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Experiment Station

BULLETIN NO. 5, JANUARY 1893.

Some Soil Analyses.

STILLWATER, OKLAHOMA.

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Oklahoma Experiment Station,

STILLWATER,

PAYNE COUNTY, OKLAHOMA.

BULLETIN NO. 5, JANUARY, 1893.

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BULLETIN NO. 5.

SOME

SOIL ANALYSES.

Analyses by GEO. L. HOLTER, B. S. Chemist.
Comments by J. C. NEAL, Director.

The Oklahoma Experiment Station intends to collect as rapidly as practicable, samples of all the soils of the Territory, analyze them and eventually publish an exhaustive Bulletin, which will be of value, to the farmer, the nurseryman, the gardener or the dairyman, in determining to a great extent their future action in selecting crops and plans to obtain the best results.

These samples will be collected and examined by the uniform method adopted by other Stations, and thus the analyses can be readily compared.

Three soils with their subsoils have been obtained, and they may be regarded as typical for the part of Oklahoma in which the Experiment Station is located.

DESCRIPTION.

The general contour of this section is that of a very undu-

lating surface; terraces, hill upon hill, ancient water levels, enclosing shallow basins, evidently formed by the juncture of creeks and rivers.

Isolated tower-like masses of sand rock occasionally occur, though generally the rock crops out at the highest points, or forms broad shelves at the bases of the clay hills.

The streams are as a rule narrow, rapid and exceedingly crooked, with very steep banks. The alluvial "first bottoms" are subject to overflows when the heavy rains of spring and autumn occur, every gorge or "draw" becoming a torrent for a few hours.

These "bottoms" are often heavily timbered with pecan, oaks, hickory, walnut, ash, redbud and cottonwood, with occasionally an elm or box elder. The undergrowth is sumach, dogwood, elder, haw and wild plum, with green briar and wild grape vines.

The second, third and fourth plateaus are fairly good farming lands, loamy or gravelly, occasionally with beds of water-worn pebbles, marking an ancient stream whose muddy current brought these fragments from regions further west and north and left them in the eddy at the base of the terrace bank, while "black jack" clay ridges show the deposit of quieter waters perhaps at the same time.

But little is known of the minerals of this region; *limonite*, iron ore, is found in great masses on the surface near the Station, and crystalized gypsum is very plentiful. There are indications of lead, zinc, copper and coal in places, and naturally enough, the finders are quite reticent in giving locations.

The botany of this part of the Territory has not been well studied, and details cannot yet be given. The common grasses, in order of figuring, are: Blue Stem and Blue Joint *Agropyrum*, Grama and Bunch grass—*Bouteloua* and *Buchloe*—Bent grass, *Agrostis*; Panic grass, *Panicum*; Dropseed—*Sporobolus* and *Muhlenbergia*—Reed grass, *Deyeuxia*; Meadow grass, *Poa*; and Poverty grass, *Aristida*.

These furnish a thin covering for the soil except in the damp draws or *arroyos*, but in no place do they furnish a good sod or sward.

In the early part of the year the prairie is gay with flowers, conspicuous among which are Rattleweed, *Astragalus*; Sorrel, *Oxalis*; Prairie Clover *Petalostemum*; Sensitive Brier *Schrankia*; Partridge Pea, *Cassia*; Onion, *Allium*; Spiderwort, *Tradescantia*; Evening Primrose, *Enotherz*; and Milkweed, *Euphorbia*, with dozens of smaller plants that make up in masses of color what they lack singly in showiness.

The occurrence of vast quantities of gypsum, the alkali spots, and the great amount of soda, as shown by analysis, is proof that this section once was the bed of an inland ocean. There are no fossils in the sandstone, and but little dip or inclination to the strata, where exposed in the banks of creeks or arroyos. The little we know of the stratification comes through the records kept by well diggers in this vicinity.

These report as an average:

Tillable soil—8 inches to 2 feet.
Yellow or red clay—3 to 5 feet.
Black or red shale—7 to 10 feet.
Red or white sand rock—15 to 20 feet.
Red shale—4 to 6 feet.
White shale with bands of hard rock—14 to 30 feet.
White or red sand-rock—2 to 6 feet.
Red shale—50 to 60 feet.
White sand rock—30 to 50 feet.

