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CHEMICAL DEPARTMENT.

The Soils of Oregon.

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THE SOILS OF OREGON

Geologically and Chemically Considered.

By G. W. SHAW.

Considerable time was spent last year in the Chemical Department of the Station in some investigations concerning Oregon soils. This work was undertaken because a knowledge of the soil, with its characteristics, lies at the very foundation of agricultural progress, and for this reason also it is too important a branch to be longer neglected. This fact is also being realized by other Stations throughout the country and they are now turning their attention to this line of work among the most prominent of which may be mentioned Maryland, Louisiana, and California.

A second reason for undertaking the work was that the data obtained might be used in a more complete agricultural and mineral survey of the State which it is hoped the Station may conduct as fast as the funds will allow.

It is well known that as to the benefits to be derived from *soil analysis alone* chemists are divided, while it is doubtless true that the general public attaches undue importance to it. The two opinions are held by equally strong adherents. The main ideas advanced by the opposition are the impossibility of securing a sample which will represent a general average; the difficulties in establishing a rule for determining deficiencies of plant food, because of the very material difference in the physical properties of the soil. The other side is equally ardent in the claim that there are vast tracts of land in the various states which are practically the same, of nearly uniform composition and physical condition, and that if a sufficiently large number of analyses are made, it is possible to establish a minimum limit for plant food elements. Prof. Hilgard, of the California Station, has shown that this is undoubtedly true of "virgin soils."

The opinions of the first class were the outgrowths of incorrect views put forth in the beginning of agricultural chemistry, and from the fact

NOTE.—The writer wishes to express his thanks to Mr. Dumont Lotz, the assistant chemist, for the excellent manner in which he has performed the greater part of the analyses given in this Bulletin.

that the results obtained were upon the worn out soils of the east and Europe. When, however, attention was directed to the soils of our newer states and territories, a different question was involved, and the translation of results obtained from *chemical and physycal examinations combined* became a different matter.

In our western states, farmers, as a rule, have hardly brought their wild lands under cultivation, and the lands not having been exhausted, artificial fertilizers are very little used, but of late there has been an increase in the number of inquiries concerning them. Twenty years hence a scientific knowledge of fertilizers and the various soils will be necessary to successful farming in many portions of the northwest. Again, the methods of dealing with our alkaline soils is a problem which of itself presents a broad field for study, and together with this comes a study of the irrigating waters of the State.

We see the necessity of thus early in the work beginning to investigate along the above lines, and especially as to the mechanical and chemical condition of the soil.

The complete study of these questions is one involving a number of years and only a portion can be carried on at once. This Bulletin, then, simply sets forth the results so far obtained without attempting to draw definite conclusions, which must be left till more data can be obtained and comparisons made.

During the year several times we have been asked why the Station did not put in simple form some scientific facts concerning agriculture that the Bulletin readers in the State might the better understand some of the underlying principles with which the scientist has to deal. The law establishing the Station also states this as one of the functions of the workers, "to diffuse among the people useful and practical information on subjects connected with agriculture." In connection with the data of this Bulletin, then, is given some of the recognized facts with reference to soils and their relation to agriculture with the hope that they may be of service to some farmers.

Geology and Agriculture.

The subjects chemistry, geology and agriculture are so closely bound to each other that it is almost impossible to deal with one without crossing the line into the others. Although the rocks of any given formation may be quite different petrographically from others of the same formation, yet there are certain laws governing the different ages which furnish a comparatively safe guide in deciding to what general class soils belong. When the term "soil" is used it must be borne in mind that the word may be taken in two senses, the one meaning simply that medium in which plants grow; the other, and the more perfect definition, implying not only that medium, but also that from which is derived more or less plant food. It is in this latter sense that we speak of the soil in this Bulletin.

The surface of a country is divided by geologists into divisions according to the nature and characteristics of the rocks from which it is formed. The composition of each group of rocks is found to be quite uniform and underneath their respective soils are found outcropping the various divisions of the rocks themselves.

ORIGIN OF SOILS.

Soils are formed by the natural disintegration of rocks, and signify that portion of rocks which after it has rotted down has been permeated by the air (and mixed with organic matter), and thereby has been changed, for the most part, to a class of compounds known as oxides, which are compounds of the various elements found in the rock with the oxygen of the air which plays a very important part in the disintegration of the rock. By the formation of these compounds the cohesion is weakened and the minerals making up the rock fall apart, and finally are worn to an inpalpable powder. Another very active agent in the decomposition of rocks is the carbon dioxide found in the atmosphere—that gas so necessary to plants and thrown off from the lungs of animals as a waste product.

