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Thesis

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T H E S I S

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- by -

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I N T R O D U C T I O N.

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All soil constituents are formed from the disintergation of rocks with the exception of a small percent. of organic matter. The soil is sometimes formed in situ, and, therefore rests directly upon the parent rock. Sometimes it is removed as fast as formed, by the action of water and air. Streams of running water, tides and waves, or the moving of immense ice fields called glaciers are the most active agencies. The land formed by the deposition of the materials carried by glaciers is usually known as drift. A large portion of the soil of the northwestern prairies has been formed in this way. Particularly is this true of the land lying east of the Missouri River in our own state. An immense field of ice swept down from the tops of the hills of the Height of Land and filling up the intervening valleys which, to-day, covered by grasses, flowers and trees and dotted here and there by farm houses and villages, constitute the great wealth of our state. The land west of the Missouri River is however of a different origin. It belongs largely to the Tertiary period. The land of the Coteans in the northeastern part of our state are terminal moraines. The Gumbo flats along the Missouri River are of sedimentary origin.

In this study of some of our peculiar soils, samples of soil from the Sioux Valley regions will be taken as typical soils of this state.

The first sample of soil was taken from the moisture plats of the Experiment Station. It is a compositive and represenative sample. Three compositive samples were taken; the first is a top soil taken to a depth of 12 inches; the second a mixed soil to an additional depth of 10 inches, and the third, the subsoil to an additional depth of 12 inches. These samples will be used as types and as standards of comparison.

This is a good farm land, producing good crops. It has been under cultivation for eighteen years and has received no fertilization except a few applications of barnyard manure. The top soil is a fine black loam about twelve inches deep, slightly inclined to be sandy. The mixed soil which is about ten inches deep consists of the top soil and subsoil mixed. It is of a reddish brown color and contains considerable clay. The subsoil is a yellow boulder clay, common throughout the greater part of the state.

The second sample was taken from the Sioux River bottoms, back about a mile from the River. This land is quite often overflowed by the river during high water. Two samples were taken. The first to a depth of about thirty inches and the second to a depth of an additional twelve inches. This land is very level. The top soil is a black loam, very rich in organic material, about thirty inches deep. The mixed soil contains considerable clay. This land has no boulder clay subsoil until a great depth is reached. The sample was taken from virgin soil.

The third sample consits of a sediment deposited by erosion. It is quite common on the western prairie of our state.

Sample four was sent in by the N. W. Railroad company. It is a cretacious formation and is loosely called gumbo. Both samples are worthless for agricultural purposes. No vegitation grows on number three and only a limited flora on number four.

Number five is a sample of gumbo from the plats west of the Missouri River, near Pierre. It is a representative sample of this type of soil. It has a vegetation peculiar to itself, consisting mainly of the Goosefoot family (Chenopodiacea), the Atriplex family, Chenopodium, etc.

Number six is a sample of pure cretacious clay taken from between layers of gumbo. This formation intersects the gumbo in striae varying from a mere trace to layers nearly two inches thick. These layers seem to be formed in sags of the gumbo.

Number seven is a sample of gum bo from land that is frequently overflowed by the Missouri River, lying just south of Bismark. The vegetation that thrives best on this soil consists of tall, heavy grasses and shrubs.

Number eight was taken from a wheatfield nine miles southeast of Bismark. It is a formation of gumbo very common in many parts of both North and South Dakota. This soil in its native condition bears no vegetation. When moist it is very plastic and upon drying cakes into a lump almost as hard as stone, contracting and causing large cracks to appear in it. When the land around these spots is cultivated the line of no vegetation decreases annually. There are many instances where this land has been entirely reclaimed, simply by the application of barnyard manure.

Number nine A is a sample of soil from the banks of one of the numerous springs near the head of Big Stone. No vegetation grows upon it. Its appearance is rather light grey, caused by the waters being highly charged with mineral substances which they deposit by evaporation. It is a composite sample taken to the depth of six inches.

Number nine B is a sample of subsoil taken to an additional depth of five inches.

Number ten A is a sample of dolomitic limestone soil, from the Coteans in the northeastern portion of the state. Where the prairies are very high, the vegetation is very scarce. Andropogon scoparius is the prevailing grass. Next in importance is one of the asters, Aster-plameracoides, one species of the pea(Kunistera caudita) is quite plentiful.

Number Ten A is surface soil taken to a depth of twelve inches; Number Ten B, mixed soil to an additional depth of six inches, and Number Ten C to an additional depth of five inches.