The shales are very free from grit, often nearly as hard as slate, occasionally very soft and damp. Water is usually found above or in the sand rocks, alkaline if it occurs in red shale, salty, if below 100 feet from the surface, and with traces of petroleum below 150 feet.

The sand rock is often little more than sand, with bands of very hard, dark "iron rock," though in places the sand has become so compressed and agglutinated as to be a superior grit, suitable for grindstones, yet easily sawed and dressed while fresh, but quite hard and durable when free from quarry moisture.

Scattered over all these elevations are alkali spots.

These out-crops of clay are irregular in size and shape, often depressed a few inches below the general level, usually bare or covered with a scanty growth of cacti or bunch grass, *Bouteloua*; where bare they are often with a salty efflorescence.

The translation of the percentages into pound values are based upon the assumption that an acre of soil one foot deep weighs four million pounds.

ANALYSES.

No. 7. Virgin, Upper Soil, Station Farm.

Fineness, 63.13 per cent. does not pass through a seive of .5 millimeters mesh (0.019685 inch in diameter). 36.87 per cent. passed through the seive. No chlorine; trace of effervescence with acid.

	Per Cent..	Lbs. per Acre.
Water and Volatile Matter	4.10 . . .	164.000
Soluble Silica	7.76 . . .	310.400
Insoluble Silica	79.99 . . .	3,196.000
Lime, Ca. O	.95 . . .	38.000
Magnesia, Mg. O	.21 . . .	8.400
Soda, Na^2 O	.31 . . .	12.400
Potash, K^2 O	.44 . . .	17.600
Manganese, Mn^3 O^4	.07 . . .	2.800
Iron Oxide, Fe^2 O^3	3.40 . . .	136.000
Clay, Al^2 O^3	2.78 . . .	111.200
Sulfuric Acid, SO^3	.15 . . .	6.000
Phosphoric Acid, P^2 O^5	.06 . . .	2 400
Humus	.51 . . .	20.400

Comments.

This is perhaps the best grade of soil on the Station farm, and represents a fair quality of land usually found on the

second plateau of rivers and creeks, north of the Cimarron river.

Its color is a warm chocolate brown, gradually becoming a dark red to the subsoil. It dries readily after rain, is easily worked and gives fairly good crop results. It is but slightly alkaline, and would be classed as a good loam in the eastern States, as it compares very well with most soils east of the Mississippi river in its percentages of the principal fertilizing essentials for plant growth, potash and humus, though not as rich in these as the bottom lands of California or Wyoming.

The weak points in this soil are the notable deficiencies in lime and phosphoric acid, but these low percentages should be expected, seeing that the soil is disintegrated sandstone, and that where lime does exist, it is in a very insoluble form, crystalized sulfate.

In the near future it is likely that there will be a demand for such fertilizers as bonemeal and acid phosphate of lime, as well as green crops to be turned under for humus.

Could there be no loss, there is perhaps enough of all ingredients in the soil to develop thirty full wheat crops, but by leaching and chemical action, these soil constituents may waste, till in a few years the crops will become too small to pay for the labor, the soil being exhausted, in a relative sense, hence the utility of adding these fertilizing agents after taking off a crop, to replace the loss.

No. 8. Subsoil of No. 7.

One to three feet below surface. Coarse materials greater than .5 millimeters (0.019685 inch) 97.52 per cent. Fine material less than .5 millimeters, 2.48 per cent. Trace of chlorine. Does not effervesce with acid.

