THE GYPSUM INDUSTRY IN OKLAHOMA

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PREFACE

Gypsum has played one of the most important roles in the Oklahoma economy, comparable to other construction minerals, because of its widespread use. It is one of the most commonly utilized minerals in the building trades today because of its versatility. It is also one of the cheapest and most abundant mineral resources in the state, occurring in large and rich formations.

The purpose of this study is to determine the importance of the gypsum industry in Oklahoma. Particular attention is given to the geographic advantages and disadvantages involved in the production, processing, and marketing of the state's gypsum.

A brief introduction is given to the mineral and its uses, and where it is produced in the world. Then the geology of the gypsum bearing deposits in the state is discussed. Special emphasis is paid to the nature and extent of the gypsum, the theories as to its origin, and whether the deposits are being utilized at present.

Unique physical and chemical properties of gypsum are pointed out which largely determine the uses which will be made of the mineral. A description of the companies in operation in the state today follows. Here the emphasis is on the methods of quarrying, processing, and distribution.

The history of gypsum and its application in the lives of ancient people and of those up to the present day are discussed. Uses of gypsum and some of the marketing problems of the mineral are considered.

Finally, the future development of the industry in the state with some national and international aspects are evaluated.

Source material in this thesis was largely obtained by field work, observations and personal interviews. Correspondence as well as government publications, trade periodicals, and other literature that were made available to the library were used. Also certain company pamphlets were supplied for this study.

The writer is especially grateful to Mr. W. Dale Reynolds, Quality Department Superintendent, United States Gypsum Company, Southard, Oklahoma; Mr. P. E. Gorby, Superintendent of the Universal Atlas Cement Company, Watonga; and to Mr. S. A. Walton, owner of S. A. Walton and Sons, Okeene, Oklahoma, for furnishing valuable information about their respective companies. The Cimarron Soil Conservation District office, and Mr. W. W. Nease, head of the Chamber of Commerce, both of Okeene, provided maps and other pertinent information about operations in Blaine County. The staff of the Oklahoma A. and M. College Library, particularly the Document Section, was helpful in securing needed information.

My sincere thanks to the Staff of the Geography Department, especially to Dr. David C. Winslow under whose guidance this study was made, and to Dr. Edward E. Keso, Head of the Department, for the help given me in the preparation of this thesis and in all matters pertaining to my work; and to Professor Ray L. Six of the Geology Department for his suggestions and criticisms on the chapter concerning the geology of the Oklahoma gypsum deposits.

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C.T.H.

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INTRODUCTION

Gypsum is a mineral which has qualities that have long been known to man. The property of gypsum rock which enables it, after losing a part of its water of crystallization in the calcining, or cooking process, to recombine with water and to set or harden into its rock-like state again has been known by man for over 4,000 years. Gypsum is the only known substance that can be restored in this manner to its original rock-like state by the addition of water alone. This important property of gypsum is what determines its uses.

Another important factor, which cannot be overlooked in any evaluation of gypsum, is its widespread occurrence in nature. Gypsum is so abundant in our country that rich deposits of the mineral have been allowed to lie idle because they were isolated from any large center of population or the freight rate to metropolitan areas was prohibitive. Yet during these years some was imported. In 1951, for instance, the United States imported 3,448,000 short tons of gypsum from foreign sources, an all time record.[1] This shows that the economics of gypsum is complicated by competition and transportation conditions.

Being a bulky material it cannot stand the expense of being transported long distances over-land. Consequently, a large company

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[1]Oliver S. North and Nan C. Jensen, "Gypsum," United States Bureau of Mines, Minerals Yearbook (Washington, D. C., 1951), p. 8.

will try not to centralize its activities in any one location with the thought of serving the rest of the nation; but instead, will spread out its operations so as to be better able to compete in price with other local productions in different areas of the country. Large centers of population adjacent to oceans, unless there is a large gypsum deposit within a competitive distance of the city, find it cheaper to import their supplies from foreign sources. The Kaiser Gypsum Company (a subsidiary of the Henry J. Kaiser Corporation) exemplifies this, finding it more profitable to import its gypsum into their West Coast plants from San Marcos Island in the Gulf of California (Mexico) rather than to tap inland deposits of California.[2] The United States Gypsum Company likewise finds it more economical to import gypsum into the New York City area from Nova Scotia in Canada rather than overland from upper New York State.[3]

Uses Of Gypsum

The two qualities of gypsum—its ability to recombine with water and to harden, and its abundance in nature—together with its fire-proofing, soundproofing, verminproofing, and insulating qualities, have long made gypsum a favorite in the building industry. Today over 95 per cent of all gypsum mineral is used for construction purposes.[4]

As it is used in the construction field today, gypsum yields diversified products. It may be ground and calcined to form a plaster

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[2] Ibid., pp. 5-6.

[3] "Building A Better Tomorrow," United States Gypsum Company (Chicago, 1952), p. 29.

[4] Virginia Butcher, "Gypsum," The Hopper, Oklahoma Geological Survey, Vol. II, No. 8, (Norman, August, 1951), p. 72.

for use on the walls and ceilings of private homes. For heavy duty construction, hard-wearing gypsum plasters such as Keene's cement, oil well cements, gauging plasters, and molding plasters, have been developed. One type of gypsum plaster known as Estrich gypsum, is widely used in Germany as a flooring plaster, but it is not produced in Oklahoma.[5] On the other hand, gypsum staff is a product intended for the sole purpose of constructing exposition and fair buildings, massive statues, and paneling. It can be rapidly and economically applied and although lacking in durability, it has long been a favorite in constructing temporary structures.

Gypsum, nevertheless, is not limited in its uses to plaster alone. Prefabricated gypsum products are also widely used in building. [The consumption of gypsum wallboard and laminated board has increased rapidly since the Second World War as a substitute for time-consuming wall plastering. When applied, gypsum wallboard may be easily finished with either wallpaper or paint. Or if trouble is encountered in the selection of the desired color in wallpaper or paint, gypsum wallboard may again solve the problem, for it is available in a form that simulates a ceramic tile wall or that resembles wood paneling.]

Gypsum sheathing is produced as an outdoor covering for houses, and is applied under shingles, stucco or brick veneer. When used with gypsum lath and gypsum wallboard, a completely fireproof wall can be constructed.

Gypsum may be further processed to produce other high-quality products. These include dental plasters, orthopedic plasters, pottery

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[5]Forrest T. Moyer, "Gypsum and Anhydrite," United States Bureau of Mines, Information Circular No. 7049 (Washington, D. C., February, 1939), p. 20.

plasters, plate glass plasters, and many more different kinds of gypsum products.

Gypsum has long been known for its casting qualities. Gypsum art and casting plasters are used to obtain an exact likeness of a clay model and for relief maps and scientific objects. This ancient use of gypsum for casting has been further developed until today we have metal-casting plasters from which precision parts can be produced for use in the automobile, aircraft, and foundry industries.

Raw gypsum that has not been changed by calcination is used in large quantities as a retarder in the set of Portland cement and as a fertilizer for the soil. When used as a fertilizer, it is usually powdered gypsum or land plaster. This variety of gypsum is very popular in the peanut belt of Southern Virginia, the Carolinas, and Georgia, where over 50,000 tons are used annually to improve the quality of the nuts.[6]

Gypsum also serves man in a large number of miscellaneous uses. It oftentimes serves in place of chalk in the manufacture of blackboard "chalk." It is used to create imitation snow scenes on Hollywood movie sets, in the variety called "Terra Alba." It is used as an adulterant in foodstuff and drugs. It is used in paints and as a salt in brewing beer. The variety of gypsum known as alabaster has long been used for sculpturing vases, statues, and other ornamental objects. Gypsum that is very white in color is used as a filler in the manufacture of textiles, buttons, poker chips, phonograph records, blasting powder, insecticides, paper, and a flux for smeltering certain metals.

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[6]Eugene W. Nelson, "The Rock That Nobody Knows," Nature Magazine, Vol. 44, No. 10, (December, 1951), p. 540.

Chief Producers of Gypsum

Gypsum is produced in 46 countries scattered throughout the world; but only in five of these does the annual production exceed 1,000,000 short tons. As Table I indicates, the United States, with a production of about eight million tons, is by far the world's greatest producer and consumer of gypsum.

TABLE I

GYPSUM PRODUCTION BY COUNTRIES, 1951[7]
(In Per Cent)

United States	32
Canada	15
Great Britain	9
France	8
Spain	7
All Others	29
	100

Within the United States, gypsum deposits occur in commercial form in twenty states. These deposits occur in two principal belts. The first belt starts in southwestern Texas and runs north through western Oklahoma, central Kansas, across Iowa, into southern Michigan, then turns south and runs along the northern edge of Ohio and finally into New York State. The second large belt begins in the Imperial Valley of California, and heads north into Nevada, and fans out into Utah. These belts range in width from one mile to 200 miles. So there is little fear that our supply of gypsum will become critical in the near future.

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[7]Based on figures appearing in the Minerals Yearbook (1951), O. S. North and N. C. Jensen, p. 12.

In Oklahoma, alone, deposits in the western part of the state have been estimated at over 125,000,000,000 tons.[8] In terms of actual production, however, as the following Table II would appear to indicate, those states which lead in the production of gypsum are situated near large population centers.

TABLE II

GYPSUM PRODUCTION BY STATES, 1951[9]
(In Per Cent)

Michigan	18
New York	15
Texas	13
Iowa	13
California	13
Nevada	7
Oklahoma	5
All Others	16
	100

Table II shows one of the pecularities of the gypsum industry. The five leading states--Michigan, New York, Texas, Iowa, and California--account for about 72 per cent of the total gypsum produced in the United States in 1951. Yet none of these first five borders on the other. Each respects the natural advantages that the other holds within its market area. New York is the leading producer of the New England and middle Atlantic states; Michigan supplies the needs of the

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[8]Charles N. Gould, "Gypsum," Oklahoma Geological Survey Bulletin No. 5 (Norman, November, 1908), p. 26.

[9]Based on figures appearing in the Minerals Yearbook (1951), O. S. North and N. C. Jensen, p. 12.

north Central states; Iowa fills the requirements of the Middle West; Texas supplies the Southwest; and California producers satisfy the needs of the Pacific Coast states. The important role that its market area and the effects of competition from other states has had on the development of the gypsum industry in Oklahoma will be discussed in more detail at a later time.

CHAPTER II

GEOLOGY OF THE GYPSUM BEARING DEPOSITS IN OKLAHOMA

The western portion of Oklahoma is a broad plain which slopes toward the southeast. In the region underlain by gypsum the streams have cut many canyons, so that while in general the region is a plain, the gypsum area is hilly and is usually considered as a physiographic unit the "Gypsum Hills Region," which separate the Low Plains to the east from the High Plains which lie to the west of the gypsum area.

Generally speaking, all commercial deposits of gypsum occur in this physiographic region which may be divided into three separate areas: the Main Line of Gypsum Hills, the Second Line of Gypsum Hills, and the Greer County Region (sometimes called the Southwestern Region), all of which will be discussed later in more detail.

Geology of the Permian Redbeds

Oklahoma gypsum deposits form part of an area extending almost uninterruptedly from north central Iowa across Kansas, Oklahoma, and Texas to near the Pecos River. The length of the outcrops from southern Nebraska to west-central Texas approximate 600 miles and the width ranges from a few miles to more than 200 miles. The most extensive deposits are in Oklahoma, where the gypsum is interbedded in the Permian Redbeds of the western half of the state.

These Redbeds consist entirely of red shales and sandstones. The red color varies greatly in shade in different horizons and from place to place in the same horizon. In general, however, vermillion and brick reds seem to be more common in the lower formations, in which shales predominate; and deeper reds in the upper formations, in which sandstones are more abundant.

The thickness of the Redbeds is another feature that varies widely from place to place. A conservative estimate of their thickness as expressed from the center of the state to the western boundary would be between 3,000 and 3,500 feet.[1] The greater portion of the Redbeds in Oklahoma are of Permian age and all of the state's gypsum occurs in rocks of that age.[2]

Stratigraphy

In describing the geologic formation of the Oklahoma Redbeds the descriptive titles are those used by Charles N. Gould in "A New Classification of the Permian Redbeds."[3] Although a more recently developed classification is in the making, Gould's 1924 classification is the one that is most widely used in the industry today. For a more detailed discussion of the proposed classification the reader is directed to Green's article (see footnote).[4]

The Blaine gypsum and the Cloud Chief are the two most important

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[1]L. C. Snider, "The Gypsum and Salt of Oklahoma," Oklahoma Geological Survey Bulletin No. 11 (Norman, July, 1913), p. 107.

[2]R. W. Stone et. al., "Gypsum Deposits of the United States," U. S. Geological Survey Bulletin 697 (Washington, D. C., 1920), p. 224.

[3]Charles N. Gould, "A New Classification of the Permian Redbeds," American Association of Petroleum Geologists, Vol. 8, (Chicago, June, 1924), pp. 322-342.

[4]Darcie A. Green, et. al., "Stratigraphy of the Permian in Oklahoma and Kansas," American Association of Petroleum Geologists, Vol. 21, (Chicago, 1937), p. 1553.

formations containing commercial deposits of gypsum, and will be covered in some detail. The Quartermaster, Day Creek dolomite, Whitehouse sandstone, Dog Creek shale, Chickasha formation, Duncan sandstone, and the Enid formation are of less importance and will be covered in much less detail.

The Blaine Gypsum is the great gypsum-bearing formation of the northwestern part of the state. It practically always stands as a pronounced escarpment, as the soft shales bordering it are more easily eroded than are the gypsums. The outcrop of this formation produces the Main Line of Gypsum Hills, which was mentioned earlier, and which is characterized by a very rugged topography.

Outcrops of the Blaine enter the state from Kansas or the south side of the Salt Fork of the Arkansas River and follow down that stream for a few miles, continuing back northwest up the Cimarron River just north of the Kansas Line, and finally down the south side of the Cimarron River and gradually recede from it. The formation is well developed southeast to Watonga but from this point on the gypsum is lenticular until it disappears a few miles north of El Reno, Oklahoma.

Gypsum again appears in outcrops of the Blaine north of Cambridge along the Kiowa County line, crossing back into Kiowa County as it follows the North Fork of the Red River to a point southwest of Carter where it lenses out. Other outcrops at Delphi continue west to the State line and south from Delphi to Jester along Elm Creek to Mangum, then west along the Salt Fork of the Red River to the Texas State line, passing a few miles north of Vinson. South of Reed, on the south side of Salt Fork, the outcrop of the Blaine continues east and south to the north bank of the Red River, at a point north of Odell, Texas, then follows the north side of the Red River west into the Texas Panhandle.

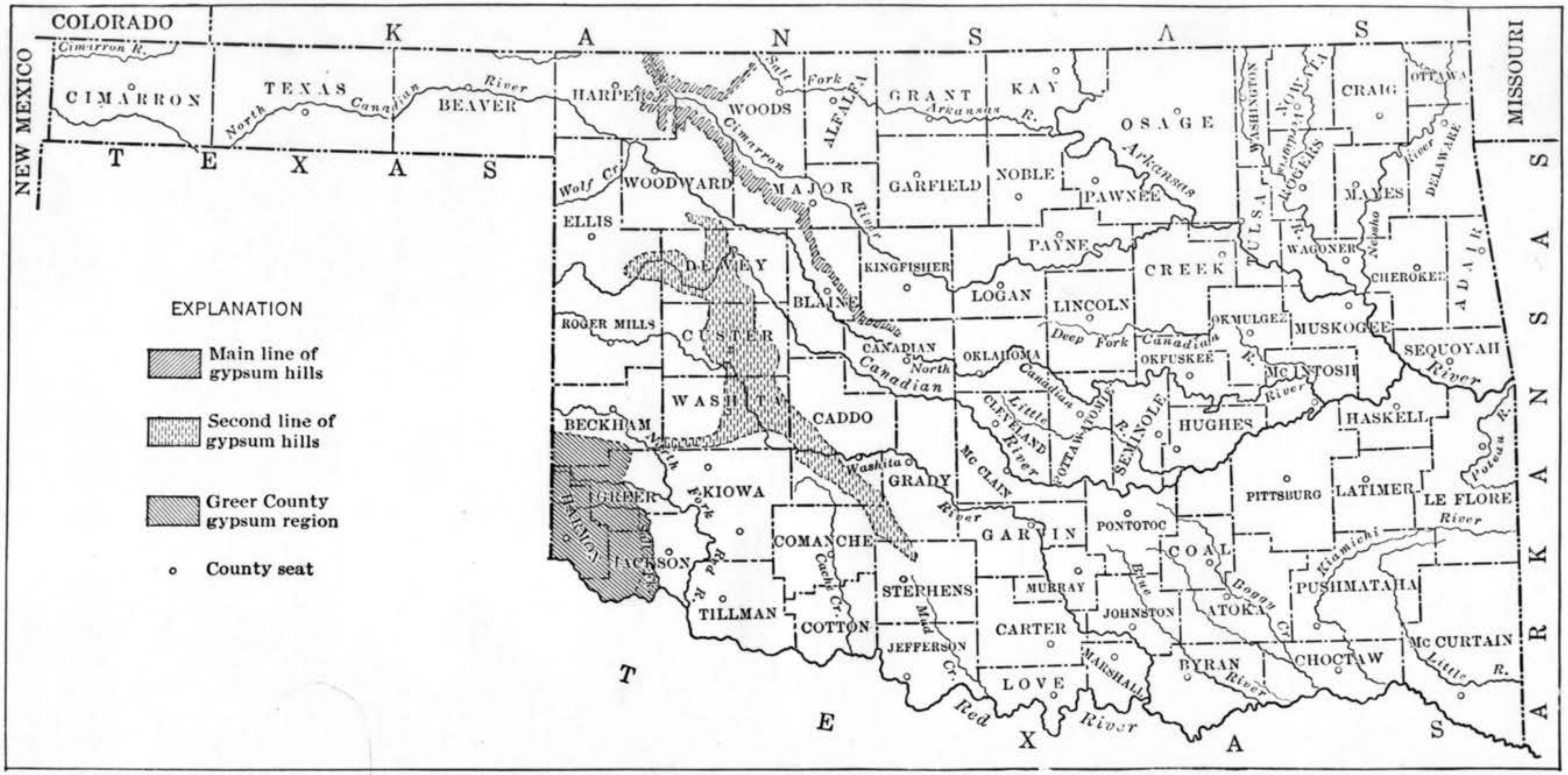

Figure 1. Map showing the location of gypsum deposits in Oklahoma.
(U.S.G.S. Bulletin 697)

This southwestern extension of the Blaine formation, the Greer County Region, occupies parts of Harmon, Greer, Jackson, and Beckham counties. It is unexploited at the present time.

