.

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Types, old, and fit only to be remanufactured.

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Works of art, painting, statuary, fountains, and other works of art, the production of American artists. But the fact of such production must be verified by the certificate of a consul or minister of the United States indorsed upon the written declaration of the artist; paintings, statuary, fountains, and other works of art, imported expressly for the presentation to national institutions, or to any State, or to any municipal corporation, or religious corporation or society.

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Zaffer.

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SEC. 2507.—Machinery for repair may be imported into the United States without payment of duty, under bond, to be given in double the appraised value thereof, to be withdrawn and exported after said machinery shall have been repaired; and the Secretary of the Treasury is authorized and directed to prescribe such rules and regulations as may be necessary to protect the revenue against fraud, and secure the identity and character of all such importations when again withdrawn and exported, restricting and limiting the export and withdrawal to the same port of entry where imported, and also limiting all bonds to a period of time of not more than six months from the date of the importation.

SEC. 2508.—All paintings, statuary, and photographic pictures imported into the United States for exhibition by any association duly authorized under the laws of the United States, or of any State, for the promotion and encouragement of science, art, or industry, and not intended for sale, shall be admitted free of duty, under such regulations as the Secretary of the Treasury shall prescribe. But bonds shall be given for the payment to the United States of such duties as may be imposed by law upon any and all of such articles as shall not be re-exported within six months after such importation.

SEC. 2509.—All works of art, collections in illustration of the progress of the arts, science, or manufactures, photographs, works in terra-cotta, Parian, pottery, or porcelain, and artistic copies of antiquities in metal or other material, hereafter imported in good faith for permanent exhibition at a fixed place by any society or institution established for the encouragement of the arts or science, and not intended for sale, nor for any other purpose than is hereinbefore expressed, and all such articles, imported as aforesaid, now in bond, and all like articles imported in good faith by any society or association for the purpose of erecting a public monument, and not for sale, shall be admitted free of duty, under such regulations as the Secretary of the Treasury may prescribe: *Provided*, That the parties importing articles as aforesaid shall be required to give bonds, with sufficient sureties, under such rules and regulations as the Secretary of the Treasury may prescribe, for the payment of lawful duties which may accrue should any of the articles aforesaid be sold, transferred, or used contrary to the provisions and intent of this act.

SEC. 2510.—All lumber, timber, hemp, manila, wire rope, and iron and steel rods, bars, spikes, nails, and bolts, and copper and composition metal which may be necessary for the construction and equipment of vessels built in the United States for foreign account and ownership or for the purpose of being employed in the foreign trade, including the trade between the Atlantic and Pacific ports of the United States, after the passage of this act, may be imported in bond under such regulations as the Secretary of the Treasury may prescribe; and upon proof that such materials have been used for such purpose, no duties shall be paid theron. But vessels receiving the benefit of this section shall not be allowed to engage in the coastwise trade of the United States more than two months in any one year, except upon the payment to the United States of the duties on which a rebate is herein allowed: *Provided*, That vessels built in the United States for foreign account and ownership shall not be allowed to engage in the coastwise trade of the United States.

SEC. 2511.—All articles of foreign production needed for the repair of American vessels engaged exclusively in foreign trade may be withdrawn from bonded warehouses free of duty, under such regulations as the Secretary of the Treasury may prescribe.

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SEC. 2513.—There shall be levied, collected, and paid on the importation of all raw or unmanufactured articles, not herein (*a*) enumerated or provided for, a duty of ten per centum ad valorem; and all articles manufactured, in whole or in part, not herein enumerated or provided for, a duty of twenty per centum ad valorem.

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a That is, in the full text of the act.

INDEX.

[For the mineral products of each State and Territory, and for special minerals, consult the lists of minerals beginning on page 667.]