	Per Cent.	Lbs. per Acre.
Water and Volatile Matter	2.92 . . .	116.800
Soluble Silica	13.10 . . .	524.000
Insoluble Silica	70.52 . . .	2820.800
Lime, Ca. O	.86 . . .	34.400
Magnesia, Mg. O	.26 . . .	10.400
Soda, Na^2 O	.33 . . .	13.200
Potash, K^2 O	.45 . . .	18.000
Manganese, Mn^3 O^4	.08 . . .	3.200
Iron Oxide, Fe^2 O^3	4.31 . . .	172.400
Alumina, Al^2 O^3 (clay)	7.33 . . .	293.200
Sulfuric Acid, SO^3	.11 . . .	4.400
Phosphoric Acid, P^2 O^5	.04 . . .	1.600
Humus, ...	.20 . . .	8.000

This subsoil is a bright red color, very tough and nearly impermeable to water. It shows an enormous increase of clay, iron and moisture, with diminished phosphoric acid and humus. The increase of soda and potash is slight, though apparently enough to make the clay into a weak "gumbo" or hard pan soil. Exposed to the air, this subsoil cracks badly, forming crust-like clods, however not so difficult to subdue as an alkali soil, and not very resistant to roots of trees that seem to penetrate it easily, as is seen upon examination. Subsoiling no doubt would greatly increase its value, without very much extra labor. Experiments now in progress, are being made by the Agriculturist to determine the value of subsoiling, tiling and trenching these soils, as well as the use of manures and crops for turning under.

No. 10. Alluvial, Virgin, Top Soil.

Coarse materials 57.15 per cent. greater than .5 millimeters.
Fine " 42.85 " " less " .5 "
Effervesces with acid, no chlorides, no sulphates.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter	3.69 . . .	147.600
Soluble Silica	5.65 . . .	226.000
Insoluble Silica	84.97 . . .	3388.000
Lime, Ca O	.44 . . .	17.600
Magnesia, Mg O	.16 . . .	6.400
Soda, $Na^2 O$	.48 . . .	19.200
Potash, $K^2 O$	.80 . . .	32.000
Manganese, $Mn^3 O^4$	.03 . . .	1.200
Iron Oxide, $Fe^2 O^3$	2.71 . . .	108.400
Alumina, $Al^2 O^3$	1.42 . . .	56.800
Sulfuric Acid, So^3	. . . .	
Phosphoric Acid, $P^2 O^5$	.04 . . .	1.600
Humus	.62 . . .	24.800

This is an extremely fertile, creek soil first bottom, color very dark brown, rather sandy, easily tilled. This land is covered with tall grasses, heavy undergrowth and some timber. The field is often covered with the overflow from the creek that is usually fifteen or more feet below the level of the banks.

Ten or more feet below the surface the soil seems as good as at the top, the layers being horizontal and parallel. Compared with the Station soil, there is an excess of sand, potash, soda, magnesia and humus, with a deficiency of clay, iron, lime, phosphoric acid and moisture, and utter absence of sulfuric acid—not easily explained.

But the crops grown on this land deserve especial notice. Two years from the sod it yielded twenty-eight bushels Fulz wheat per acre and fifty bushels corn, all of first quality. The next year the same land gave thirty-five bushels of wheat, sixty bushels of corn and fifty bushels of oats. Two years from the seed, peach and apple trees grew to be eight feet high, and other trees show equally as good growth. On such land, anyone should succeed in general farming and stock raising.

No. 11. Subsoil Below No. 10.

To the depth of two feet from the surface. Trace of chlorine. Slight effervescence with acids. Coarse materials 76.88 per cent. Fine materials 23.42 per cent.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter	1.82	72.800
Soluble Silica	7.95	318.000
Insoluble Silica	81.98	3,279.200
Lime, Ca O	.27	10.800
Magnesia, Mg O	.12	4.800
Soda, $Na^2 O$	.88	35.200
Potash, $K^2 O$	.76	30.400
Manganese, $Mn^3 O^4$	.06	2.400
Iron Oxide, $Fe^2 O^3$	3.11	124.400
Alumina, $Al^2 O^3$	3.32	132.800
Sulfuric Acid, SO^3	. . . . .	. . . .
Phosphoric Acid, $P^2 O^5$	.11	4,400
Humus,	.69	27,600

Color red brown, quite sandy and friable. In this we have a tremendous increase of soda, clay, sand and magnesia. A slight decrease of potash with an increase of lime and moisture, perhaps the result of leaching downward of the soluble salts. Still this subsoil is good, very tillable and easily penetrated by roots.