Throughout most of the Blaine formation, from the Kansas State line to Canadian County it is composed of three ledges of massive gypsum, varying up to 18 feet in thickness. In ascending order these gypsums are known as the Ferguson, Medicine Lodge, and Shimer members. The Ferguson which in northwestern Canadian County is the thickest and most prominent of the three members, gradually thins to the north until in the vicinity of the Glass Mountains in Major County it has lost its identify as a ledge, and its place is represented by a gypsiferous band in the red clays. The middle gypsum ledge, the Medicine Lodge, which is the chief cliff-maker of the Gypsum Hills, consists in places of anhydrite. The upper gypsum, the Shimer, is usually less conspicuous than the Medicine Lodge type.

Throughout a large part of the Greer County extension of the Blaine formation, five distinct ledges of gypsum are visible. In ascending order these are: the Chaney, Kaiser, Haystack, Cedartop, and Collingsworth members. In the absence of more definite information, Gould, provisionally correlated the Shimer with the Collingsworth, the Medicine Lodge with the Cedartop, and the Ferguson with the Haystack members of the Blaine. The Chaney gypsum member is the base member of the Blaine formation in the southwestern counties. It is a hard massive ledge, three to five feet thick, and usually white, but sometimes gray or bluish in color. The Chaney is most prominent in the east losing its structure as it progresses west, and finally becomes simply a gypsiferous band in Beckham County.

The Kaiser member is exposed throughout the western area of the Blaine. It is rarely white and in this regard differs from all other ledges of the Blaine formation. It varies from a bluish or greenish tint to a drab or gray color. The Kaiser is very soft and particularly susceptible to weathering, and for this reason it is frequently inconspicuous.

The upper part of the Blaine formation, in this region, consists of three layers of massive gypsum and one of dolomite (the Mangum dolomite), interstratified between beds of red clay shales. The lowermost of these three thicker layers is the Haystack--the third gypsum member from the bottom of the formation. It is composed of massive gypsum, almost pure white or occasionally grayish in places, with a few thin bands of gypsiferous sandstone. This ledge is often cut by joints which divide the rocks into rectangular blocks. These blocks frequently weather out and roll down the slope and in places render it conspicuous for miles by the whiteness of the rock. The Haystack varies from 19 to 25 feet in thickness, and is believed to be the thickest gypsum member of the Blaine in the southwestern area.

The Cedartop is a massive white gypsum, very similar in appearance to the Haystack. It has a constant thickness of 18 to 20 feet throughout the region of outcrop. Very conspicuous in the western part, the Cedartop forms the caps of a number of buttes and bluffs in the region.

The Collingsworth is the upper ledge of the Blaine in this area and is quite similar to the Haystack and the Cedartop in its characteristics. Like them, it is massive and white throughout, and like them, also, it is cut by a series of massive points into rectangular blocks. When exposed, the thickness varies from 18 to 20 feet, being approximately as thick as the Cedartop, and not quite as great as the Haystack.

As it is the upper gypsum member it has often been eroded, and for that reason does not always appear in a region.

The second great gypsum-bearing formation is the Cloud Chief. This formation outcrops in two areas. The eastern area extends from the southeast corner of Woodward County, southeast through Dewey and Custer Counties. From eastern Washita County, the Cloud Chief extends west along the south side of the Washita County line as far as Carter in Beckham County and outlines extend east through southwestern Caddo, Grady, and Stephens Counties. The eastern outlier of the Cloud Chief formation produces a Second Line of Gypsum Hills.

The Cloud Chief consists of red shales and red sandstones with subordinate amounts of gypsum and dolomite. Stratification in this line of hills is erratic and the gypsum ledges are not continuous over large areas as is the case in the first line of gypsum hills. Ledges of gypsum several feet in thickness may pinch out or grade laterally into sandstones in the distance of a few yards. As the result of this stratification the hills in this region differ strikingly from those of the main line of hills (the Blaine formation). Instead of a single bold escarpment with outlying buttes, the hills are a series of rounded knolls usually covered by grass, or a series of long, rounded ridges. Good exposures of any considerable thickness of rock are comparatively rare. The eastern margin of the hills lies from 25 to 50 miles west of the main line. The width of the gypsum outcrop varies from almost 5 to 30 miles.

The Enid formation consists almost entirely of red shales and red sandstones. The upper part is usually gypsiferous where it has come in contact with gypsum ledges. Its average thickness is 1,500 feet and is exposed in all or part of the following counties: Murray, Garvin, Stephens, McClain, Cleveland, Oklahoma, Pottawatomie, Canadian, Logan, Kingfisher, Blaine, Major, Garfield, Noble, Payne, Kay, Grant, Woodward, Alfalfa, Harper, and Woods.

The Duncan Sandstone is a prominent scarp-forming sandstone formation composed of gray to brown sandstone separated by shales varying in thickness from 40 to 200 feet. It is exposed as a narrow zone in Jackson, Greer, Comanche, Caddo, Garvin, Stephens, and McClain counties.

The Chickasha formation is found above the Duncan and is composed of sandstone and sandy shales. It varies in color from a soft purple, greenish, gray in Stephens County to a brick red near the base of the Gypsum Hills further north. These rocks contain considerable amounts of gypsum, usually in the form of satin spar and selenite.

The Dog Creek shale is exposed west of the line of the Blaine gypsum and usually in the same counties. It is composed predominantly of red clay shales (30 to 400 feet thick).

The Whitehorse Sandstone occurs between the Dog Creek shale and the Day Creek dolomite. It consists of red sandstone averaging 200 feet in thickness, which weathers rapidly producing a thick sandy soil.

The Day Creek dolomite occurs as a thin layer averaging between one and five feet in thickness and is often seen capping prominent buttes and hills in Woods, Woodward, Harper, Dewey, Custer, Blaine, Washita, and Caddo counties. It is usually white in color.

The Quartermaster is the upper formation of the Permian as exposed in western Oklahoma. This formation, which has a known thickness of about 300 feet, typically consists of soft, red sandstone and sandy clays and shales.

Gypsum Deposits in Oklahoma by Counties

The gypsum deposits of Oklahoma have been established by Gould to be about 126,300,000,000 tons. This may be broken down by counties as appears in the following table.[5]

TABLE III

ESTIMATED GYPSUM RESERVE OF OKLAHOMA
BY COUNTIES AND BY AREAS

Estimated Reserve by Counties

County	Tons
x Woods	8,000,000,000
x Harper	10,000,000,000
x Woodward	8,000,000,000
x Major	12,000,000,000
x Blaine	2,500,000,000
x Kingfisher	50,000,000
x Canadian	50,000,000
xx Dewey	1,000,000,000
xx Ellis	500,000,000
xx Roger Mills	1,000,000,000
xx Custer	6,000,000,000
xx Washita	20,000,000,000
xx Caddo	3,000,000,000
xx Comanche	200,000,000
xxx Beckham	12,000,000,000
xxx Greer	14,000,000,000
xxx Harmon	15,000,000,000
xxx Jackson	13,000,000,000
	126,300,000,000

Estimated Reserves by Areas

x Main Line of Gypsum Hills	40,600,000,000
xx Second Line of Gypsum Hills	31,700,000,000
xxx Greer County Region	54,000,000,000
	126,300,000,000

[5] Charles N. Gould, "Gypsum," Oklahoma Geological Survey Bulletin No. 5 (Norman, November, 1908), p. 26.

Since all three gypsum operations in the state at present are located within Blaine County in the Main Line of Gypsum Hills, and while it is obvious that other counties and areas have far greater reserves, it becomes apparent that other factors are more important to a successful gypsum operation than large reserves alone. One of the principal factors in the development of the gypsum deposits of Oklahoma has long been the nature of the beds themselves.

Woods County marks the beginning of the Blaine gypsum in northern Oklahoma. The three gypsum members of the Blaine are visible throughout the most of the county; but the absence of lower or in-between beds of shale, which have been carried away by solution, complicates their structure. This removal by ground water has produced numerous sinkholes and caves in the area, the most famous of which are the Alabaster Caverns, often described as a "miniature Carlsbad," because of their resemblance to the great Caverns of New Mexico. Gould has estimated the deposits of gypsum in Woods County to be over 8,000,000,000 tons, but at the present time it is not being utilized.

Crossing the Cimarron River to the south bank, a continuation of the Blaine formation is visible in Harper County. All of the gypsum is selenitic and the effects of solution are quite prominent. The gypsum is well exposed for quarrying and a number of good sites are available along the Cimarron River and Buffalo Creek. Although deposits have been estimated at 10,000,000,000 tons, they are not being utilized at the present time.

Continuing southeast along the south bank of the Cimarron River into Woodward County, the stratigraphy of the Blaine gypsum is practically identical with that found in Woods and Harper counties. The hills are very rugged and the canyons deep and steep-sided. Many peculiar erosional forms have been developed due to the capping of very soft sands and clays by the relatively resistant gypsum. One of the most striking of these is Chimney Butte, a tall slender ghost-like column which was formerly capped with gypsum. Gould's estimate of the total available gypsum is 8,000,000,000 tons and at the present time this source is not being utilized.

Following the Cimarron River through Major County, the outcrop of the Blaine begins to recede away from the stream until at Fairview the foot of the main line of hills is over ten miles from the river. The outcrop is very irregular and is indented by several streams. The presence of anhydrite, which is more resistant than either the gypsum or the shales, help to create a very rugged topography. Numerous sinks, caves, and buttes occur.

Probably the most famous of the latter mentioned is the series of buttes northwest of Fairview, called the Glass Mountains. These are a group of outliers or buttes capped by the Ferguson or by the Medicine Lodge gypsum members where the Ferguson is absent. When sunlight strikes the mountains, it causes the tiny gypsum crystals to glisten, thus giving rise to the name Glass Mountains. At the present time no use is being made of the gypsum deposits although the amount present has been estimated at 12,000,000,000 tons.

As the Blaine gypsum formation turns south away from the Cimarron River, it enters Blaine County. Here the nature of the gypsum has changed from the coarsely crystalline selenitic form (which is their principal feature in the northwest) to a fine-grained dense form, the typical rock gypsum. This form is not as easily dissolved as is the selenitic gypsum. Caves and sinks, while present, are not nearly as well developed as in Major County, where the anhydrite mentioned earlier occurs, reaching its maximum development near the town of Ferguson. The anhydrite accounts for the steep sides of many of the canyon walls. Thick ledges of almost pure white gypsum near the surface, together with extensive gypsite deposits, have led to extensive exploitation of the deposits in Blaine County. At the present time the only three gypsum mills in operation within the state are located near Southard, Watonga, and Okeene in Blaine County. Gypsum deposits in the county have been estimated at 2,500,000,000 tons, a tremendous reserve for exploitation.

The Blaine gypsum continues across the southwestern corner of Kingfisher County. Here the stratification becomes erratic and good exposures are rare. Little attempt has been made to utilize the gypsum deposit of Kingfisher County estimated to be around 50,000,000 tons.

Canadian County marks the southern limit of the Main Line hills. Here the hills are not conspicuous and the slopes are gentle. The outcrop of the gypsum beds becomes discontinuous and the ledges cannot be followed. Deposits have been estimated at about 50,000,000 tons. There is no gypsum quarrying activity in the county at the present time.

The Second Line of Gypsum Hills has its beginning in Woodward County, where the Cloud Chief formation underlies about one township. The deposits are very thin and are of no commercial value at the present. The estimate of probable reserves of 8,000,000,000 tons is mainly based on those deposits in the northeast part of the county in the Blaine formation.

The Cloud Chief continues south into Dewey County where deposits have been estimated at about 1,000,000,000 tons. The gypsum is of good quality and quite abundant, but, the irregularity of its occurrence and the amount of stripping which would be necessary to secure a sufficient supply for a mill for any length of time, renders its development improbable at least as long as there are better deposits more profitably mined elsewhere.

From Dewey County the Cloud Chief branches to the south into Custer County, and to the west into Ellis and Roger Mills Counties. In Ellis County the deposits have been estimated at about 500,000,000 tons and in Roger Mills at 1,000,000,000 tons. Gypsum is exposed along the south bank of the river in Roger Mills County, but it is of no commercial importance.

The Cloud Chief continues into Custer County where the gypsum occurs over the greater part of the county. Many of the beds outcrop near the base of hills or in the bottom of ravines, which detract from their commercial value. Only in the extreme southeastern part of the county are deposits of potential commercial importance. Here in the vicinity of Weatherford ledges up to sixty feet thick occur. There is no development of the gypsum of the county at present, but it is promising. The extent of these deposits have been estimated at 6,000,000,000 tons.

In Washita County the Cloud Chief formation has two areas of expanse; one extending west along the southern line of the county, the other southeast into Caddo County. There are two beds of gypsum in the eastern part of the county. The lower bed outcrops along the Washita River, the upper bed caps the hill along the river. These beds are separated by shales and sandstone, 100-150 feet thick. The gypsum, for the most part, is fine-grain, massive, and pink, with very little selenite occurring. Three beds of white gypsum occur in the western exposure. The lower ledge is composed of very hard gypsum which is largely anhydritic. The second ledge is composed entirely of selenitic gypsum. The upper ledges are entirely white. The gypsum deposits have been estimated at 20,000,000,000 tons, a greater amount than that of any other county in the state, but there is no commercial development.

The southeast extension of the Cloud Chief continues into Caddo County where deposits have been estimated at 3,000,000,000 tons. The ledges are not continuous but the gypsum appears as rounded knobs on the prairie, or as irregular ledges along the sides of streams. The gypsum consists of a mixture of rock gypsum and gypsite. The larger gypsite beds have been largely worked out, and there is no activity now in Caddo County.

The Cloud Chief crosses a small area in the northeast corner of Comanche County, where the deposits have been estimated at 200,000,000 tons. The gypsum is exposed in irregular ledges along the slopes or on top of rounded hills. The deposits in Comanche County are not exploited.

The Cloud Chief formation continues southeast across the northwestern corner of Grady County and into northwestern Stephens County. There it disappears. No rock gypsum deposits occur in either county; however, some gypsite is found in Grady County. There is no commercial production from the deposits in either county.

The last important gypsum-bearing region of the state is the Greer County region. In this region is found a continuation of the Blaine formation and an extension of the Cloud Chief. Although both formations are present in this area it is usually always the Blaine that outcrops appear on the surface. The five distinct ledges, characteristic of the

Blaine formation in this area, are visible throughout much of Beckham, Greer, Harmon, and Jackson counties.

In Beckham County the available gypsum deposits are in the extreme southeastern part. From the southeastern corner a bluff 150 to 200 feet high extends for 10 miles or more up the south side of the North Fork of the Red River. This bluff is made up of red shales with four ledges of massive white gypsums, aggregating about 70 feet in thickness. The estimated amount of gypsum in this bluff alone is 1,000,000,000 tons. Deposits in other parts of the county show an estimated reserve of 12,000,000,000 tons, none of which is being utilized at the present time.

A continuation of the outcrop of the Blaine formation from southern Beckham County enters Greer County along the banks of Elm Creek. All five ledges are usually present and they outcrop on bold bluffs which are ordinarily capped by a thick ledge of dolomite. The presence of dolomite along with the gypsum has created a rugged topography along the line of the outcrop. Hills, buttes, and canyons are common features in this area. Gypsite, as well as gypsum, is present in large quantities. One bed of gypsite, northwest of Mangum, covers about 300 acres and is exposed from four to fourteen feet thick. Gypsum deposits are also numerous giving the county an estimated reserve of 14,000,000,000 tons. The greatest handicap to the utilization of these deposits would be the considerable amount of stripping necessary for any extensive exploitation.

The outcrop of the Blaine formation enters Harmon County along the banks of Elm Creek. Although the entire county is underlain by gypsum, commercial outcrops of the mineral occur only along this

Creek and its tributaries. Since most of Harmon County south of Elm Creek is a level plain with few good exposures of gypsum, it is very doubtful that the county's deposits, estimated at 15,000,000,000 tons, will ever be utilized as long as better deposits are available elsewhere.

The gypsum deposits in Jackson County are located in the western half of the county. Exposures, for the most part, are poor. The only outcrops worthy of mention are along the Salt Fork of the Red River near Olustee, and along Boggy Creek in the vicinity of Creta. Although the deposits in this county have been estimated at 13,000,000,000 tons, only a comparatively small amount is obtainable with excessive stripping or by using underground mining methods. However, what Jackson County lacks in available gypsum, it more than makes up for in its gypsite beds which are among the most important in the state. The largest bed known in the county occurs near Elderado and covers about 400 acres. Another large bed of 375 acres occurs east of Duke, and smaller beds of 75 to 100 acres are common throughout the county.[6] Neither gypsite nor gypsum deposits are being utilized at the present time.

Although gypsum deposits have been reported as occurring in other counties of the state, for the most part they are local in nature and are of no commercial importance. One of the first plaster mills in the state was located at Peckham where it utilized the gypsite deposits of Kay County.