Chemical Constituents	Station Plats Surface	Station Plats Mixed	Station Plats Subsoil	Sioux River Bottom Surface	Sioux River Bottom Mixed	Leached Gumbo from R R	Gumbo from R R	Gumbo from Pierre
Insoluble Matter	81.5310	81.8800	76.9345	58.3860	81.3190	59.3710	79.0060	74.1800
Potash (K_2O)	.3523	.5989	.2124	.0907	.4807	.0281	.5619	.3675
Soda (Na_2O)	.4311	.7796	.5645	2.6095	.4205	.7769	1.8362	1.0638
Lime (CaO)	.9325	2.9945	1.7557	12.3445	3.8726	12.2310	.3088	1.2136
Magnesia (MgO)	.7727	1.0565	6.7750	1.8558	1.6304	.7608	1.3135	1.6718
Manganous Oxide (Mn_3O_4)	.0000	.0000	.0000	.0000	.0000	.0000	trace	trace
Ferric Oxide (Fe_2O_3)	2.9342	3.3130	5.0085	5.0085	2.6595	.1892	2.2525	5.9435
Alumina (Al_2O_3)	4.0258	4.9251	.1390	.1390	3.6009	2.8189	9.9914	8.4776
Phosphorous Pentoxide (P_2O_4)	.1600	.1919	.2430	.2750	.1321	.1119	.1876	.1439
Sulphur Trioxid (SO_3)	.1484	.1156	.4936	.4936	.1714	14.8360	.2849	.3776
Organic Matter	8.3600	4.1150	5.3130	14.5906	4.0001	7.5179	3.1040	4.2241
Carbon Dioxid (CO_2) + Loss	.3520	.0299	.3692	4.2164	1.7128	.3588	1.1572	.3666
Total	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000

Chemical Constituents.	Clay between layers of Gumbo	Gumbo from Bismarck	Gumbo from Bismarck	Alkaline Earth		Limestone Soil from high prairies		
				Surface	Mixed	Surface	Mixed	Subsoil
Insoluble Matter	53.0003	77.1050	87.5440	71.8050	53.8480	55.6265	55.7140	62.1850
Potash (K_2O)	.2965	.2527	.3187	.1669	.1592	.0875	.1621	.0771
Soda (Na_2O)	1.2656	1.9154	1.0645	1.5945	3.6702	.1958	.1874	.3118
Lime (CaO)	6.1209	2.6406	1.3011	5.5078	14.1837	13.0754	15.8138	13.0559
Magnesia (MgO)	2.9792	2.1779	1.0630	2.0486	.3290	2.6811	3.5459	1.2126
Manganous Oxid (Mn_3O_4)	.0300	.1200	.0000	.0000	.0000	.0000	.0000	.0000
Ferric Oxid (Fe_2O_3)	6.9857	4.0695	4.0696	2.87[illegible]	4.1450	3.1042	2.8821	3.5390
Alumina (Al_2O_3)	12.3531	4.8466	.3687	4.4427	4.8898	3.1349	2.0040	1.1158
Phosphorous Pentoxid (P_2O_4)	.1567	.3070	.2142	.2302	.3677	.1759	.1439	.0927
Sulphur Trioxid (SO_3)	10.3715	.1373	.0789	1.8918	1.5571	.2189	.6102	.1029
Organic Matter	6.8294	6.5743	4.[illegible]	8.9245	12.3246	13.7232	12.8273	16.6079
Carbon Dioxid (Co) + Loss	.0000	.0000	.0000	.5111	.5279	7.9766	6.1093	11.6993
Total	100.3889	100.2457		100.0000	100.0000	100.0000	100.0000	100.0000

In drawing conclusions from the chemical analysis of soils it is extremely difficult to point to one soil and say with any degree of precision that it is fertile, or that another one is not fertile, without having some knowledge of its physicial properties.and the climatic conditions of that region. The soils of some of our western deserts assume a fertility that is almost wonderful when supplied with the water, necessary to sustain plant life. Take, for example, the decomposed granite that ordinarily furnishes our best alluvial soil. Let the granules be reduced fine enough and you will have a soil that will puddle as bad as the despised , unproductive gumbo.

Again the amount of the different soluble chemical constituents of the soil changes from day to day, and will vary according to the time the sample is taken. During a season that is very wet, much of the magnesium, sodium, calcium and sometimes potassium salt will be dissolved by the percolating water and washed out of the surface soil to be caught and held by the subsoil. They will again be drawn back to the surface on account of their creeping tendencies and the capillary attraction.

The amount of insoluble matter under ½ mm. diameter varies greatly with the character of the soil. Speaking in general, it should not fall much below 80%. By an examination of the tables it will be found that sample 2A contained only about 68% of insoluble matter, yet it is a very productive, while samples 4A, 5 A, 7A, 8A contain from 74% to 87.5% and are soils that are practically barren. The reason for this is the size of the particles of sand. Sample 2A contains over 3% of grits larger than ½mm

in diameter, while samples 4A, 5A, 7A and 8A contain none. The insoluble matter in these consits almost entirely of silt. The consequence is that it "puddles" very readily and during dry seasons becomes nearly as hard as stone. Samples 3A, 6A, 9A, 10A, 10B and 10 C owe in part their barrenness to the lack of coarser insoluble material.