No. 12. Subsoil to No 11.

To three feet. Trace of chlorine, effervesces with acid, Coarse materials 67.08 per cent. Fine materials 32 92 per cent.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter,	2.18	87,200
Soluble Silica,	7.68	307,200
Insoluble Silica,	81.77	3270,800
Lime, Ca O	.32	12,800
Magnesia, Mg O	.18	7,200
Soda, $Na^2 O$	.39	15,600
Potash, $K^2 O$	1.21	48,400
Manganese, $Mn^3 O^4$	.03	1,200
Iron Oxide, $Fe^2 O^3$	3.07	122,800
Alumina, $Al^2 O^3$	3.33	133,200
Sulfuric Acid, SO^3	....	....
Phosphoric Acid, $P^2 O^5$	.05	2,000
Humus,	1.54	61,600

At the depth of three feet this soil is far richer than the best of the Station soil, having over three times the humus, and over two times the potash. Soils like these are practically inexhaustible if the plow runs deeper each season, or a system of trenching be employed to bring the rich subsoil to the surface.

No. 5. Virgin Top Soil.

Summit of a clay ridge on Station farm, northwest corner of northwest quarter of southwest quarter of northeast quarter of section 15, township 19, range 2 east. Coarse materials 58.62 per cent., fine materials 41 38 per cent. Effervesces with acid. Trace of chlorine. Color, dull red gray.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter	2.06 . . .	82,400
Soluble Silica	4.47 . . .	178,800
Insoluble Silica	87.91 . . .	3516,400
Lime, Ca O	.76 . . .	30,400
Magnesia, Mg O	.18 . . .	7,200
Soda Na^2O	.35 . . .	14,400
Potash, K^2O	.32 . . .	12,800
Manganese, Mn^2O^4	.05 . . .	2,400
Iron Oxide, Fe^2O^3	2.80 . . .	112.000
Alumina, Al^2O^3	1.05 . . .	42,000
Sulfuric Acid, SO^3	.16 . . .	6,400
Phosphoric Acid P^2O^5	.06 . . .	2,400
Humus	.51 . . .	20,400

This alkali spot is very scantily covered with dwarf bunch grass, *Bouteloua*, and prickly pears. Very little in the analysis suggests the utter uselessness of this soil. In humus it stands far above the average of soils like No 7. In the other essentials, potash and phosphoric acid, it is fully the equal of most of our bottom lands, but the lack of lime and clay, and the excess of soda renders it practically barren.

After a rain it bakes to a tough crust, cracks and becomes covered with a frost like efflorescence of the soluble salts of soda, potash and magnesia. Glauber salts—*sulfate of soda*, being the principal salt, with varying qualities of common salt, *sodium chloride*, epsom salts, *sulfate of magnesia*, baking soda, *soda carbonate*, and small quantities of potash chloride. Plowing this land only forms hard clods that no amount of harrowing and rolling will convert into tillable soil, and when ordinary land is easily worked, and becomes like an ashbed, this remains refractory, and though drained and manured

it has as yet baffled all our efforts to reclaim it.

These conditions occur from the excess of alkali, which consolidates the clay and hinders its becoming friable, despite its large percentage of humus and sand. Plants grown in this soil act as if frosted, turning yellow, and the stems rotting at the surface of the ground, probably from the corrosive action of the free alkali, or the ferrous, *iron*, salts that may be produced.

Fortunately for us, there is in Oklahoma an abundance of gypsum, that after burning and pulverization will be available for the cure of these alkali spots, especially where carbonate of soda, or ferrous salts are the causes leading to the barrenness. Land plaster, as the gypsum product is called, used liberally will in a great measure change both the character and the chemistry of these places.

Where the land contains chloride, as salt, thorough drainage will give great relief by washing out the excess of the alkali, or where the offending ingredient is copperas, alum or epsom salts, the use of lime, plaster and drainage will do wonders in "sweetening" the soil. The rainfall of this section —over 32 inches—is ample, with good drains, to flood much of this land so effected and wash out the soluble salts.