Theories of Origin of Gypsum

Several theories have been advanced to account for the origin of gypsum, all of which are probably applicable to different deposits.

[6] L. C. Snider, "The Gypsum and Salt of Oklahoma," p. 201.

However, conditions which determine whether calcium sulfate will be deposited as gypsum or anhydrite are not fully understood.

Gypsum may be formed by the action of sulfuric acid or soluble sulfates on limestone. Sulfuric acid can be formed by iron pyrites which have become oxidized as a result of falling rain. Should this sulfuric acid come in contact with limestone, which is made up largely of calcium a chemical reaction would take place forming calcium sulfate or gypsum.

Gypsum is formed likewise by sulfurous acid which escapes around the fumaroles of volcanoes or from sulfur springs and which, when it is converted into sulfuric acid, attacks rocks which contain lime.

Anhydrite may be changed into gypsum by taking up water and recrystallizing. In this reaction great pressure is developed, for there is an increase of 33 per cent in volume. The force of the expansion is sufficient to lift a considerable thickness of overlying strata and has been considered to be the cause of the hummocky surface over some gypsum deposits.[7]

In applying the above theory to the Blaine formation at Salt Creek Canyon in Blaine County, Muir in his article on the "Anhydrite Gypsum Problem of Blaine Formation, Oklahoma,"[8] concluded that "The gypsum of the area has formed near the surface by the hydration of anhydrite; that there was no increase in volume when this hydration took place, and that the anhydrite probably was the primary precipitate in a desiccation basin, being deposited in a hot and dry climate."

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[7]R. W. Stone, et. al., "Gypsum Deposits of the United States," p. 26.

[8]J. Lawrence Muir, "Anhydrite-Gypsum Problem of Blaine Formation, Oklahoma," American Association of Petroleum Geologists, Vol. 18, (Chicago, October, 1934), p. 1297.

The White Sands National Monument near Alamogordo in New Mexico offers another good example of how gypsum deposits may be formed. In the dry Tularosa Basin, gypsum-carrying streams from the mountains combine with gypsum-carrying water from underground sources to deposit their sediments on the basin floor. Evaporation is rapid and produces a crust which is disintegrated and blown to eastward by the wind into drifting dunes. The various salts which were carried along with the gypsum in solution are subsequently redissolved, leaving dunes composed of practically pure gypsum.

It is generally believed that most of the important deposits of rock gypsum of the world have been formed by the evaporation of sea water. A scarcity or total absence of fossils in the gypsum-bearing rocks shows that the water in which they were deposited had reached a degree of concentration unfavorable to life. Sea water contains 3.5 per cent of mineral salts in solution. The most abundant salt is sodium chloride, which constitutes more than 77 per cent of the total solids, whereas calcium sulfate constitutes only 3.6 per cent.

Calcium sulfate is not precipitated until about 80 per cent of the water has been evaporated. With these facts in mind, it is difficult to account for the great thickness of some gypsum beds. The quantity of water of normal salinity which would have to be evaporated to make a gypsum deposit 50 or more feet thick is so great that no known ocean basin would hold it. It would require a normally shaped ocean basin covered to a depth of 43,000 feet to precipitate 30 feet of gypsum.[9] Proponents of this theory believe that the body of water that supplied

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[9] R. W. Stone, et. al., "Gypsum Deposits of the United States," p. 22.

the inland sea, and then was cut off from it, had already reached a considerable degree of concentration so that the interior basin would be supplied with highly concentrated waters instead of normal sea water. The greater thickness of a gypsum bed, may also have resulted from currents shifting the unconsolidated gypsum along the bottom.

The most probable theory that would account for Oklahoma's gypsum deposits is that they were formed by the evaporation of water in relatively shallow basins, which at least temporarily had more or less connection with the sea.[10] The presence of marine fossils in the thin dolomites immediately beneath some of the gypsums is proof that there was at least occasional connections with the ocean.

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[10] L. C. Snider, "The Gypsum and Salt of Oklahoma," pp. 21-24.

CHAPTER III

CHEMICAL AND PHYSICAL PROPERTIES OF GYPSUM

Gypsum ($CaSO_4 \cdot 2H_2O$), a hydrate of calcium, is widespread in nature. This mineral, sedimentary in nature, usually occurs in five forms: as rock gypsum, alabaster, selenite, satin spar, and gypsite. All of these occur in Oklahoma and some are widespread in distribution.

Rock gypsum, or as it is sometimes called amorphous gypsum or massive gypsum, is the form of the mineral which is most commonly found in Oklahoma, and which is of the greatest economic value. It is white as it occurs in nature, but may be altered by impurities to produce tints of blue, red, green, and other colors. The color may be evenly distributed, banded, or mottled in the rock. In this state deposits occur of high quality and beds up to 60 feet in thickness are known. This thickness is even exceeded in other regions.[1]

Gypsum, when it is pure, contains 32.5 per cent of calcium oxide and 42.6 per cent of sulfur trioxide. It also contains 20.9 per cent water. In the following table (Table IV) a sample of gypsum taken from Southard shows the comparison between pure gypsum and gypsum as it is commonly found in nature.

The impurities (iron and aluminum oxides and silica and insoluble residue) found in the Southard sample, are not necessarily the impurities

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[1]L. C. Snider, "The Gypsum and Salt of Oklahoma," Oklahoma Geological Survey Bulletin No. 11 (Norman, July, 1913), p. 5.

TABLE IV

PRINCIPAL ELEMENTS IN GYPSUM
(In Per Cent of Weight)

	Pure Gypsum[2]	Sample taken from Southard, Oklahoma[3]
Calcium oxide (CaO)	32.5	32.27
Sulfur trioxide (SO_3)	46.6	45.30
Water (H_2O)	20.9	20.07
Iron and aluminum oxides (Fe_2O_3) (Al_2O_3)		0.21
Silica and insoluble residue (SiO_2, etc.)		0.24

that would be found in other samples taken from different localities. Elsewhere the impurities may be sodium chloride (common salt) or magnesium oxide or any number of other elements.

Alabaster is a type of very fine-grained rock gypsum. It is pure white in color but may be stained, by impurities, blue, pink, and other colors. Alabaster is very soft and may be easily carved into vases, statues, and other artistic objects which is done to sell to tourists. Near Freedom, Oklahoma, in Woods County, it has created a natural wonder, the "Alabaster Caverns." This feature is so unusual that it has been set aside as a State Park.

The name alabaster is also given to other minerals of different chemical makeup. Although not widely referred to as such today, in

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[2]George I. Adams, _et. al._, "Gypsum Deposits in the United States," _U. S. Geological Survey Bulletin 223_, Department of Interior (Washington, D. D., 1904), p. 12.

[3]Raymond B. Ladoo and W. M. Meyers, _Nonmetallic Minerals_, Second Edition (New York, 1951), p. 260.

ancient times the word alabaster was also used to refer to cave onyx and marble. Oriental alabaster, or cave onyx, as it is called today, is a carbonate of lime, made and formed as stalactites and stalagmites in caves.

Selenite and rock gypsum both are found in crystalline form distinguishable on the basis of the size of the crystals in each. If the individual crystals are too small to be observed by the unaided eye it is called rock gypsum. If the crystals are large enough to be discerned by the human eye, it is called selenite.[4] Selenite is often mistaken for mica but a simple test determines the difference. If a thin sheet of mica is bent it will return to its original form once the pressure has been removed. Selenite, on the other hand, shows very little elasticity, and will retain the new form in which it has been bent.

Selenite crystals are clear and transparent and often reach tremendous proportions. One large crystal recovered from a mine in Chihuahua, Mexico, was as long and as heavy as a man.[5] Crystals six to eight inches in length are common.

Satin spar is a crystalline variety of gypsum made up of needle-like fibers which may be very beautiful. The fine fibers lay parallel to one another, and are packed so closely together that the mass usually takes on a white satiny appearance. Satin spar occurs in thin veins, seldom over three or four inches thick, in shales, or other rocks associated with massive gypsum deposits. These veins are believed to have been deposited by the evaporation of gypsiferous water from the

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[4]L. C. Snider, "The Gypsum and Salt of Oklahoma," pp. 5-6.

[5]"A Natural Rock Flower," Science, new series supplement, Vol. 68 (July 13, 1928), p. 12.

surface of the slopes below the gypsum beds. In Oklahoma, satin spar is of very little commercial value by itself since it is found in such small deposits as to be unprofitable to process.

Gypsite is an impure variety of gypsum developed at the surface by the evaporation of gypsiferous water. It is sometimes called gypsum earth or gypsum dirt, which fairly well describes its very loose consolidation and gray, creamy, rusty, pink, and red color. The color is due largely to the other materials which have been mixed in with the gypsum—clay and sand, etc., and oftentimes it is so perfectly blended into the surrounding materials that it is hard to distinguish the gypsite. Its calcium sulfate content varies from 50 to 75 per cent which finds wide usage in the plaster industry. Although gypsite beds cover only a few acres in extent, Oklahoma is fortunate in having many large deposits. One of the largest beds, near Eldorado in Jackson County, averages about 12 feet thick and covers over 400 acres. Smaller beds occur throughout the gypsum-bearing areas of the state.

Anhydrite is a distinct mineral and cannot be considered as a form of gypsum, and for this reason was omitted from the descriptions above. However, it is so closely associated with gypsum in nature as well as chemically that it is often considered in this connection in any discussion of gypsum. Anhydrite is calcium sulfate, $CaSO_4$. Gypsum is calcium sulfate with the water of crystallization, $CaSO_4 \cdot 2H_2O$. Both are calcium sulfates, but the anhydrite does not have the water of crystallization and is referred to as anhydrous calcium sulfate or anhydrite.

In the field, gypsum is readily distinguished from anhydrite by the difference in hardness. For example, the crystalline form of gypsum, selenite, is the standard for the second degree (hardness 2) in the Moh's scale of hardness. It is so soft it can be scratched with the fingernail. In contrast, anhydrite has a hardness of 3.

Another method used to distinguish between the two is by ocular observation of the effects of weathering. The weathering of anhydrite is very different from that of selenite, for it remains hard and white instead of breaking down to a soft weathered powder as gypsum does. The surface of a weathered block of anhydrite is usually rough, being covered with innumerable pits and separated by thin sharp ridges. This difference of gypsum having water of crystallization while anhydrite does not is significant in the use of the two minerals, and will be discussed later.

Physical Properties

Gypsum owes its economic importance as a mineral to its property, after being calcined or heated, to unite with water and to set or harden again. When water is added to the powdered gypsum, it makes a mortar, or a pliable mass that can be formed into any desired shape and hardened, retaining the shape given it while still pliable. This substance, plaster of Paris, becomes a hard, rock-like mass because it has been transformed back again into the rock form it was before it was heated. Gypsum is the only known substance that can be restored in this way to its original rock-like state by the addition of water alone.

By controlling the amount of temperature and time in the calcining of gypsum, it is possible to produce a plaster of almost any specifications. By calcining at a low temperature a stucco, or plaster of Paris, can be produced that will set in 6 to 10 minutes.[6] By calcining

[6] R. B. Ladoo and W. M. Meyers, Nonmetallic Minerals, p. 267.

at a high temperature it is possible to produce a hydraulic plaster which when set will have a compressive strength of 1.6 gross tons per square foot.[7]

A unique property of stucco plaster is its ability to expand sharply just before taking its final set. This quality is especially desirable in the making of casts of clay or other models where an exact likeness is desired. Just as the stucco takes its final set and expands, every minute crack and crevice is filled leaving an exact likeness of the original.

Aside from the control of temperature and time in producing a fast setting stucco plaster or slow setting hydraulic plaster, the set can further be controlled by the use of retarders and accelerators. By the use of retarder substances such as glue, glycerin, flour, blood, and sugar (hoof meal or low grade of hair, caustic soda, and lime, is the most common combination of ingredients used in the United States) it is possible to slow the setting time of plaster. By using potassium sulfate, alum, or common salt the set may be accelerated to a matter of a few minutes.

To review the physical properties and characteristics that have made gypsum the desired mineral that it is today we would have to list:

1. Power to recombine with water to form a hard non-crystalline mass. This quality first brought gypsum to man's attention.
2. Ease and dependability in which the setting time of gypsum can be controlled by calcining, and through the use of

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[7]Robert Grimshaw, "Industrial Applications of Gypsum - II," Scientific American Supplement, Vol. 95, (October 6, 1906), p. 25719.

retarders and accelerators. This versatility has won for gypsum the trust and respect of men in the construction field.

3. Products of gypsum simplify construction needs by incorporating the good qualities of lumber (it can be sawed, planed, and nailed) with the more permanent features of cement. Gypsum products are soundproof, fireproof, and verminproof.

4. Abundance of gypsum in nature leads to a great demand in the construction field where a cheap material is needed, and in a large number of industrial uses where an economical substance is required as a filler in such products as paints, paper, foodstuffs, drugs, poker chips, phonograph records, and many other similar products.

Truly, gypsum is a "white magic" mineral, versatile in its qualities and use.

CHAPTER IV

GYPSUM COMPANIES IN OPERATION IN OKLAHOMA

At the present time, there are three gypsum companies operating in Oklahoma: the United States Gypsum Company at Southard, Universal Atlas Cement Company at Watonga, and S. A. Walton and Sons at Okeene. All of these establishments are in Blaine County in the western part of the state.

As the figures in Table V indicate, the largest producer is the United States Gypsum Company's plant at Southard; during the last five years (1949-1953) this plant accounted for 77 per cent of the total gypsum produced in Oklahoma.[1]

The second most important operation is the Universal Atlas Cement Company's plant near Watonga. In the same five-year period this company produced about 21 1/2 per cent of the state's total production.

The S. A. Walton and Son quarry near Okeene is the only other commercial producer of gypsum at the present time. This operation accounted for approximately 1 1/2 per cent of the total gypsum produced in Oklahoma.

The United States Gypsum Company

The United States Gypsum Company purchases the site at Southard from G. H. Southard and family in the autumn of 1912.[2] Since then, the

[1]Based on figures appearing in Table V.

[2]"Southard is Special" Gypsum News, United States Gypsum Company (Chicago, July, 1953), p. 2.

TABLE V

PRESENT GYPSUM OPERATIONS IN OKLAHOMA*

Name of Company	No. men worked	No. days worked	Total tons produced
1953			
United States Gypsum Co.	53	284	237,648
Universal Atlas Cement Co.	10	127	82,097
Walton and Sons	6	94	3,706
	69	505	323,451
1952			
United States Gypsum Co.	54	283	276,016
Universal Atlas Cement Co.	11	129	77,605
Walton and Sons	5	89	6,050
	70	501	359,671
1951			
United States Gypsum Co.	73	308	320,922
Universal Atlas Cement Co.	10	147	85,572
Walton and Sons	4	160	7,200
	87	615	413,694
1950			
United States Gypsum Co.	54	307	269,027
Universal Atlas Co.	12	112	65,419
Walton and Sons	4	109	5,300
	70	528	339,746
1949			
United States Gypsum Co.	55	300	262,175
Universal Atlas Cement Co.	14	200	84,415
Walton and Sons	4	123	9,000
	73	623	355,590

*Forty-fifth Annual Report of Mines and Mining in Oklahoma, Department of Chief Mine Inspector (1953), p. 14.

plant has been enlarged several times until at present it is one of the most well-integrated operations in the Southwest, producing approximately 130 to 140 different products. These include: gypsum board, wall plasters, special plasters, industrial fillers, and many other calcined and raw gypsum products.

The importance of this establishment to Oklahoma can be evaluated in another way. At Southard the Company provides year-round work in an area of limited industrial employment, for some 300 people from Blaine County. It has an annual payroll of about $1,000,000.[3]

Quarrying

The production of gypsum products consists primarily of two operations, the quarrying of the raw material, and the processing into finished gypsum items. The first operation is quite simple while the second is more complex.

Although open pit quarrying is the present technique being followed at Southard, some of the work does approach shelf mining. Underground mining formerly was practiced, but now it is cheaper to take off the overburden and cut out the layers of gypsum. Since open cut development is much more economical than underground mining methods, it is doubtful whether the latter will ever be utilized to any extent in Oklahoma as long as there are areas where profitable stripping can be practiced.

The stripping process consists in removing the overburden comprised of rock, soil and vegetation, to expose the gypsum ledge. In the Southard area the three ledges of the Blaine formation are exposed in horizontal layers. The overburden covering the Shimer gypsum ledge averages between 20 to 40 feet in depth. Overburden covering the second ledge, the Medicine Lodge, averages 20 to 30 feet. At the

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[3] W. Dale Reynolds, Quality Department Superintendent, United States Gypsum Company, Southard, Oklahoma, Personal Interview, (July 13, 1954).