This pulverization and decomposition is known as "weathering" and the various agents concerned are water, air, rain, wind and frost, which are constantly at work on the earth's surface. In the formation of soil cultivation and vegetation also assist very materially, since they expose fresh surfaces to the action of the various agents. Of course the more rapid changes take place near the surface, but the action is extended even to the hard rock, which becoming exposed to frequent alterations of dryness and moisture soon crumbles to fragments. In this connection the mechanical action of falling rain must not be forgotten, which, especially when heavy, washes away great quantities of surface soil leaving fresh surfaces exposed to the formative agents. In short suffice it to say that by the combined chemical and mechanical action of all these forces the parent rock is changed into the plant supporting soil. This is well illustrated today in the formation of the hard volcanic lavas of comparatively recent eruptions in our own State.

Soon after disintegration has begun the simplest form of microscopic vegetable life begins, and every where the soil is teeming with a great variety of forms of life which assist in preparing the soil and making it suitable for the various crops. Although the individuals producing these important changes are extremely small their countless numbers fully compensate for their size. When the organisms have done their work they die and their remains are left to form the necessary organic matter in the soil. From the putrefaction of these, and other vegetable accumulations, is formed a mold called black "humus."

During the decay of this matter the carbon unites with the oxygen to form carbon dioxide; the hydrogen unites with the nitrogen to form ammonia; and the ammonia undergoes further change resulting from the action of minute oxidizing germs which change the ammonia into nitric acid. This process of nitrification resulting in the conversion of ammonia into nitric acid through the action of living microbes, occurs only in the upper strata of the soil where access of oxygen for supporting the existence of the acting organisms is greatest; and is of a necessity increased by the porosity of the soil and by exposing new surfaces to action. The most recent Rothamstead experiments demonstrate that little or no nitrification occurs in the subsoil; 2-3 feet being evidently the extreme depth at which the phenomenon occurs. The nitric acid of the soil below this depth is doubtless carried thither in the drainage or by diffusion.

The depth at which nitrification may occur, however, is capable of considerable variation, not only because of the physical condition of the soil, and access of oxygen, but depends largely on the chatacter of the crop grown ; leguminous plants, like the vetch and the clover, seeming to possess the property of considerably increasing not only the depth at which the transformation may occur, but also the activity of nitrifying organisms. *

Just how these plants bring about this change is not well understood, but this general fact is of vast agricultural importance, and has given this group of plants—the leguminoseæ—the term of "nitrogen gathers."

There are a large portion of our soils that are not formed by decomposition of rocks in place, but are the results of water deposition, either fresh or salt, being made of material prepared elsewhere and finely abraided from erosive action. In all running water fine material is carried to a lower level and the streams are continually moving soils from one place to another. These "alluvial soils," or "bottom lands," are of the most fertile nature from reasons which are very obvious.

CLASSIFICATION AND COMPOSITION.

The great bulk of soils is sand and clay and upon the variable amounts of these materials is based their popular classification. The sand and clay comes for the most part from the decomposition of the underlying rocks. The gradation between sandy and clayey soils are roughly expressed by such terms and distinctions as the following:

	Per cent. of clay or Impalpable matter.	Per cent. sand.
Heavy clay	75 to 90	10 to 25
Clay loams	60 " 75	25 " 40
Loam	40 " 60	40 " 60
Sandy loam	25 " 40	60 " 75
Light sandy loam	10 " 25	75 " 90
† Sand	0 " 10	90 " 100

Analyses of two typical soils of the State will serve to show the component physical parts. Soil 1 is from The Dalles and represents a great extent of country. Soil 2 is one very common in the Willamette valley and was taken from the foot hills south of Eugene.

	No. 1.	No. 2.
(1) Coarse sand	30.4	80.5
(2) Sand	24.0	2.5
(3) Fine sand	12.2	3.0
(4) Silt or clay	33.4	14.0

The remainder of mineral matter in the soil—not amounting to more than five pounds in one hundred of soil—consists of chemical compounds

* Stockbridge's Rocks and Soils.
† Johnson's How Crops Feed.

of lime, potash, soda, magnesia, iron, aluminum, manganese, chlorine, silicic acid, phosphoric acid, sulphuric acid, nitric acid and carbonic acid and water in varying proportions. Of the greater portions of the soil the plant makes no use except as a medium in which to fix its roots. It is the compounds of the above substances that constitute the plant food in the soil. The acids above mentioned are united with the bases to form the salts which occur as chlorides and silicates of potassium and sodium, calcium (lime) sulphate, phosphates of iron, calcium, magnesia, manganese and ammonium, and probably salts of soda, potash and lime with certain vegetable acids.