Many plants however do not seem to mind the excess of soda compounds, and the beets, turnips, cabbage, radish, carrot, castor bean, cotton, alfalfa and the sorghum family will succeed in many such places where everything else will fail.

Experiments along this line are to be tried this year for future reports.

No. 6. Subsoil to No. 5.

One to three feet below. Trace of chlorine. Effervesces strongly. Color, gray to yellowish, changing to red at the bottom. Coarse material, 94.84 per cent. Fine materials 5.16 per cent.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter	2.39	95.600
Soluble Silica	14.91	596,400
Insoluble Silica	65.13	2605 200
Lime, Ca. O	1.75	70,000
Magnesia, Mg. O	.26	10,400
Soda, Na^2O	.44	17,600
Potash, K^2O	.33	13,200
Manganese, Mn^3O^4	.11	4,400
Iron Oxide, Fe^2O^3	4.92	196,800
Alumina, Al^2O^3	9.09	363,600
Phosphoric Acid P^2o^5	.04	1.600
Sulfuric Acid So_3	.81	32,400
Humus	.53	21,200

This subsoil shows a rapid change with great increase of clay, iron and sulfuric acid. In fact this "gumbo" subsoil is a queer combination, making a sour, tenacious mass that utterly prevents penetration of roots, and will take years to sweeten and make of any value whatever.

No. 9. Alkali Flat.

Bottom land near No. 10 and on the same level. Trace of chlorine. No vegetation. Effervesces. Coarse material 83.71 per cent. Fine material 16.29 per cent.

	Per Cent.	Lbs. per Acre
Water and Volatile Matter	1.96	78,400
Soluble Silica	6.00	240,000
Insoluble Silica	82.87	3314,800
Lime, Ca O	1.06	42,400
Magnesia, Mg O	.06	2,400
Soda, Na^2O	.69	27,600
Potash, K^2O	.52	20,800
Manganese Mn^3O^4	.07	2,800
Iron Oxide Fe^2O^3	3.64	145,600
Alumina Al^2O^3	4.06	162,400
Phosphoric Acid P^2O^5	.03	1,200
Sulfuric Acid SO^3	....	....
Humus	.62	24,800

This soil is richer than its near neighbor No. 10, in humus manganese, iron, lime and clay, and greatly deficient in potash, with a tremendous excess in soda. This last no doubt is the disturbing element. In this case deep drains will carry off the excess of salts and the use of gypsum will cure the evil.

SUMMARY.

The analyses only serve as guides to a reasonable study of soils, they do not prove the soils fertile or otherwise.

No 9 is utterly worthless. No 10 adjoining is among our best soils.

A good "Hammock" soil from Florida gives 720 pounds Phosphoric Acid to the acre, 240 pounds Potash and 10,000 pounds Humus, the Alkali soil 1200 pounds Phosphoric Acid, 20,800 pounds Potash and 25.200 pounds Humus, but the Florida soil is very productive, the Oklahoma species of "Alkali" does not grow even cacti or ragweed. In this case the

Florida soil is so porous that the roots of plants easily reach the small percentage of fertilizing ingredients.

No. 10 is one of our best soils, practically as good at 15 feet below the surface as at the top. It shows up poorly with a California valley soil, having 6800 pounds Phosphoric acid, 66,400 Potash and 86,400 pounds Humus to the acre. Still there is some compensation, the valley soil [Napa] is stiffish and bakes hard in the ordinary heat of the summer, the Oklahoma soil is very free and easily worked.

Prof. Hilgard's conclusions are that to make a good soil requires at present .25 per cent lime .05 per cent Phosphoric acid .05 per cent Potash from .02 to .04 per cent of Sulfuric acid. This means 10,000 pounds Lime per acre, 2000 pounds Phosphoric acid, 2000 pounds Potash, 800 to 1600 pounds Sulfuric Acid and 12,000 pounds Iron oxide. Taking these figures as correct, even our poorest lands stand well. The weak points are easily supplied by Phosphates and Gypsum, and the most costly ingredient—Potash is in quantity to endure a generation or so.

FREE

OKLAHOMA

Experiment Station,

STILLWATER, O. T.

Director.