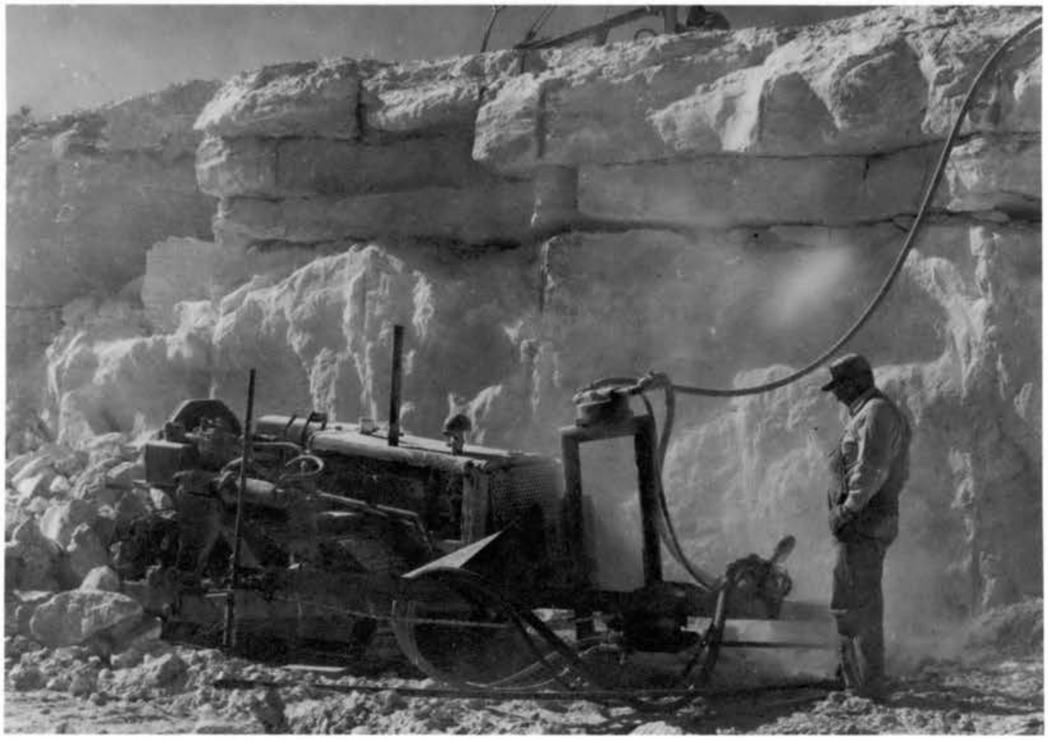

Figure 2. Drilling Operation on Gypsum Ledge
(Courtesy of United States Gypsum Company)

Figure 3. Loading Rock Gypsum at the Quarry
(Courtesy United States Gypsum Company)

present time it is not economically feasible to continue operations to the bottom-most ledge (the Ferguson) because of the amount of overburden and difficulty of its removal. A poorer quality of gypsum also prevails in the lower ledge.

Stripping may be accomplished by the use of any number of different earth-moving machines. The ones most commonly in operation include bulldozers, carry-alls, concrete rippers, and shovels. A dragline, operated on natural gas, is used occasionally but has proved uneconomical to operate. Much of the mobile equipment is on tracks to facilitate movement through loose materials.

After the overburden has been removed, the gypsum rock strata are revealed. Holes for primary blasting are drilled into the rock by compressed air drills. This is done to the full depth of the bench in a line parallel to and at a distance of about 20 feet back from the face of the rock wall opening on the pit. Dynamite is then used to blow out the lump gypsum. Additional small charges are utilized when necessary to reduce the size of the largest rocks.

The material is then loaded by hand or mechanically by shovel for transportation to the mill, about two miles distant. In the Keene's quarry the loading operation is done by hand because of the necessity of selecting high quality rock to maintain a pure product suitable for filling drugs and foodstuffs, etc. The lump Keene's rock as it is called, is loaded into Dempster dumpsters which are later picked up by specially equipped trucks and carried to the mill.

The lower grade of rock is referred to as dark rock, and contains about two or three per cent more impurities than does the lump Keene's rock. Since it is not necessary to sort this material by hand, large diesel shovels (Bucyrus Erie, 54-B), equipped with two and one-half yard scoop shovels are employed. At the present time the Southard plant has two such shovels, one of them is reported to be the largest in capacity of any within the state today.[4]

After the so-called dark rock has been quarried, sometimes it is necessary to break it up with dynamite. The material is loaded into nine ton dump trucks and hauled to the mill.

Processing

The first step in the processing of the gypsum is to crush the rocks into smaller material about 1 1/2 inches or smaller in size. The crushers can accommodate a piece of rock as large as 42 by 48 inches. After crushing, the rock is stored in one of two large siloes capable of holding 3500 tons each. The lump Keene's rock is run through the crusher at one time and is stored separately in one silo; the dark rock is run through the crusher separately and is stored in the other silo.

The fine slack material which results is collected at the bottom of the crusher. It is waste material so that it is screened and sold to farmers for use as land plaster, a fertilizer-amendment.

The crushed matter is now ready to be sent to the plant proper. From the siloes the gypsum rock is transported by means of a large rubber conveyor belt to the top of the plant structure where it is dumped into mills to be further reduced in size.

Dark rock is dumped directly into a large Raymond mill where it is reground. The lump Keene's rock is carried to the buhr mills, where large granite wheels grind the gypsum rock very fine.

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[4]W. D. Reynolds, Personal Interview, (July 13, 1954).

To this point in processing, little trouble is experienced in conveying and elevating the crude gypsum. Now, as the finely ground product leaves the grinding mill it is very soft and powdery. Hence, it must be transported by screw-conveyors, which run within close-fitting pipes, to an air separator and screen. The material is now ready for the calcining kettles. There are five such kettles at the Southard plant, each having a capacity of fifteen tons of finished material.

When the gypsum is heated it gains steadily in temperature until it reaches about 250° F., at which point the gypsum appears to boil vigorously and to rapidly give off steam. This apparent boiling is caused partly by the mechanical agitation of the "rabble arms" (long metal bars inside the kettle which constantly stir the mixture), but chiefly by the release of the water of crystallization in the form of steam which, as it escapes upward, tends to float the finer particles of gypsum.

The temperature remains about the same until the boiling becomes more subdued, then it rises at an increasing rate. Between 300° and 330° the boiling action ceases, little or no steam is given off, and the contents of the kettle have settled to 10 to 14 per cent less than the original volume. This quiet period indicates that most of the gypsum particles are dehydrated to the hemihydrate condition ($2CaSO_4 \cdot H_2O$). Heating is continued until the contents of the kettle register about 350° F. At this point a gate near the bottom of the kettle is opened and the calcined gypsum flows rapidly into the hot pit where it is allowed to cool.

At this stage the material that is intended to be used as wall plaster is conveyed to the tube mills to be further pulverized. The tube mill is merely a large cylindrical steel shell with a number of plastic balls inside. As the tube mill revolves on its side the plastic balls grind the calcined gypsum into an unusually fine powder.

The product that is thus obtained has an increased bulk, plasticity, and sand-carrying capacity. Practically all wall plasters are ground in the tube mills, however, calcined gypsum intended for use in wall-board, block, gauging or other type of specialty plasters usually are not run through this process.

It is interesting to note that this greater bulk, produced by the tube milling was to leave a lasting mark on much of the entire line of United States Gypsum Company products. This was because the standard 100 pound burlap bags proved to be too short to contain the increased bulk of the plaster, and it was necessary to sew a red strip of material on the tops of the bags. This red top distinguished these products to the trade. So it was that the trade mark Red Top was introduced, then patented, and later it was to become one of the most famous of all the Company's brand names.[5]

From the tube mill the material is elevated and once again run through an air separator and screen. The portion passing through the screens is conveyed to the bins over the mixers, while the coarser material is reground. In the bins a retarder and a substance such as wood fiber is added, the latter to increase the "body" and the strength of the finished product. The material is then passed to mixers and fed into sacks holding 100 pounds each. The product is then ready to be used as wall plaster, or in most of the common uses of calcined gypsum, or it may be transported to the gypsum board fabrication building.

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[5]W. D. Reynolds, Personal Interview, (July 13, 1954).

At the board plant the calcined gypsum is mixed with water, paper fiber, and an accelerator of set. Oftentimes raw gypsum is added. The mixture is then poured between two continuous sheets of heavy, coarse paper. As the embryo board moves mechanically up the line it is glued, folded, pressed, stamped with the plant identification number, and cut to desired size.

The board is then fed into a gas drying kiln, about three hundred feet long. The dried board is then ready to be cut in short lengths, bound together, labeled, and shipped to building material dealers. It is noteworthy that practically no board is stored but is immediately shipped.

Certain special plasters are prepared by a different method than that previously described. In the Hydrocal plant at Southard gypsum rock of two inch lump size is placed in a closed cylinder or autoclave (sometimes called "digester") to which steam is applied. No agitation is required, and as the temperature rises the water of crystallization in the gypsum is eliminated, producing the equivalent of a hemihydrate. Calcination is completed at a temperature of around 250° F.

The calcined material is then dryed, ground, passed through an air separator and screened. The finished product, marketed as "Hydrocal," possesses properties that are different from other plasters. When mixed with water to produce a smooth-flowing plaster, it is apparent that far less water is required than is ordinarily added to the usual plasters. With plasters this is important because the less water that is required the greater the strength of the end product. Hence, the finished material is said to have super strength. It is widely used for orthopedic plasters, dental plasters, and oil well cements.

A so-called super oil well type, made at Southard, is unusually quick hardening and of superior strength. It is known as "Hydromite." Resins and other ingredients are added in a secret process. The plant has the distinction of being the only one in the world producing this specialized product.

Another important operation at the Southard plant is the Keene's mill. Here the lump Keene's rock is loaded into beehive kilns which are sealed and cooked for three days at a temperature of 1200° F. The resultant material is then run through a pot crusher where it is finely ground. The product is then passed through an air separator and screened, and finally deposited in a storage bin until needed.

The intense heat in the beehive kilns completely dehydrates the gypsum and produces an anhydrous calcium sulfate. This anhydrite does not possess the property to recombine with water and set again as gypsum does; but when finely ground and mixed with certain accelerators, such as borax, alum, or other sulfates, it will set slowly. This product is known as Keene's cement. It is widely used where strong, durable plasters are required; and as industrial fillers in paints, paper, toothpaste, candy, and other such products.

Throughout the production of finished products at Southard, an interesting phase to watch is the various testing to which the materials are subjected at different stages in their preparation. Separate quality laboratories are set up in the different plants to test the amount of time it takes plaster to set; whether its tensile strength and compressive strength are up to required specifications; and other similar tests that guarantee the quality of the company's products. Samples are taken of each batch of material to have a permanent record and to recheck in case a complaint comes from customers.

Employment at Southard

The employment situation at Southard is another healthy feature of the company's operation. Since there are no pronounced seasonal peaks, work is relatively steady throughout the year. Most of the employees work a forty or forty-eight hour week.[6] The board plant is the only operation that continues on Sunday and it closes every three or four weeks for about sixteen hours to allow for maintenance work on the machines. All processing in this plant continues round the clock.

Transportation at Southard

Adequate transportation is available to the Southard plant through a short spur which connects with the main line of the Frisco Railroad. Special flat cars as well as regular box cars are utilized. Twenty-five carloadings are made each day. Materials brought in are practically limited to paper for wallboard, additives for use as retarders and accelerators in controlling the set of gypsum plasters, some paints, shellacs, printing inks, and office supplies.[7]

The Community of Southard

The community of Southard is another company-owned enterprise. The store and hotel-restaurant are leased to private individuals, following company policy. The residential area comprises 107 houses which are usually rented to employees at nominal rates, although a few of them are privately owned. Many of homes do not have bathrooms, but water and lights are ubitiquous. The village claims two distinctions in that there is thought to be more television sets per capita in the

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[6]W. D. Reynolds, Personal Interview, (July 13, 1954).

[7]W. D. Reynolds, Personal Interview, (July 13, 1954).

town than anywhere else in the state and that it is the only completely paved community in the vicinity.[8]

Water is furnished from a 100,000 gallon water tank located nearby. The supply is obtained from underground wells and is quite adequate for community needs except during periods of prolonged drought when rationing is necessary.

A modern brick building furnishes educational facilities for about 130 children with grades from one to twelve being taught. A number of teachers are employed.

For recreation, a community building is available. It serves for the usual social activities and is also used for Sunday School. Tennis courts, playgrounds, and softball diamonds are available. Even a six hole golf course is under construction. The community is proud of its Boy Scout troop.[9]

The Universal Atlas Cement Company

The Universal Atlas Cement Company near Watonga began operations on their present site April 10, 1925. A subsidiary of United States Steel Corporation, the plant's most important function is to supply company-owned cement plants, as well as a number of independent cement companies, with raw gypsum for use as retarder in the manufacture of Portland cement.

The company's quarry is located about eight miles north of Watonga at Bucher, a stop on the Rock Island Railroad. Over the railway raw gypsum is shipped to Universal Atlas Cement Company plants in Kansas,

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[8] W. D. Reynolds, Personal Interview, (July 13, 1954).

[9] "Southard is Special," pp. 4-6.

Missouri, Texas, Indiana, Minnesota, Pennsylvania, and Alabama; as well as to independent cement producers in Oklahoma, Kansas, and Missouri.[10]

The methods that are used to quarry the gypsum deposits are quite similar to those employed at Southard. Although all three gypsum ledges of the Blaine formation are present, it has been considered economically feasible to utilize only the top layer. The ledge ranges from four to eighteen feet thick, but averages about twelve feet.[11]

The overburden, which averages about ten feet thick, is removed by bulldozer after loosening by a cement-breaking ripper. When the underlying ledge has been exposed, holes are then made with churn drills, dynamite charges set, and large pieces of the face of the ledge are blasted off.

The broken material is then loaded by a one-yard shovel (Marion 43-B) into waiting trucks. Two 9 yard trucks and two five yard trucks are in operation to transport the gypsum about three-fourths of a mile to the primary crusher building. Here the rock is crushed and conveyed to the main processing plant for additional crushing and screening. Conveyors then move the gypsum to different loading platforms where it is dropped into railroad dump cars for shipment.

Prior to 1947, push cars were in use to transport the broken rock, but at the present time the entire operation is done mechanically. The company holdings comprise 680 acres and the operation gives employment to ten men and one woman.

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[10]P. E. Gorby, Superintendent, Universal Atlas Cement Company, Watonga, Oklahoma, Personal Interview, (July 13, 1954).

[11]"Marion One Yard Machine Handles Entire Production at Oklahoma Gypsum Quarry," The Marion Groundhog, Vol. 25, No. 6, Marion Power Shovel Company (Marion, Ohio, December, 1952), p. 11.

Figure 4. Secondary crushing and screening plant is shown here. Loading platforms drop gypsum into cars. (Courtesy of Universal Atlas Cement Company)

The S. A. Walton and Sons Mill

The S. A. Walton and Sons mill is located about nine miles southwest of Okeene on the Frisco Railroad on the same line that serves the United States Gypsum Company at Southard. The tracks pass diagonally across the western portion of the 320 acre farm, belonging to S. A. Walton. He has his home here and farms the land as well as quarrying from it. He has leased an additional 40 acres from his brother to farm. Purchases in 1913 from the Okeene Gypsum Mill Company, the first thirty-five years it was only farmed. Not until 1948 was gypsum again produced on a commercial scale. In that year, working only four days Walton produced ninety tons.[12]

Since that time the production of the company has climbed to the point where on the average about 150 railroad cars (each car averaging about 50 tons) are loaded and shipped out annually.

The entire production at the present time is shipped to the Dewey Cement Company at Dewey, Oklahoma, for use as a retarder in the set of Portland cement.[13] However, the operation does show signs of expanding, and at the present time Walton is conducting experiments to determine the effects of gypsum land plaster on Oklahoma soils. Mr. Walton has furnished agricultural gypsum to farmers in Cherokee and Guthrie as well as in Blaine County with which to experiment on their farms. Results are not always reported, but this probably is because of the length of time, sometimes two or three years, that is often necessary before any marked improvement in the soils and crop yield are noticed.

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[12] S. A. Walton, owner, S. A. Walton and Sons, Okeene, Oklahoma, Personal Interview, (July 13, 1954).

[13] S. A. Walton, Personal Interview, (July 13, 1954).

The Walton operation consists in quarrying the rock gypsum, crushing it, and loading it into cars. The finer material, while suitable for agricultural purposes, is a natural waster by-product of the crushing and cleaning processes. Thus it appears that there would be little added capital necessary for this operation to produce high-quality land plaster, if and when the need for this material arises.

CHAPTER V

HISTORY OF GYPSUM

Since earliest times man has known gypsum and how to make use of it. First mention of its application was made by Herodotus, who found the ancient Ethiopians employing gypsum as a means of preserving their dead. First the gypsum rock would be burned and then applied as a watered mixture to the dried body, thus creating a solid covering of the body retaining its human form. Upon hardening, the plastered body surface would be painted and in this condition preserved for posterity.

The ancient Egyptians utilized gypsum for mortar in building their pyramids. Many of these great monuments are still standing today in an almost perfect state of preservation, after having withstood the harsh attacks of sun, wind, and sand for many thousands of years. The great Pyramid of Cheops was built with mortar composed of 83 per cent gypsum.[1]

The Greeks also used gypsum extensively. One transparent mica-like form of gypsum was placed in their temple windows. When it was noticed how the sun would shine through this material and grace the altars with the effect of moonlight, they decided to honor the mineral substance by naming it after the Moon Goddess, Selene. Today the mineralogical term for this particular variety of gypsum is selenite. Later, selenite was also adopted by the early Christians as the symbol

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[1]Marco Pedrotti, "Gypsum and Its Utilization," Scientific American Supplement, Vol. 96, (February 23, 1907), p. 26033.

of purity and chastity. It was used particularly to decorate statues of the Blessed Virgin Mary.

Another ancient use of gypsum is recorded by Pliny the Elder (23 - 79 A.D.), who credits Sysistrates of Sicyon with using it in the production of casts. Sysistrates was the first man to take a cast of a human face in plaster, and by pouring wax into the mold, obtain an exact reproduction. This technique was widely copied, and still is followed.

Alabaster also dates back to ancient times where we find it being used then, much as it is today, for carving and sculpturing vases and statues, and for the ornamentation of buildings. Fine sculpturing, using alabaster or plaster of Paris, was later developed as a great art in Italy by men such as Margaritono and Nani. The name alabaster, however, was applied to marble and onyx as well as gypsum by the ancients and it is often difficult to tell which was meant.[2]

Proof of gypsum being applied as mortar in northern Europe dates back to the fourteenth and fifteenth centuries. In Germany, buildings are still standing in which gypsum mortar was used more than five hundred years ago.