None of these samples show any marked peculiarity in the amount of potash they contain. In most cases it is nearly uniform in the surface, mixed and subsoil where the third the three samples were taken. The gumbo all show a fairly good percentage of this essential plantfood. In the soda however we notice a decided departure. Not only do some of the samples show an exceedingly large amount but where there were three samples taken there is a decided increase in almost every case the deeper we go. This is due to two properties of sodium salts. First, that they are all easily soluble, and second that they rise and fall with the fluctuation of the soil waters. These samples were taken immediately after a rain when large portions of the sodium salts would be found in the subsoil: but as the water upon the surface evaporates and that lower down is brought up by capillary attraction, the sodium salts are brought nearer the surface. This is also due largely to the creeping tendency of these salts.

These soils are all rich in calcium. In samples 3A and 6A it is largely in the form of sulfate or gypsum, as is also the case in samples 9A and 9B. In the last two samples, undoubtedly, some of the calcium is a combination with magnesia as the double carbonate or dolomitic soil as is plainly manifest by the large quantities of calcium, magnesium and carbon dioxide.

There is a large amount of magnesia present in all samples. The percent. usually varies with the depth at which the sample was taken and the time since a heavy rain-fall. This is explained in the same manner as the variations in the sodium. In sample 3A, 4, 5, 6, 7, and 8 it is present mostly in the form of sulfate; in the others, probably in the most cases, as carbonate.

In a few samples traces of manganos oxid were found, but in only two in sufficient quantity to premit a determination. Its presence or absence from a soil has little or nothing to do with soil fertility. It is not an essential plantfood, although some plants assimilate it.

The quantities of ferric oxide show but slight variation. Its occurence is of such slight importance that we make no discussion of it here

Alumina (Al_2O_3) forms the basis of clay. Clay is formed by the decomposition of feldspar, mica and a few other less important minerals. It gives strength, xxx waterholding capacity and elasticity to the soil, most of the gumbos contain quite a large percent. of it. Only one, sample 8A, fell below 4.84%. These soils do not contain it in sufficient quantity to injure them for plantgrowth.

None of these soils show any marked characteristics in the amount of phosporic acid they contain. Hilgard gives the maximum amount found in sandy loams as .30% and the minimum amount at .01% when there is plenty of lime present. The percent. of P_2O_5 does not in any case fall below .0927, and in one case reaches .3677%. The amount of sulfuric acid in three cases is exceptionally large, in 3A it reaches 14.8360%.

It is in the form of gypsum ($Ca\ S\ O_4$), Epsom salts ($Mg\ S\ O_4$), and glauber salts ($Na_2S\ O_4$). 8A contains 10.8715%, mostly in the form of gypsum, epsom salts, and glauber salts. 9B contains 5.5571% consisting probably very largely of sodium sulfate.

All the samples contain fair percentages of organic matter.

The large variations put down as carbondioxide ($C\ O_2$) and loss in samples 10A, B and C is due to the large amount of $C\ O_2$ in combination as the double carbonate of calcium and magnesium.

S U M M A R Y.

As I said in the introduction, sample 1 is a typicial upland soil. It belongs to the drift period and may be taken as a type of our common farmlands. It raises good crops of all cereals, and is well adapted for grazing.

Number 2 is a common bottom land, exceedingly fertile, and produces immense crops of wheat, oats, corn, etc. It will last many years without needing any fertilizer other than barnyard manure. It contains really more calcium than is necessary. The only place of weakness is in the potash.

Sample 3 A. is simply worthless from an agricultural standpoint. It contains large amounts of calcium sulphate, magnesium sulphate, and sodium sulphate. It is deficient in potash and in soluble material.

Samples 4A., 5A., and 7A. are closely related. The chief trouble is that the particles are so fine that the soil "puddles" readily. This might be relieved somewhat by the addition and thorough mixing with the soil of coarse sand, and somewhat by the application of large quantities of barnyard manure. The percentage of soda (Na_2O), however, is rather large. This is probably mostly present as the sulphate and might possibly be removed by good under-drainage. It is extremely doubtful however if anything can ever be done economically to reclaim the larger portion of the great gumbo plains. west of the Missouri River.

Sample 6A. is of such small extent that it will never have any economic value. The only marked percentage is the large amount of alumina

12.35%. There is no reason why it should not make a good soil, unless from a physical point of view the particles would be too small.

Sample 8A. can be entirely reclaimed by frequent deep plowing and subsoiling and the addition of barnyard manure.

Samples 9A. and 9B. represent a purely alkalie soil. It bears no vegetation. It is largely salts that have been left on the surface by the evaporation of highly charged mineral water.. It is very doubtful if any thing could be done to their land to improve it. Possibly by underdrainage and application of gypsum it might be ameliorated to some extent.

Sample 10 A., B., and C. is purely dolomitic soil. It contains too much carbonate of lime and magnesia. A good system of drainage, the application of barnyard manure and the growing of long-rooted leguminous plants, such as the clovers, might in time reduce it to a fair state of fertility. It would not be long however before it would be necessary to apply potash.