In later years in France, Portugal, Greece, and Spain, wine was treated with gypsum to make it ripen earlier for bottling, and to give it a more fiery color.[3] This process was called "plastering," and was especially practiced on red wines. The process consisted of adding a certain amount of burned or ground gypsum to the wine, and sometimes even to the grapes prior to being pressed. The gypsum would act on the

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[2]Ibid., p. 26033.

[3]Ibid., p. 26034.

wine by separating the tartrate of lime into an insoluble form and causing it to settle thus producing a mechanical clarification of the beverage and speeding up the process prior to bottling.

Gypsum also acted on the phosphates in the wine causing them to release phosphoric acid which enhanced the intensity of the coloration of the wine. It was later discovered that while the addition of gypsum was not injurious to the human stomach it did cause an increase in the amount of potassium sulfate, an active laxative. Because of this the "plastering" of wines was prohibited in some countries while in others it was permitted, but only under the strict supervision of the law. These laws hold to this day.

Gypsum, today, is produced and used in many countries scattered throughout the world. Proof of the international role that gypsum has played in history may be shown by some of the terminology used in the industry. One of the root words from which "gypsum" is derived is an Arabic word "jibs" meaning "plaster," or "mortar." "Selenite," as was pointed out previously, is from the Greek word "Selene," the Greek Moon Goddess. And lastly "plaster of Paris" is named after the Paris Basin in France, for many years the chief world supplier of gypsum.

History of Gypsum in the United States

Gypsum has been quarried and used in the United States for 146 years. It was discovered in New York as early as 1792, and a stock company was organized in 1808 to quarry the rock for land plaster, but it was not until 1892 that the first actual production was reported.[4] In 1835,

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[4]R. W. Stone, "Gypsum Deposits of the United States," United States Geological Survey, Bulletin 697, U.S.D.I., (Washington, D. C., 1920), p. 33.

exploitation of gypsum for land plaster began in Virginia.

With the crossing of the Appalachian Mountains by settlers in the early years of the nineteenth century, the gypsum industry followed. Whenever homes were being built there was a need for gypsum products. Gypsum mortar was needed to fill the open spaces between timbers in the early log cabins. Gypsum plaster and lath were requisite for interior decoration purposes. And wherever the trees were cleared and farming was begun there developed a market for gypsum land plaster, as fertilizer. It was only natural then that wherever people settled in large enough numbers to create a market for gypsum products, that some early industrialist began to look around him for the white rock which was so abundant everywhere and yet so expensive to ship in from a distance.

The years from 1840 to the present saw gypsum being discovered, mined, processed, and sold in ever-increasing quantities. About 1840, deposits were discovered near Grand Rapids, Michigan, and before 1850, gypsum was being mined in the vicinity of Sandusky, Ohio. The year 1872 saw a continued migration of people westward mirrored by a similar movement of the gypsum industry. In that year, the important deposits near Fort Dodge, Iowa, were developed, and three years later production began in California.

The history and development of the gypsum industry in the United States has been closely tied in with population growth. As the population increased the need arose for new homes and industrial construction. Since more than 95 per cent of the gypsum mined in the United States is used for construction purposes, it is easy to see why the two have advanced hand in hand.

The History and Development of the Gypsum Industry in Oklahoma

The first plaster mill was built in Kansas in 1889, and the first mill in Oklahoma was constructed at Okarche a few years later. In 1899, eight years prior to the admittance of Oklahoma as a state, there were four mills in operation in the territory. These were located at Okarche in Canadian County, at Watonga and Ferguson in Blaine County, and at Peckham in Kay County.[5] The mill at Peckham was erected in 1899, to utilize the gypsite deposits available nearby.

Table VI shows the total tonnage of all gypsum produced in the state in each year from 1894 to 1953, and also the total value of the gypsum produced. Tonnage figures are not available for five of these years—1905, 1906, 1907, 1930, and 1931. The figures giving the total value of gypsum sold in each particular year are not available for the following years: 1930-1936, 1945-1953.

Following the admittance of Oklahoma as a state in 1907 and its fast population growth, there was a great boom in the gypsum industry throughout the state. By 1910, a total of twelve mills had been erected at the following locations: McAlester, Eldorado, Rush Springs, Alva, Okarche, Ferguson, Wilson, Southard, Okeene, Bickford, and two at Watonga.[6] Production rose from a total of 1,300 tons valued at $7,500 in 1894, to 162,788 tons valued at $451,000 in 1910. The

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[5]George I. Adams, et. al., "Gypsum Deposits in the United States," House Documents, Vol. 59, Document 675, U.S.D.I., (Washington, D. C., 1904), p. 61.

[6]L. C. Snider, "The Gypsum and Salt of Oklahoma," Oklahoma Geological Survey Bulletin No. 11 (Norman, July, 1913), p. 72.

TABLE VI

GYPSUM PRODUCTION IN OKLAHOMA*
1894 - 1953

Year	Tonnage	Value $
1894	1,300	7,500
1895	13,100	46,125
1896	8,000	24,000
1897	10,734	40,050
1898	3,150	12,000
1899	23,526	62,600
1900	24,937	75,380
1901	15,930	66,031
1902	34,156	111,215
1903	69,158	234,261
1904	53,523	190,245
1905		191,000
1906		356,000
1907		404,000
**1908	44,632	288,000
**1909	122,093	370,000
1910	162,788	451,000
1911	108,653	287,591
1912	135,074	268,618
1913	147,876	330,416
1914	113,103	312,856
1915	110,790	294,230
1916	161,661	429,350
1917	158,017	562,767
1918	126,208	637,644
1919	114,313	708,660
1920	135,379	816,768
1921	209,201	1,289,226
1922	242,932	1,651,837
1923	290,121	2,248,895
1924	316,134	2,600,081
1925	320,931	2,599,463
1926	324,021	2,301,049
1927	271,484	2,073,944
1928	397,752	2,021,635
1929	369,433	2,255,374
1930		
1931		
**1932	65,611	
1933	97,008	
1934	105,620	
1935	125,177	
1936	156,545	
1937	159,639	266,091
1938	141,341	207,503

TABLE VI (Concluded)

GYPSUM PRODUCTION IN OKLAHOMA*
1894 - 1953

Year	Tonnage	Value $
1939	161,748	207,503
1940	176,166	227,534
1941	258,258	344,489
1942	243,545	321,652
1943	371,893	501,203
1944	295,604	472,789
1945	32,343	
1946	138,314	
1947	239,468	
1948	292,605	
1949	355,590	
1950	339,746	
**1951	413,694	
**1952	359,671	
**1953	323,451	

*"Oklahoma's Metallic and Nonmetallic Minerals 1952," Oklahoma Planning and Resources Board, Industrial Development Division (Oklahoma City, 1952), pp. 14-15.
**Forty-fifth Annual Report of Mines and Mining in Oklahoma, Department of Chief Mine Inspector, 1953, p. 24.

latter figure represented the highest production enjoyed by Oklahoma prior to our entrance into World War I in 1917.

But the bright future that was being prophesied by everyone in the industry at that time, was not to continue for long. The early years of the 1900's saw large production and considerable profit enjoyed by the industry. This encouraged expansion by those already in the industry at the time, as well as the construction of additional mills by newcomers entering the field. By this time the settlers who had moved into the state a decade before had already built their homes and other structures while the number of new settlers coming in was not large.

Thus, the limited building program by 1910 was not sufficient to sustain the twelve mills in operation. As a result there was a recession in the construction industry and this in turn was reflected in the gypsum industry. By 1913, only a few mills were still operating at capacity. The remainder still held on as best they could by operating their mills only part time and selling their products at prices so low as to prevent a reasonable profit being made by others.

In 1915, just five years after the big boom of 1910, only nine mills were still in operation in the state. The company at Alva had been forced out of business and the mill had been torn down. Fire had destroyed mills at Okeene, Cement, and Marlow; and mills at Peckham and Okarche were abandoned when the gypsite deposits became exhausted.

Production increased again in 1921, and for the next nine years, until 1929, each year saw over one million dollars worth of gypsum being sold. These were indeed the "golden years" of the gypsum industry in Oklahoma. Never before this time had the total annual value of gypsum reached the million dollar mark.

The world-wide depression of the early 1930's produced another major relapse in the Oklahoma industry forcing nine mills to close, until in 1934, there were only two plaster mills operating in the state. One mill was at Eldorado in Jackson County and the other was located at Southard in Blaine County, both of which were owned by the United States Gypsum Company. In addition there were quarries operating at Ideal and Watonga producing rock gypsum for sale to cement companies.[7]

Production slowly began to increase in 1936, and for the next five

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[7]Charles N. Gould, et. al., "Construction Materials of Oklahoma," Emergency Relief Administration of Oklahoma, Project No. 5-F2-89 (December, 1934), pp. 9-10.

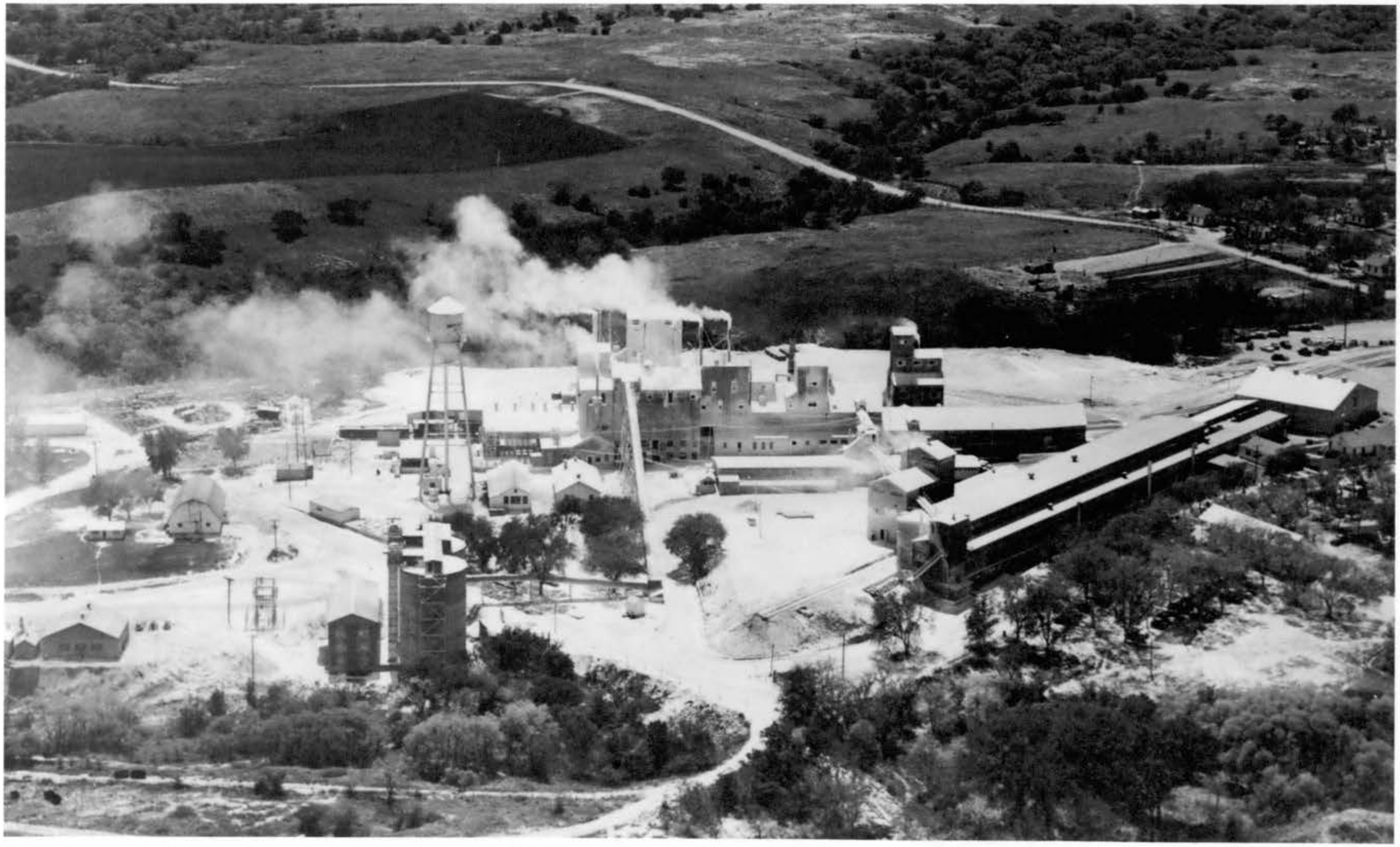

Figure 5. Air Photo of a Gypsum Plant, Southard.
(Courtesy of United States Gypsum Company)

years, until the Second World War began in 1941, the industry produced an average of about 160,000 tons a year. Yields during the War remained high and continued so during the period of rapid expansion of construction which followed. From 1949 to 1953 production did not drop below the 300,000-ton figure and reached an all-time record for Oklahoma of 413,694 tons in 1951.

At the present time there are only three gypsum producers in the state: Walton and Sons at Okeene, Universal Atlas Cement Company at Watonga, and the United States Gypsum Company at Southard, all in Blaine County.[8]

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[8] John H. Warren, "Oklahoma Mineral Producers," The Hopper, Oklahoma Geological Survey, Vol. 14, No. 5, (Norman, March, 1954), p. 65.

CHAPTER VI

USES OF GYPSUM

There are two general classes of gypsum products, raw and calcined. In the past, when the United States was largely an agricultural nation, raw gypsum production was the more significant. With the increased urbanization of our country, however, the emphasis shifted away from the agricultural gypsum class to the calcined gypsum class.

The principal use of raw gypsum, today, is in the cement industry, where it is used as a retarder to the set process in hardening of Portland cement. The retardation effect desired governs the amount of gypsum (or gypsum-anhydrite mixture) that is used. Usually one and one half to two per cent of gypsum is added. With cement of ordinary composition, this amount gives the maximum retarding effect, and also the maximum increase of tensile strength. The initial set is usually retarded from one to two hours, the final set from four to eight hours.[1] Excessive amounts of gypsum accelerate the set and weaken the cement. For this reason the amount that is added is controlled by standard specifications which state that the sulfur trioxide in ordinary finished cement must not exceed two per cent by weight. Cement producers purchase gypsum on a basis of its sulfur trioxide (SO_3) content,

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[1]Charles N. Gould, et. al., "Construction Materials of Oklahoma," Emergency Relief Administration of Oklahoma, Project No. 5-F2-89 (December, 1934), p. 11.

generally specifying that it be between 36 and 42 per cent, which corresponds approximately to raw gypsum 75-90 per cent pure.[2]

The second largest demand for raw gypsum at the present time is in agriculture. Agricultural gypsum, sometimes called "land plaster," acts as a direct, as well as an indirect fertilizer. As a direct fertilizer it is a source of sulfur trioxide which is an essential food for such plants as cereals, hays, legumes, tobacco, cotton, and peanuts. As an indirect fertilizer, gypsum provides plant food by breaking down potash into a form that can be utilized by the plants, and by stimulating the growth of nitrogen-fixing bacteria in the soil thus increasing the supply of nitrogen available to the plant. Gypsum also proves beneficial when sprinkled over piles of manure. The gypsum unites with the nitrogen of the manure to form ammonium sulfate, an important plant food.

Gypsum has also been applied to correct black alkali soils. By the addition of gypsum, the carbonates of soda, potash, and magnesia, which form black alkali, are changed to sulfates, which are less injurious to plants. In this use gypsum is considered an amendment which improves the soil condition, rather than a fertilizer.

Raw gypsum has several other applications in addition to the two mentioned above. Terra Alba, a finely ground form of white rock gypsum, is often used as a filler for textiles, paints, buttons, poker chips, phonograph records, blasting powder, and in nearly all grades of fine paper. Terra Alba has also been extensively incorporated in drugs and foodstuffs as an adulterant.

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[2]Oliver S. North and Nan C. Jensen, "Gypsum," Minerals Yearbook, 1949, Bureau of Mines (Washington, D. C., 1951), p. 506.

An important type of rock gypsum is the fine-grained variety known as alabaster, which for centuries has been used in the raw form for sculpturing statues, vases, novelties, and in ornamentation of buildings. Alabaster is very soft, and may be carved with a knife, or cut and shaped while turning on a lathe. Beautiful alabaster art objects have been made experimentally of fine grained Oklahoma gypsum from Freedom and Clinton, but at the present time these deposits are not being utilized.

Another use that is made of raw gypsum is in some smeltering operations where it is used as a flux. Gypsum is also added as a salt in brewing beer. It is a base for mixing with Paris green or other insecticides. It is sometimes added to rubber products to make them hard and durable. Even on Hollywood movie sets powdered gypsum is used as imitation snow.

In addition to the many uses of raw gypsum that have been mentioned perhaps its greatest use in the future will be as a source of sulfuric acid, the chief industrial acid. Of the many processes that have been patented and used in its manufacture, the most successful consists of heating a mixture of gypsum, clay, and coal, and adding sand and slag to form sulfur dioxide gases and a Portland cement clinker. These gases are then purified and turned into sulfuric acid.[3]

Another patent covers a process for the conversion of gypsum mixed with coal, coke, clay, or other substances into calcium sulfide, sulfur, sulfur dioxide, and lime. Too, there is a process for the conversion of gypsum mixed with ammonia, and carbon dioxide into ammonium sulfate,

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[3]Forrest L. Moyer, "Gypsum and Anhydrite," Bureau of Mines Information Circular 7049 (Washington, D. C., February, 1939), p. 14.

which may be further treated with sodium nitrate.[4] Although these processes and others have long been known and utilized in some European countries they have never been considered economically feasible in the United States until the present time.

Although our present supply of sulfur appears to be adequate, it has been estimated that the demand for sulfur compounds in 1960 will gradually bring on the market increasing quantities of by-product sulfur.[5] With the continued exhaustion of our sulfur deposits, the gypsum substitutes will be able to compete in price with the natural sulfur and a new era of exploitation may develop for raw gypsum.

Uses of Calcined Gypsum

Calcined gypsum products are noted for their light-weight, fire-resisting, low-heat-conduction, sound-proofing, and vermin-proofing qualities. Recognition of these characteristics in gypsum products cause one to see why they have long served as favorite materials in the construction field. Today, more than 95 per cent of all gypsum mined is used in construction, where it is primarily used as a plaster for covering interior walls and ceilings of structures.[6]

The hard wall plasters are prepared from calcined gypsum, by adding a retarding agent to control the time of set and a binder to add to the cohesiveness of the plaster when it is made plastic with water. The two basic types of wall plaster, according to their uses, are base-coat plasters and prepared finishing plaster.

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[4] *Ibid.*, p. 14.

[5] Virginia Butcher, "Gypsum," *The Hopper*, Oklahoma Geological Survey, Vol. 11, (Norman, August, 1951), p. 79.

[6] *Ibid.*, p. 72.

As the designation would imply, base-coat plasters are those which are applied for the "scratch" or first coat, and for the "browning" or second coat. These are also divided according to the material which is used in each, into three classes, "neat" gypsum plasters (or cement plasters), wood plasters, and "ready sanded" plasters.[7]

Neat plasters consist of calcined gypsum, a fiber such as hair, a retarder, and other materials that will add plasticity to the plaster. This type is mixed with two or three parts by weight of sand when ready for use. Neat plaster will set in eight to thirty-two hours. It has a tensile strength of 150 pounds per square inch, sufficient for most construction purposes.

Wood fiber plasters consist of calcined gypsum, wood fiber, a retarder, and other material to improve plasticity. They may be used with or without an equal amount of sand, and are intended for use where sand is expensive or scarce or where an unusual toughness, light weight and some flexibility of the finished wall or ceiling are desired. This type of plaster contains almost one per cent by weight of wood fibers made from a nonstaining wood. The mixture will set in about one and one half to eight hours and has a tensile strength of 125 pounds per square inch.

Ready-sanded plaster is neat plaster to which the sand is added at the mill or mixing plant rather than on the job, and is intended for use in localities where substitute sand is expensive or scarce. It has a tensile strength of 75 pounds per square inch and will set in one and one half to seven hours.

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[7]F. L. Moyer, "Gypsum and Anhydrite," pp. 17-18.

The second basic type of wall plaster, according to its utilization, is prepared gypsum finishing plaster. Plasters of this kind are made of calcined gypsum and are especially prepared for application as the final plaster coat. A plastic material, such as clay or talc, may be added to improve its working qualities. These plasters may or may not have retarders added, and may require the addition of water only to be ready for application. When the plaster has no retarder added, it usually sets in 20 to 40 minutes, but with the addition of a retarder setting time varies from 40 minutes to more than six hours.

This type of wall plaster may be subdivided into trowel-finish, which contains no sand; sand-float finish, which, contains clean white sand; and gauging plasters, which contain two parts by weight of dry, hydrated lime and which are commonly used as finishing plasters for kitchens. Although the calcined gypsum that is used in finishing plasters is either white or gray, specially colored gypsum finishing plasters are available in as many as thirteen standard shades. These are prepared by adding color pigment to normal plasters.

In addition to the two basic types of wall plasters, base-coat and finishing plasters, there are many special kinds of wall plasters that are intended to do a specific job. Most important of these are molding plasters. These are made from specially selected and prepared calcined gypsum and are ground much finer than other plasters, so that the molds or casts will be unusually dense, hard, and durable, and will present a smooth-finished surface, free from pin holes and cavities. Molding plasters are widely used as cornices, moldings and other ornamentation. They will set in 20 to 40 minutes and have a tensile strength of 200 pounds per square inch.

Insulating plasters are another kind of wall plaster. These are specially prepared mixtures of calcined gypsum with other materials or chemicals that are added for their fire-resistant or nonconductive qualities. Filler leads to light weight in the finished product. Calcined gypsum mixed with asbestos fibers is used as an insulating cover on pipes and boilers.

By another process certain chemicals are mixed with calcined gypsum to make an insulating plaster. When water is added these chemicals react and give off a gas that expands the mass to several times its original bulk. As the set of the plaster is timed to take place near the period of the greatest expansion, the resulting mass is porous, light weight, and full of sealed cavities that act as insulaters.

A dry insulation product recently developed and sold under several trade names is made by passing scrap wallboard or lath through a hammer mill. The product is light and fluffy, and is placed as filler in the spaces to be insulated.[8]

Another important kind of wall plaster is used in theatres, churches, auditoriums, restaurants, hotels, and other buildings where good acoustic qualities are desired. These plasters are called acoustical plasters and are composed of mixtures of calcined gypsum with either chemicals, or porous materials, or both. The chemicals react with the water after mixing, and form minute interconnected cavities or cells, many of which break through to the surface before the plaster sets. The sound waves are absorbed in these small, winding passage ways. Pumice, or volcanic ash, is used as a porous, sound-absorbent material in acoustical plasters. It also acts as a trap for sound waves. Plasters for acoustical purposes are substituted for, and applied in, the same manner as the usual plaster coat.

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[8] *Ibid.*, p. 19.

Keene's Cement is another popular wall plaster. It is prepared from crude gypsum, which has been selected for color and purity, and is calcined at a very high temperature (1,000° F.) until all the chemically combined water is driven off and the material becomes anhydrous. This calcined product is finely ground, and an accelerator of set, such as potash salts or alum, is added. The finished product has unique properties that distinguish it from the ordinary gypsum plaster. It will keep indefinitely, and can be retempered (made plastic again) after the initial set has developed. It also possesses a high compressive and tensile strength (450 pounds per square inch). It may be colored, and patterns introduced by the inclusion of dyed threads that are removed before the plaster sets, leaving an intricate design which may be brought down to a highly polished surface. Keene's Cement is used for hard-finish wall plasters, for making imitation marble columns and panels, and for ornamental plaster work.

"Staff" is a gypsum plaster that serves as the exterior walls of temporary exposition or fair buildings. It is composed of calcined gypsum mixed with excelsior, manila, or other fiber. Additions of cement glycerine, and dextrine to the staff yield compositions that fit it for massive statuary or smaller art objects and decorative panels. Although staff lacks durability it is easy to apply and is economical for such temporary and ornamental purposes.

Just the opposite of staff in regard to its lasting qualities is Estrich gypsum, sometimes called "hydraulic cement," a special type of flooring plaster. Although not used to any great extent in the United States, it is used extensively in Germany in place of Portland cement for indoor work and for covering walks. It is prepared by calcining rock gypsum to a temperature of about 1,560° F., at which point some of the gypsum is decomposed into lime, which remains in the material, and sulfur dioxide, which passes off as a gas. The quantity of lime in the final product ranges from four to ten per cent. This gypsum product has a very slow-set, and with tamping will form a dense, hard, durable mass that is quite resistant to wear.

Gypsum plaster also finds wide usage outside of the construction field where it is used in everything from plate glass plasters to dental plasters. In the plate glass industry, gypsum plaster is used to hold the glass firmly in place while it is being polished. Only a very finely-ground gypsum free from grit and with fast set is practical. When the glass has been polished on one side it is broken loose and reset on the table, using new plaster. When this has set, the other side of the glass is then polished. As a dental plaster only a very pure, extremely fine-grained plaster of Paris is used. Usually an accelerator, such as commonsalt, is added. This plaster is used by dentists and dental laboratories in taking impressions for false teeth.

Casts of statues and other art objects, and of relief maps and models for various sorts of scientific purposes, are made from gypsum art and casting plaster. A model of the desired object is made of clay or some other plastic material. A negative of plaster is made by pouring the liquid plaster over the clay object. When this has been allowed to set it is removed from the object and is washed with water to free it of any clay particles. The surface is then coated with some non-absorbent material, such as shellac, and the plaster is poured over the negative object. The unique property of stucco plaster is that it expands sharply just before taking its final set, filling as it does every minute crack and crevice; hence, it produces an exact likeness of the original. The coating of shellac over the negative prevents the plaster of the cast from sticking to the plaster of the negative. Any number of casts may be made by this method from the one negative.

Gypsum is also used in large quantities in the making of molds for pottery. The molds may be made in one or two pieces. When made in two pieces they are fastened together and the clay is poured into the mold. When the clay is partially dried, the mold is removed. Molds made from gypsum pottery plasters are especially suited for this purpose because of the rapidity in which they absorb water from the clay. In addition, the molds may be used several times and are thus economical. For this reason, these plasters have been widely used in the pottery industry in Oklahoma, e.g., at the Frankhoma Pottery Company, and at the Tamac Pottery Company.

At the present time gypsum is being consumed in increasing quantities in producing metal casting plasters which are used in casting non-ferrous metal. This plaster produces molds of precise accuracy which are dimensionally stable and virtually unaffected by change in atmospheric conditions. During the Second World War, metal casting plasters were used in the tool and dye industry to produce molds for casting vital parts for aircraft and for weapons. At the present time this super-strength gypsum plaster is gaining wide acceptance in the aircraft, automotive, and foundry fields.

Another wartime as well as peacetime use of calcined gypsum is in producing orthopedic plasters. This type of plaster is used when a rigid bandage is needed for broken bones. First the broken bone is covered in sterilized wool or flannel, and this is wrapped with a roll of gauze. The orthopedic plaster is then added to the bandage and allowed to set, producing a strong bond but yet one which can be easily and safely removed when necessary.

Oil well cements are popular gypsum products used in Oklahoma and the southwest. These cements are used in constructing the "cellar" or foundation for the surface casing and anchoring any additional casing used in the well. In anchoring the casing the desired amount of cement is pumped through the bottom of the casing and up the outside of it and allowed to set. During oil well drilling operations when foreign waters enter the well, it sometimes becomes necessary to seal off these waters by cementation. It is also used in plugging the lower end of the pipe so as to exploit a higher horizon of oil bearing strata

Calcined gypsum is employed in a number of miscellaneous uses which, though small in actual tonnage consumed, are nevertheless important to the individual industry involved. One of the most "unknown" uses of gypsum is in blackboard chalk. Most of the chalk used in schools today is not true chalk at all, but is soft gypsum plaster molded into sticks.

The fire-resistant qualities of gypsum are also widely utilized in a number of different ways. Some safes and filing cabinets containing money or valuable papers are further protected against loss by using fire-resistant gypsum in their walls.

Gypsum Board

In addition to the many uses of gypsum in the construction field as a wall plaster, the mineral is even more widely used in the form of gypsum board. Gypsum board may be divided into three general types, lath or plasterboard, wallboard, and sheathing board. Although they are designed for different use, all consist essentially of a layer of gypsum plaster, enclosed between sheets of slightly absorbant, fiberous paper. The plaster is composed of calcined gypsum, to which sawdust, cork, starch, rosin-soap foam, or other filling material has been added.

Gypsum lath is usually manufactured in 3/8 inch thicknesses and is intended for use as a strong, fireproof plaster base in place of wood or metal lath. It provides a uniform surface with an exceptionally strong bond for succeeding plaster coats and requires less plaster than other types of lath. In tests conducted by the United States Bureau of Standards, the adhesion of gypsum plaster to gypsum lath was found to be three times as great as to wood lath, and 40 per cent greater than expanded metal lath.[9] Other advantages of its use are that it is easily and quickly erected and neither warps nor buckles after the application of wet plaster.

A perforated lath is manufactured by drilling a number of holes (1/2 to 1 inch in diameter) in standard board after it is bundled. The holes provide a mechanical key for plaster coats. This is a result of plaster mushrooming through the regularly spaced holes in the lath and forming keys which lock it to the lath, holding the plaster coat firmly in place. An improved method of perforating lath is to stamp the holes by machine while the lath is either wet or dry.

Gypsum wall board, sometimes called sheetrock (registered trade mark of the United States Gypsum Company), is designed for use on interior walls, ceilings, or partitions without the addition of plaster. Wallboard is usually manufactured in 3/8 inch thicknesses, and has a smooth surface on which wallpaper or paint can easily be applied.

Some wallboards are finished to simulate a ceramic tile wall or to resemble wood paneling. Wallboards are also available finished with a natural-wood veneer for paneling, with aluminum foil backing to increase

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[9] "Adhesion of Gypsum Plaster to Various Backings," Gypsumist, United States Gypsum Company (Chicago, December, 1925), p. 7.

their heat-insulating qualities and with asphaltic backing to increase water resistance. Wallboard may be made into laminated board by joining several thicknesses together.

Gypsum sheathing board consists of a gypsum core encased in a tough fiberous covering, the outer surface and end of which are moisture-proofed. It is usually manufactured in 1/2 inch thicknesses and is used for sheathing on frame structures under shingles, stucco, or brick veneer.

Gypsum Tiles and Blocks

Gypsum tile and blocks are made in various sizes and designs for flooring, roofing, furring, non-load-bearing partitions, and fireproof covering of columns, beams, and shafts. They are light in weight (40 per cent lighter than hollow clay tile[10]) and may be cut with a hand saw. In addition they are fireproof, verminproof, soundproof and display good insulating qualities. Gypsum tiles and blocks may be either solid or hollow (cored).

Roofing and flooring tiles are available in either long or short spans. They are usually reinforced with metal fabric or rods or both, and may be laid in place on T-shaped subpurlins or on the main purlins. Gypsum plank two or three inches thick, reinforced with wire mesh and metal tongue and groove edges, was developed by United States Gypsum Company in 1937 and has since proved to be satisfactory in roof and floor construction. Gypsum roof tile is fireproof, and can be erected at a low cost and requires less supporting steel than concrete roof

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[10] L. C. Snider, "The Gypsum and Salt of Oklahoma," *Oklahoma Geological Survey Bulletin II* (Norman, July, 1913), p. 91.

docks. For this reason roof tile has been used with increasing success on large surface areas of factories and government buildings, including naval gun shops, ammunition warehouses, and docks.[11]

Partition tiles are obtainable either solid or hollow and in several thicknesses varying from two to eight inches. The usual widths and lengths are 12 and 30 inches respectively. Partition tile is not reinforced and is used only in non-load-bearing walls. Because of their light weight and large uniform size, it is easily and quickly laid in gypsum mortar to readily yield an even surface. Wide application today is seen in its use for partitions, corridors, and firewalls, elevators and stairway enclosures, column and beam covering and ventilating and heating ducts.

Gypsum furring tiles have about the same characteristics and dimensions as partition tile. They may be either hollow or solid and are about two inches thick. They are fastened to the wall by nailing and are used for soundproofing, fireproofing, insulators from heat or cold and damp proofing. They furnish substantial support for ceiling, wall, and wainscoting covering.

Gypsum studding consists of two selected nailing strips inbeded in a plaster preparation. It can be nailed into and can be sawed as easily as wood studding. Partitions of this studding with gypsum wallboard or with gypsum lath and plaster are entirely fireproof.

The uses of gypsum that have been described here are but a few of the many possibilities of this versatile mineral. Today, gypsum serves

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[11]R. W. Stone, "Gypsum Deposits of the United States," U. S. Geological Survey Bulletin 697 (Washington, D. C., 1920), p. 44.

man in more than 900 ways.[12] Although primarily used as a building material, we have seen how it may also be used in foodstuffs, drugs, blackboard chalk and a number of other applications. Gypsum will continue to be used as a building material and with the advances in chemistry, we can look for even wider, more diversified uses of the mineral and its products.

Uses of Anhydrite

Anhydrite, because of its properties, does not lend itself to the great variety of uses for which gypsum is adapted. Therefore, in this country it is regarded as an undesirable constituent of a gypsum deposit if present in appreciable amounts. By contrast, in some foreign countries, considerable quantities are used for chemical processes and as building material. In the United States despite this some anhydrite is used for land plaster and as a cement retarder.

As a fertilizer, anhydrite is favored by some over gypsum. It is pure, easier to apply, and has the same fertilizing qualities as does gypsum. Because it is regarded as an impurity in the gypsum industry, it is more economical to use.

Anhydrite also serves as a cement retarder. In retarding the set of Portland cement, anhydrite has less strength and is less effective than pure gypsum. About four times as much pure anhydrite as pure gypsum of equal fineness is required to produce the same retardation.[13] However, gypsum-anhydrite mixtures, with an anhydrite content varying from 30 to 50 per cent, have been used satisfactorily as a retarder.

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[12] "Gypsum at War," Business Week (July 8, 1944), p. 76.

[13] F. L. Moyer, "Gypsum and Anhydrite," p. 19.

Since anhydrite contains no water of crystallization, calcination has little or no effect on it. However, experiments show anhydrite can take on water of crystallization and then can be changed into gypsum in a relatively short time by fine grinding and mixing with water.[14] After being hydrated in this manner, the material may be calcined to form building plaster.

The high sulfur trioxide content and the absence of water in anhydrite makes it a more suitable raw material than gypsum in such chemical and high-temperature processes as in the manufacture of sulfides, sulfates, and limes. This fact may prove to be an important asset of the mineral, should the day come when our natural sulfur deposits become exhausted and we are forced to turn to gypsum or anhydrite as a substitute.

Anhydrite has also been used as a road base material in place of chat. The United States Gypsum Company's plant at Southard, Oklahoma, has experimented with anhydrite on company roads and reported a saving of $10,000 per mile over the cost of using chat shipped in from southern Oklahoma. The important value of anhydrite as a rock base lies in local road construction. It cannot compete with chat in economy or durability in areas where both are found in abundance.[15]

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[14] Marie Farnsworth, "The Hydration of Anhydrite," Industrial and Engineering Chemistry, Vol. 17, No. 9, (1925), p. 967.

[15] John Dexter, "Blaine Finds Road Materials at Home," Daily Oklahoman (Oklahoma City, May 23, 1954), p. 4.

CHAPTER VII

MARKETING OF GYPSUM AND GYPSUM PRODUCTS

Domestic production of raw gypsum in 1951 totaled 8,666,000 short tons as compared with total imports from abroad of 3,448,000 short tons.[1] Both figures represent an all time high for domestic production as well as for imports. The leveling off of construction which has been continually predicted since 1947 apparently is still quite a distance in the future. Federal action in encouragement of home ownership as well as an unprecedented expansion in industrial building are the chief factors which have contributed to our record consumption of gypsum.

Shortages in gypsum products immediately after World War II have, for the most part, disappeared because of rapid expansion in production facilities throughout the gypsum industries. However, it was not until the lull in building activities occurred in the winters of 1948-1949 that distributers were able to accumulate normal stocks of gypsum board and lath. As late as 1950, new housing starts had to be delayed in some metropolitan areas because of marked shortages.

Consumption of all major gypsum products has increased in recent years. In terms of percentages the most rapid increase has been in gypsum board. In 1928, a big building year, building plasters represented

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[1] Statistical Abstract of the United States - 1953, United States Department of Commerce (Washington, D. C., 1953), p. 757.

43 per cent of the total sales of all gypsum products, while in 1951 they represented only 19 per cent.[2] Gypsum board (excluding lath) on the other hand, increased from 27 per cent of the total sales value of all gypsum products sold in 1928, to 46 per cent in 1951. Many factors have accounted for this shift. In 1928 gypsum board utilization was still in its infancy and the depression years that followed failed to bring about any marked increase in its consumption.

Following the Second World War, however, in 1946 wallboard began to gain on gypsum building plasters because of several reasons. Probably the most important was the desire for cheap, rapid construction materials. Ease of working with it was also a factor. The armed services were rapidly being demobilized and the creation of new families added to the already critical shortage of housing which had developed during the conflict under the requisite curtailment of civilian construction. This prompted the desire for rapid and cheap housing facilities. A second important fact was the system of price control in effect at that time. Under this system it was possible to make a higher margin of profit in the manufacture of wallboard than in the production of plaster.[3]

With the passing of the severe housing shortage of the early post-war years, home buyers began once again being more critical of the materials which they purchased for their homes. Gone was the urgency of former years. Home buyers began once more to appreciate the qualities of wall plaster and other materials in comparison with wallboard.

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[2]Oliver S. North and Nan C. Jensen, "Gypsum," Minerals Yearbook, 1951, Bureau of Mines (Washington, D. C., 1954), p. 5.

[3]Charles L. Harness and M. G. Downey, "Gypsum," Minerals Yearbook, 1946 (Washington, D. C., 1948), p. 596.

Therefore, permanence and more pleasing appearance of wall plaster forced the two into a deadlock on tonnage consumed in 1951. In that year, building plaster consumed 2,838,000 short tons, while wall board and laminated board used 2,842,000 short tons. However, in terms of total value, they were not quite so close to each other. Building plaster accounted for a total value of only $43,531,000 while the sale of wallboard represented a total value of $105,128,000.[4] So while the tonnage consumed was about the same for both, the value added to the finished product was considerably higher for gypsum wallboard.

This great difference between the value added by bulk gypsum products (Portland cement retarder, agricultural gypsum, etc.) compared with the value added through calcining, and other methods of changing the characteristic of the raw gypsum, may be further illustrated by the following example. In 1951, raw gypsum for Portland-cement retarder, base-coat plasters, and gypsum lath all consumed close to 2,000,000 short tons each, yet the gypsum that was consumed for cement retarder purposes was valued at only $6,292,000, the base coat plasters had a total value of $30,166,000, and the gypsum lath incurred a total value of $64,552,000. From this example it is obvious that any figures giving solely the tonnage consumed in producing different gypsum products is practically worthless in any evaluation. Only with accompanying data showing the value added by each product has significance.

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[4]O. S. North and N. C. Jensen, "Gypsum," p. 7.

Prices

The average value of raw gypsum mined in 1951 was $2.77 per short ton, compared with $2.78 in 1950 and $2.77 in 1949.[5] Among the calcined uses, the unit value of Portland cement retarder increased from $3.23 to $3.48 per ton, while that of agricultural gypsum declined from $4.28 to $3.99. The average values of industrial plasters (plate glass, pottery, orthopedic and dental plasters) showed gains of approximately $2.00 per ton each. The value of all building plasters (base-coat, sanded, gauging, molding, finishing and Keene's cement) increased approximately $2.18 each with the exception of miscellaneous plasters which declined slightly. The average value of all prefabricated gypsum products (lath, wallboard, sheathing and partition tile) increased approximately $2.53 per thousand square feet.

Foreign Exports

The exports of gypsum and gypsum products from American producers to foreign markets has never been of major significance to the industry. In 1951 we exported products valued at $1,584,000, while in the same year the United States imported 3,448,000 tons of raw gypsum valued at $3,547,000. Never in the history of the American gypsum industry has the total value of our exports surpassed the $2,000,000 mark.[6]

Probably a number of factors have contributed to this lack of American export. The great distances which gypsum products from the United States would have to be shipped to reach profitable foreign

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[5] Ibid., p. 8.

[6] "Building a Better Tomorrow," United States Gypsum Company (Chicago, 1952), p. 29.

market areas probably has been the chief factor. Aside from the added freight that must be included in the cost of selling the American product, higher cost of labor in this country must also be added. Both of these factors as well as others, have created a negative attitude within the industry in regard to foreign trade possibilities.

Foreign Imports

Despite the abundance of gypsum in the United States, our gypsum companies still find it profitable, in some instances, to import raw gypsum from foreign sources. In 1951, the United States imported 3,448,000 short tons of raw gypsum, 90 per cent of which came from Canada. Most of the Canadian imports come from the United States Gypsum Company's holdings in Nova Scotia and are shipped by company-owned ocean-going craft to their mills at New York, New York, Boston, Massachusetts, Philadelphia, Pennsylvania, Norfolk, Virginia, and Jacksonville, Florida.

The large import of gypsum from Mexico is chiefly from the rich deposits on San Marcos Island off lower California. From this deposit the Kaiser Gypsum Company (a division of the Henry J. Kaiser Company) ships to its plants at Long Beach and Redwood City, California. It is planned that eventually ships will come as far north as Seattle when the new plant is constructed there.[7]

Oklahoma

Gypsum and gypsum products processed in Oklahoma plants are marketed in nearly every state of the Union and a large number of foreign countries. The gypsum industry here is less dependent on its home

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[7] O. S. North and N. C. Jensen, "Gypsum," pp. 5-6.

market area than are gypsum producers in some other states because of several factors. The most important condition is that the two largest gypsum producing operations in the state are owned by strong, powerful outside companies which are the United States Gypsum Company, Southard, and the Universal Atlas Cement Company, a subsidiary of United States Steel Corporation. This enables them to ship their products into other trade areas and to sustain the loss incurred by overland transportation in order to sell their products.

Universal Atlas Cement Company, for instance, ships raw gypsum for use as a retarder in the manufacture of Portland cement to company-owned plants in the following cities: Waco, Texas; Leeds, Alabama; Hannibal, Missouri; Independence, Kansas; Buffington, Indiana, North Hampton, Pennsylvania; and Duluth, Minnesota. In addition raw gypsum is shipped to the following independent cement producers for use as a retarder: Monarch Cement Company, Humboldt, Kansas; Lehigh Portland Cement Company, Iola, Kansas; Asho Gravel, Lime, and Portland Cement Company, Chanute, Kansas; Consolidated Cement Corporation, Fredonia, Kansas; Missouri Portland Cement Company, Prospect Hill, Missouri; Alpha Portland Cement Company, Lemay, Missouri; and the Ideal Cement Company, Ada, Oklahoma.[8] It is obvious that the raw gypsum that is marketed in distant areas, such as Pennsylvania, Alabama, Minnesota, and Indiana, would not be considered economically feasible if it were not for the fact that these cement plants and the Watonga operation are all owned by the same company. When forced to compete on the open market in selling their product to independent cement companies, the

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[8]P. E. Gorby, Superintendent, Universal Atlas Cement Company, Watonga, Oklahoma, Personal Interview (July 13, 1954).

effect of competition from other gypsum producers is more apparent, and their market area is reduced to cement companies operating in Oklahoma, Kansas, and Missouri.

On the other hand, an independent gypsum producer, such as the S. A. Walton and Sons operation at Okeene, Oklahoma, is very limited in the market area in which their product can be profitably sold. Unlike the Universal Atlas Cement Company's gypsum operation, this independent company has no affiliated plants in distant states and so it must rely on sales made within its home market area. Consequently the entire output of S. A. Walton and Sons operation is marketed in Oklahoma where it is sold to the Dewey Cement Company at Dewey, Oklahoma, for use as a retarder in the production of Portland cement.

A second factor that has made the gypsum industry in Oklahoma less dependent on its home market area has been the high purity and quality of the state's gypsum deposits. This has made it possible for a producer, such as the United States Gypsum Company's plant at Southard, Oklahoma, to manufacture a large variety of finished products which cannot be easily duplicated in other gypsum producing areas of the United States. In the production of Keene's products Oklahoma gypsum, because of its whiteness and purity, is in wide demand at home and abroad. Some products manufactured at Southard are exported to the far corners of the world as well as to distant points of the continental United States. While visiting the Southard plant the writer checked railroad cars loaded with gypsum products destined for Brooklyn, New York; Las Vegas, Nevada; and other distant points in the United States.

However, it is well to remember that it is only the special products (e.g. Hydromite made by United States Gypsum Company) or products for affiliated plants quarrying raw gypsum (Universal Atlas

Cement Company) that can withstand the cost of transportation to distant markets. Bulky items or raw gypsum products that have no specific advantages over similar products processed elsewhere are still dependent upon the home market area except possibly during periods of unusual demand, such as in wartime.

CHAPTER VIII

PAST, PRESENT, AND FUTURE SIGNIFICANCE OF THE GYPSUM INDUSTRY IN OKLAHOMA

The gypsum industry in Oklahoma had its inception at Okarche, and by 1899 there were four mills in operation. The great amount of building in Oklahoma following its admission as a state in 1907 furnished a good local market for plaster. Several mills were built to supply this demand. By 1910, a total of twelve mills had been erected in the state. But in the years that followed, the industry began to show signs of decay; and in 1934 only two plaster mills were still in operation. Even the more pronounced optimists in the industry were willing to admit that the "boom" was over.

Many reasons have been given to account for the decline of the gypsum industry in Oklahoma at the time. The three reasons most often cited are: (1) the distance of the gypsum mills from fuel, (2) the distance from a large market, and (3) the decline of the market within the state after the initial building was accomplished.

The gypsum area of western Oklahoma was a considerable distance from any source of fuel at that time. Coal had to be imported all the way from the McAlester field in the southern part of the state, or from mines in Colorado or Arkansas. Cost of coal was much higher then than in many other regions at the same distance from productive coal fields. This was because the geologic conditions under which the Oklahoma coal was found made mining more expensive in the eastern and central parts of the state.[1] Mining methods in use during this time were also extremely wasteful, which further operated to make the cost of coal unduly high. Added to these difficulties was the poor transportation facilities with which to readily transport the coal to the gypsum mills.

Although the difficulty of obtaining an economical fuel for the mills was an important factor, probably it was not the principal reason for the decline in the industry. If the mills had been close to a large metropolitan area, they could have absorbed the high fuel prices and still have produced their products at a profit. But it was this lack of an available market for their products that led to the decline of the gypsum industry. At the present time there is only one plaster mill operating in the state, and this is at Southard. This mill successfully and profitably supplies the gypsum needs of its surrounding area. We can well imagine the cut-throat competition and the small margin of profit that must have existed in the gypsum industry in 1910. At that time twelve mills were operating in the western part of the state, where today there is only one. In regard to market area, the Southwest is far more densely populated today than it was forty-four years ago. Even with the increased population it is very doubtful whether twelve mills could operate successfully in the state today.

Present

The great enthusiasm which accompanied the early days of the gypsum industry in the state has been reduced to more subdued comment today. Men still talk with optimism about the potential greatness of the industry in the state, but their tones have quieted down some in

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[1] L. C. Snider, "The Gypsum and Salt of Oklahoma," Oklahoma Geological Survey Bulletin No. 11 (Norman, July, 1913), p. 79.

the last fifty years. Any gypsum company coming into the state in the near future will study the market area first before making its decision whether to locate in Oklahoma or elsewhere. The presence of a virtually inexhaustible supply of gypsum with many excellent quarry sites will always serve as a temptation for newcomers, but markets are remote and competition is intense.

Just how many gypsum plants the state could successfully sustain is open to conjecture. However, the fact that only one gypsum mill is now operating in Oklahoma would seem to indicate that unless the market area increases in population, or that for some other reason the consumption of gypsum products should increase because of new discoveries, or inventions only the present owners can successfully stay in production. Small operations, in which the gypsum is mined and sold in the uncalcined form for land plaster or Portland cement retarder will continue to its small scale. At the present time there are two such enterprises in Oklahoma; they are the Universal Atlas Cement Company at Watonga, and S. A. Walton and Sons at Okeene.

The present economic status of the gypsum industry in Oklahoma is satisfactory and the future is bright. Early difficulties of securing coal have been overcome by substituting natural gas and petroleum. Transportation facilities also have been greatly improved. The post-war building boom in the nation, as well, has been reflected in the Southwest. An all-time record for Oklahoma had been reached by gypsum production in 1951 of 413,694 tons. This record tonnage, which had been produced by three plants (320,922 tons came from the Southard plant alone), which compares very favorably to the 162,788 tons which had been produced by twelve plants in 1910.

The gypsum mills of today reflect the changes that have been taking place in the industry. In earlier years a gypsum operation consisted of only a plaster mill for producing the finished product. Today a well-integrated operation such as the plant at Southard, not only maintains a plaster mill, a board plant, a Keene's Cement factory, but a Hydrocal plant as well. The plaster mill alone produces a greater variety of plasters than the earlier mills knew existed. Pottery, molding, metal dye, dental, orthopedic, plate glass plasters, and many others are now produced at the one gypsum plant, the United States Gypsum Company at Southard.

Its board plant yields a large amount of prefabricated gypsum board. It was just in its infancy as a product in 1910. It was in the middle 1890's when Augustine Sackett invented a wall board which consisted of three layers of gypsum plaster sandwiched between four plies of wood felt paper.[2] It was heavy and awkward to handle; its open edges were easily damaged and prone to crumble. It had little nail-holding power. Because of the roughly finished surfaces, this first board was also unattractive, and its only suitable use was as a plaster base.

Few people in the 1900's could visualize Mr. Sackett's "sandwich" as anything but a fragile piece of paper and plaster that was unsuitable for most building purposes. But with this early wall board as an inspiration, the industry finally developed wall board as we know it today. Those pessimists who predicted a short life for gypsum board, would be astonished today to find that in 1951, gypsum board (lath and tile included) accounted for 75 per cent of all gypsum

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[2]"Building a Better Tomorrow," United States Gypsum Company (Chicago, 1952), p. 18.

products produced, far surpassing gypsum building plasters.[3] Now it is not uncommon to find the emphasis being placed on the production of gypsum board rather than gypsum plaster as a building material.

Hydrocal, a molding product (sometimes called by different names in different companies), is another new addition to the well-integrated gypsum plant. This product was developed by the United States Gypsum Company's research chemists in 1930.[4] The development of this super-strength gypsum cement opened the door to sales opportunities which were distinctly apart from building. These cements are rapidly replacing old-fashioned material for accurate molding and castings in America's light and heavy industries. It is especially desirable where precision casts are required, such as in the automotive, air craft, and foundry fields.

Diversification has brought many changes since the gypsum plant operations of 1910. No longer is the gypsum mill a small-scale activity producing one or two different items. The United States Gypsum Company plant at Southard alone manufactures 125 different products ranging from Keene's Cement to industrial plasters for use as fillers in food-stuffs, drugs, and paper. Custom orders are filled and research brings new items into production.

This diversification has also been carried on throughout the larger companies of the industry. The United States Gypsum Company, being the largest producer of gypsum products in the United States and the operator of the largest plant in Oklahoma, provides a good example. This company

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[3]Oliver S. North and Nan C. Jenson, "Gypsum," Minerals Yearbook, 1951, Bureau of Mines (Washington, D. C., 1954), p. 5.

[4]"Building a Better Tomorrow," p. 34.

has expanded its facilities through the years until at the present time it is actively operating plants to manufacture: gypsum products, plaster, wallboard, block, Hydrocal, lime, paint, asbestos shingles, asphalt roofing, felt paper, metal products, insulation board, mineral wool, and acoustical tile. The company owns timberlands and its own fleet of ships for foreign trade.

This expansion into other fields by the larger companies has done much to create a condition of economic stability and security. The large gypsum companies are no longer dependent on the building industry alone for their existence and prosperty. Recession in the construction field will hurt the gypsum companies, but will not cause a mass exodus of labor from the industry as in earlier years. The gypsum industry has indeed reached a state of maturity. Gone are the fumbling days of growth when the industry was groping in all directions not sure just what course to take in expansion. The gypsum industry in Oklahoma had its birth a little over a decade before the territory was proclaimed a state. Since that time the two have progressed together. Any industrial or residential expansion in the state was paralleled by similar progress in the gypsum industry. It is obvious then, that any future growth in the state of Oklahoma will produce a similar growth in the gypsum industry.

Future

The future of the gypsum industry in Oklahoma promises to be even brighter than the past or present. With the development of the vast resources of the great Southwest eventually will come increased industrialization and an influx of people from other areas seeking new opportunities here. New uses will expand the market for gypsum products.

The efforts that are being put forth by state agencies and local Chambers of Commerce to induce industry to move to Oklahoma, will continue to obtain results. During the recent war and the period since considerable expansion has been made. Already many industries have moved to Oklahoma. Probably the most noteworthy, in regard to the gypsum industry, has been the construction of paper mills at Pryor, Oklahoma, by the National Gypsum Company and the Certain-teed Corporation.[5] These mills will produce a tough, fibered liner paper used to cover gypsum wallboard. Both plants have a daily capacity of over 100 tons of liner paper which is shipped out to each company's gypsum plants in neighboring states.

This example of a gypsum related product would seem to show some indication on the part of business to move to Oklahoma. Paper mills are constructed by gypsum companies in areas only where there is a large market for their wallboard. Gypsum wallboard is a primary material used in building. Thus the construction of these paper mills at Pryor, both costing over $4,000,000, would seem to indicate their faith in Oklahoma's future growth. Neither of these two companies are newcomers to the gypsum industry. Together with the United States Gypsum Company they constitute the "Big Three" of the gypsum industry.[6] Should the future growth of Oklahoma warrant it, Certain--teed and National Gypsum (referred to affectionately in the industry as "Little Gyp") to expand their gypsum operation into Oklahoma, they would join with the United States Gypsum Company (referred to as "Big Gyp") to represent the three greatest names in the gypsum industry all in operation within our state.

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[5]"Industry Growth Marks 1952," Resourceful Oklahoma, Vol. 3, No. 9, Oklahoma Planning and Resources Board (Oklahoma City, September, 1952), p. 4.

[6]"All Quiet on the Gypsum Front," Business Week, (April 8, 1939), p. 32.

Other related businesses and consumer industries have begun to realize the advantage of location in the Southwest. Oklahoma is close to the geographical center of the United States (located in north central Kansas) which enables industries to ship to any area of the nation with equal facility. Then, too, the center of population of the country is moving toward Oklahoma (it is now located in eastern Illinois). These factors, and others, have materially changed the situation that forced the industrialists of thirty years ago who were looking for new sites for location of their industries to seek marketing concentration.

Aside from the locational advantages of Oklahoma, the availability of fuel and adequate transportation facilities will play a large part in bringing in industry. Since the great oil and gas development of Oklahoma, the state has become criss-crossed with pipe line carrying low-cost fuel (natural gas) to all parts of the state, and railroad facilities have been expanded.

Some of the advantages of locating an industry in Oklahoma have been pointed out because of their importance to the gypsum industry. In order to prosper, producers must have an adequate market for their products. The very nature of gypsum—its abundance in nature and its weight in bulkiness—have made it prohibitive to ship most gypsum or gypsum products long distances overland. However, today, the products from Oklahoma are shipped to every state and abroad. Nevertheless, the gypsum industry in Oklahoma must depend on the home market area for a part of their trade, particularly for the cheaper products.

Within this market area, in cities such as Tulsa, Oklahoma City, producers within the state would have a natural advantage. Gypsum plants more distant from Tulsa and Oklahoma City would have to pay added freight costs. The reverse is true, of course, when Oklahoma producers are forced to ship their products to outside areas and compete with products from mills close to those markets. It is true, of course, that since the larger companies are national or international in size they can distribute special products throughout their total territory.

In many cases it would be impractical to ship gypsum products, manufactured in Oklahoma to eastern markets because of the competition that would be encountered from products produced by mills in New York, Virginia, and Pennsylvania. Markets in the Middle West, especially in the Chicago, St. Louis, and Kansas City trade areas are accessible to supplies from Ohio, Michigan, Iowa, and Kansas rather than from Oklahoma. To the south, Oklahoma-produced gypsum must compete with that from Texas. To the west there are no large markets until the Pacific Coast region is reached, and this area normally is supplied by mills in Utah, Nevada, and California. To the northwest, the mills of Wyoming and Montana amply meet most needs. Gypsum in the future will be confronted with many of the problems which have faced the industry in the past. However, new factors could enter the picture in the future which could produce different results, probably a result of new discoveries leading to new uses.

Because gypsum is so abundant in nature, man will continue to create new uses for this relatively cheap mineral. The possibility of manufacturing sulfuric acid and highly technical and specialized products, which can stand the expense of shipping to other areas, will bring about increased consumption.

Products are being manufactured at the present time at Southard which possess certain qualities of whiteness and purity that gypsums in some other areas do not possess. In such cases they can successfully compete even overseas. Shipment of such products to distant places such as Saudi Arabia, New Zealand, and Alaska are reported.[7]

It is by the production of special products, plus the prospect of an increased population number within its market area, that the future progress of the gypsum industry in Oklahoma depends. Fortunately, the abundance and quality of new materials foster continued production or even growth of the industry.

Summary

The story of the growth of the gypsum industry has been a part of the history of the growth of America. When early pioneers began to push westward from the original thirteen colonies, the gypsum industry followed suit. In some cases, such as its early development in Oklahoma, the gypsum mills were quickly erected in anticipation of the greater settlement of the state. Probably no other industry more closely reflects the growth of America than does the gypsum industry.

Aside from the role that gypsum has played in developing America, credit must also be given to the part that our country has played in the development of gypsum. Although the early Egyptians, Greeks, and Ethiopians knew about the use of gypsum in one form or another, it remained for a highly industrialized country, like the United States, to develop the many uses for which it is exploited and manufactured today; and it required a country with a high standard of living and an expanding population to best put these products to use.

The quality of gypsum which enables it to recombine with water and to harden into its rock-like state again has been the chief characteristic

[7]W. Dale Reynolds, Personal Interview (July 13, 1954).

of the mineral which has determined its use. But gypsum has been developed to the point where it is widely used in a number of different industries. In everything from chocolate candy, which may cause tooth decay; to toothpaste, which may prevent it; to dental plasters to form the molds which enable one to start the cycle all over again, gypsum has continued to serve man in an ever-increasing number of uses.

The plants that make these products have also undergone a change. Gone are the large numbers of plaster mills which produced only one or two finished products. Today the trend is toward fewer plants, but with greater mechanization and diversification. The result is a far greater range of finished products produced from each individual plant than was ever thought possible in earlier times.

The gypsum industry in Oklahoma has reflected the changes brought about by the desire for mechanization and diversification in the industry. From an ambitious beginning which saw twelve mills in operation in the state by 1910, to the present, the industry though decreasing in the total number of those in operation, has continued to increase in stature until today it is enjoying an era of stability and prosperity unknown in the earlier days of operations in the state.

This modernization of plants and products reached an all-time high in the period following World War II. Any expansion of plant facilities was impossible during the War. When the War was over the industry rapidly prepared itself for the biggest building "boom" in the nation's history.

Although there was a shortage of gypsum building materials immediately after the War, supplies have once more begun to accumulate. While construction activities show signs of leveling off, the total consumption of gypsum products continues to increase.

The gypsum industry promises to have a bright future for some years to come. Because gypsum is so closely related to the construction field, the high level of residential and industrial building will continue to increase the consumption of gypsum products for several years. At the same time chemists and engineers will be busy finding new uses for gypsum. Its fireproofing, insulating, and vermin-proofing qualities are significant in its utilization.

Oklahoma, because of its central location, promises to play an important part in the future growth of the gypsum industry. High quality of Oklahoma gypsum plus a reserve of over 125,000,000,000 tons will further strengthen the position in this field. Despite these advantages, however, the future development of the gypsum industry in Oklahoma will depend on increased consumption and discovery of new uses for gypsum products.

BIBLIOGRAPHY

General

Debo, Angie. Oklahoma Foot-loose and Fancy-free. Norman: University of Oklahoma Press, (1949).

Encyclopedia Americana. New York: Americana Corporation, Vol. 13, (1953).

Gould, Charles N. Geography of Oklahoma. Oklahoma City: Oklahoma Herald Publishing Company, (1908).

Keso, Edward E. Conserving Our Resources. Oklahoma City: Times-Journal Publishing Company, (1946).

Ladoo, Raymond B., and Myers, W. M. Nonmetallic Minerals. New York: McGraw-Hill Book Company, (1951).

Moore, Raymond C. Introduction to Historical Geology. New York: McGraw-Hill Book Company, (1949).

Morris, John W. Oklahoma Geography. Oklahoma City: Harlow Publishing Corporation, (1953).

Oklahoma Almanac. Oklahoma City: Oklahoma Publishing Company, (1931).

Tilden, Freeman. The National Parks. New York: A. F. Knopf Company, (1951).

Twenhofel, William H. Treatise on Sedimentation. Baltimore: The Williams and Wilkins Company, (1926).

Periodicals

Adams, John E., et. al. "Standard Permian Section of North America," American Association of Petroleum Geologists, Vol. 23, (November, 1939).

"All Quiet on the Gypsum Front," Business Week, (April 8, 1939).

"A Natural Rock Flower," Science-Supplement, Vol. 68, (July 13, 1928).

"Annual Gypsum Production," Rock Products, Vol. 57, No. 1, (January, 1954).

Evans, Noel. "Stratigraphy of Permian Beds of Northwestern Oklahoma," American Association of Petroleum Geologists, Vol. 15, (April, 1931).

Farnsworth, Marie. "The Hydration of Anhydrite," Industrial and Engineering Chemistry, Vol. 17, No. 9, (September, 1925).

Gould, Charles N. "A New Classification of the Permian Redbeds," American Association of Petroleum Geologists, Vol. 8, (June, 1924).

Green, Darcie A., et. al. "Stratigraphy of the Permian in Oklahoma and Kansas," American Association of Petroleum Geologists, Vol. 21, (December, 1937).

Grimshaw, Robert. "Industrial Applications of Gypsum - I," Scientific American-Supplement, Vol. 95, (October 6, 1906).

Grimshaw, Robert. "Industrial Applications of Gypsum - II," Scientific American-Supplement, Vol. 95, (October 6, 1906).

"Gypsum," Pit and Quarry, Vol. 45, (January, 1953).

"Gypsum as a Drying Agent," Science-Supplement, Vol. 75, (January 26, 1934).

"Gypsum at War," Business Week, (July 8, 1944).

"Gypsum Plaster in Radiant Heating Systems," Architectural Record, (November, 1953).

"Gypsum Price War?" Business Week, (March 11, 1939).

Mohr, C. L. "Subsurface Cross Section of Permian from Texas to Nebraska," American Association of Petroleum Geologists, Vol. 23, (November, 1939).

Muir, J. Lawrence. "Anhydrite-Gypsum Problems of Blaine Formation, Oklahoma," American Association of Petroleum Geologists, Vol. 18, (October, 1934).

Nelson, Eugene W. "The Rock Nobody Knows," Nature Magazine, Vol. 44, (December, 1951).

Pedrotti, Marco. "Gypsum and its Utilization," Scientific American-Supplement, Vol. 96, (February 23, 1907).

Pedrotti, Marco. "Gypsum Plaster and Gypsum Products as Building Materials," Scientific American-Supplement, Vol. 97, (July 13, 1907.

Sawyer, Roger W. "Areal Geology of a Part of Southwestern Oklahoma," American Association of Petroleum Geologists, Vol. 8, (June, 1924).

"The Fineness of Calcined Gypsum," Scientific American, Vol. 124, (June 11, 1921).

"The Manufacture of Plaster of Paris or Stucco," Scientific American-Supplement, Vol. 62, (August 4, 1906).

"Versatile Gypsum," Scientific American, Vol. 169, (July, 1943).

Wilder, Frank A. "Some Conclusions in Regard to the Origin of Gypsum," Bulletin of the Geological Society of America, Vol. 32, (December 1, 1921).

Winslow, David C. "Army Paradise--White Sands National Monument," National Parks Magazine, Vol. 17, No. 72, (January-March, 1943).

Employee Handbooks

"Adhesion of Gypsum Plaster to Various Backings," Gypsumist, United States Gypsum Company, Chicago, Illinois, (December, 1925).

"Agricultural Gypsum in Texas and Oklahoma," United States Gypsum Company, Chicago, Illinois, Bulletin IGL-AG-45, (September, 1953).

"Agricultural Gypsum Will Clear Muddy Farm Ponds," United States Gypsum Company, Chicago, Illinois, Bulletin IGL-AG-47, (October, 1953).

"Building a Better Tomorrow," United States Gypsum Company, Chicago, (1952).

"Home Use of Agricultural Gypsum in the Southwest," United States Gypsum Company, Chicago, Illinois, Bulletin IGL-AG-43, (July, 1953).

"Marion One Yard Machine Handles Entire Production at Oklahoma Gypsum Quarry," The Marion Groundhog, Vol. 25, No. 6, Marion Power Shovel Company, Marion, Ohio, (December, 1952).

"Mineral Wealth in the Friscobelt," Saint Louis-San Francisco Railway, Saint Louis, Missouri, (1943).

"Southard is Special," Gypsum News, United States Gypsum Company, Chicago, Illinois, (July, 1953).

"Southard is Special," Gypsum News, United States Gypsum Company, Chicago, Illinois, (August, 1953).

"Stucco Exteriors in Italian Architecture," Gypsumist, United States Gypsum Company, Chicago, Illinois, (February, 1925).

Government Publications

Adams, G. I., et. al. "Gypsum Deposits in the United States," U. S. Geological Survey, Bulletin 223, (1904).

Arundale, Joseph C., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1948).

Arundale, Joseph C., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1949).

Berger, Ernest E. "Calcium Sulfate Retarders for Portland Cement Clinker," U. S. Bureau of Mines, Technical Paper 451, (1929).

Harness, Charles L., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1946).

Houk, Lawrence G., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1947).

Moyer, Forrest T. "Gypsum and Anhydrite," U. S. Bureau of Mines, Information Circular 7049, (February, 1939).

North, Oliver S., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1950).

North, Oliver S., and Downey, M. G. "Gypsum," U. S. Bureau of Mines, Minerals Yearbook, (1951).

Santmyers, R. M. "Development of the Domestic Gypsum Industry, by States," U. S. Bureau of Mines, Information Circular 6173, (October, 1929).

Statistical Abstract of the United States, U. S. Department of Commerce, (1953).

Stone, R. W., et. al. "Gypsum Deposits of the United States," U. S. Geological Survey, Bulletin 697, (1920).

State Publications

Burrill, Meredith F. "A Socio-Economic Atlas of Oklahoma," Agriculture Experiment Station Miscellaneous Paper, Oklahoma Agricultural and Mechanical College, Stillwater, (June, 1936).

Burwell, Albert L. "Oklahoma Fuels and Minerals for Chemical Industry," The Hopper, Oklahoma Geological Survey, Vol. 13, No. 1. Norman, (January, 1953).

Butcher, Virginia. "Gypsum," The Hopper, Oklahoma Geological Survey, Vol. 11, No. 8. Norman, (August, 1951).

"Certain-teed Paper Mill Producing," Resourceful Oklahoma, Vol. 3, No. 9. Oklahoma Planning and Resources Board, Oklahoma City, (September, 1952).

Dott, Robert H. "Geology and Industrial Minerals of Oklahoma," The Hopper, Oklahoma Geological Survey, Vol. 10, No. 10. Norman, (October, 1950).

Forty-Fifth Annual Report of Mines and Mining in Oklahoma, Department of Chief Mine Inspector, Oklahoma City, (June 30, 1953).

Freie, A. J. "Sedimentation in the Anadarko Basin," Oklahoma Geological Survey, Bulletin 48. Norman, (January, 1930).

Gould, Charles N., et. al. "Construction Materials of Oklahoma," Emergency Relief Administration, Project No. 5-F2-89, (1934).

Gould, Charles N. "Gypsum," Oklahoma Geological Survey, Bulletin 5. Norman, (November, 1908).

Gould, Charles N. "Index to the Stratigraphy of Oklahoma," Oklahoma Geological Survey, Bulletin 35. Norman, (September, 1925).

"Gypsum Industry is Vital Business for State Town," Resourceful Oklahoma, Vol. 1, No. 6. Oklahoma Planning and Resources Board, Oklahoma City, (June, 1950).

"Industry Growth Marks 1952," Resourceful Oklahoma, Vol. 3, No. 9. Oklahoma Planning and Resources Board, Oklahoma City, (September, 1952).

Oklahoma's Metallic and Nonmetallic Minerals, Oklahoma Planning and Resources Board, Oklahoma City, (1952).

Six, Ray L. "Oil and Gas in Oklahoma, (Blaine, Dewey, Custer, and Roger Mills Counties)," Oklahoma Geological Survey, Bulletin 40-UU. Norman, (May, 1930).

Suffel, G. G. "The Dolomites of Western Oklahoma," Oklahoma Geological Survey, Bulletin 49. Norman, (January, 1930).

Warren, John H. "Preliminary List of Oklahoma Mineral Producers," The Hopper, Oklahoma Geological Survey, Vol. 14, No. 5. Norman, (May, 1954).

Personal Letters

Butemeyer, Don. Employment Supervisor, United States Gypsum Company, Southard, Oklahoma, (July 7, 1954).

McFarlin, M. L. Secretary, Chamber of Commerce, Watonga, Oklahoma, (July 12, 1954).

Powell, C. C. Supervisor, Advertising Department, United States Gypsum Company, 300 West Adams Street, Chicago 6, Illinois, (July 12, 1954).

Walton, S. A. Owner, S. A. Walton and Sons, Okeene, Oklahoma, (July 7, 1954).

Personal Interviews

Gorby, P. E. Superintendent, Universal Atlas Cement Company, Watonga, Oklahoma, (July 13, 1954).

Nease, W. W. Secretary, Chamber of Commerce, Okeene, Oklahoma, (July 13, 1954).

Reynolds, W. Dale. Quality Department Superintendent, United States Gypsum Company, Southard, Oklahoma, (July 13, 1954).

Walton, S. A. Owner, S. A. Walton and Sons, Okeene, Oklahoma, (July 13, 1954).

Newspapers

"Blaine Finds Road Material at Home," The Daily Oklahoman, Oklahoma City, (May 23, 1954).

"Oklahoma is Vast Mineral Reservoir," The Daily Oklahoman, Oklahoma City, (March 1, 1953).

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