There are only three of these, lime, phosphoric acid and potash, which as a rule require attention so far as deficiency of plant food is concerned, for the other mineral substances are furnished in abundance by natural agencies. It must be remembered, however, that it is only the soluble portion of the material that the plant uses for food. It is these substances then that invite our attention. Just what constitutes a sufficiency of these materials for successfully growing a crop will differ somewhat with the nature of the crop and the physical condition of the soil. In an article published in 1881, Prof. Hilgard, than whom no one is more competent to judge, states the following as to the minimum percentage for a thrifty growth of general crops:

Lime.—0.10 per cent. in the highest sandy soil; 0.25 per cent. in clay loams; 0.30 per cent in heavy clay soils, and it may rise with advantage to one or two per cent. [The present indication is that we may consider .40 as a fair average for soils of the Willamette valley. G. W. S.]

Phosphoric Acid.—In sandy loams, 0.10 per cent. when accompanied by a good supply of lime. The maximum found in the best Mississippi table lands was 0.25 per cent.; in the best bottom land of the same region 0.30. His investigation in connection with the Northern Pacific survey also showed that this ingredient was more abundandant in the soils of Oregon and Washington than in the soils of California. * In the basaltic soils it may even run as high as .30 or more.

Potash.—The potash percentage of heavy clay upland soil and clay loams ranges from about 0.8 to 0.5 per cent.; lighter loams from 0.45 to 0.30; sandy loams below 0.30 and sandy loams of great depth may fall below 0.10 consistent with good productiveness and durability. Virgin soils with a less percentage than .06 he finds deficient. The same author also says in another article that no virgin soil having .50 per cent. or over of potash will wear out first on that side of the store of mineral plant food; and much less will suffice in the presence of much lime and humus.

Sulphuric Acid.—In the best soils this ingredient is slight, 0.02 per cent. is adequate; but it frequently rises to 0.10 per cent.

Iron.—He puts 1.5 to 4.0 as the ordinary percentage of ferric oxide in soils but little tinted; ordinary loams from 3.5 to 7.0; highly colored red lands 7 to 12, and sometimes upwards of 20.

Humus.—This is of great interest to us since it is the storehouse of the

* Cal. Exp. Station Report 1888.

nitrogen supply and its determination serves as a measure of the nitrogen. In oak uplands of the cotton states the range is usually between .70 and .80 per cent.; in the poorer sandy soils from .40 to .50 per cent.; in black calcareous soils 1.2 to 2.80 per cent. In western Oregon it is not uncommon to find 3 and even 6 per cent.

Whether or not the above are applicable to the soils of Oregon remains to be ascertained from a sufficient number of examinations from various portions of the State, and other data that may be collected, and this is a portion of the present work of the Station.

That comparison may be made the analysis of a few typical soils are given below:

	1V—Eugene Lane Co. Foot-hills.	1Q—Toledo Benton Co. Bottom land.	1J-College Farm Benton Co. Adobe
Insoluble Matter	63.02	52.72	72.70
Soluble Silica	8.77	14.54	5.93
Potash (K_2O)	.09	.33	.47
Soda (Na_2O)	.07	.09	.24
Lime (Ca O)	.60	.27	1.60
Magnesia (MgO)	.27	.25	1.03
Manganese (Mn_3O_4)	.02	.20	.10
Iron (Fe_2O_3) Aluminum (Al_2O_3)	15.90	18.31	9.23
Sulphuric Acid	.02	.03	.03
Phosphoric Acid	.16	.12	.05
Water and Organic Matter	10.51	12.90	8.00
Total	99.43	94.76	99.38
Humus	1.21	1.16	.76
Soluble Phosphoric Acid	.12	.07	.027

The above serve to give an idea of soil composition. For further illustrations the readers attention is directed to other pages in this bulletin.

TOPOGRAPHICAL AND GEOLOGICAL.

The State, comprising an area of 96,000 square miles, lies between 117° and 125° west longitude, and 42° and 46° north latitude. It is naturally divided into eastern and western Oregon by the Cascade mountains. The eastern portion is about 3000 feet above the level of the sea and embraces about two-thirds of the State. That part of the State together with a part of Washington often goes by the name of the "Inland Empire," since it is so surrounded by various mountain systems. The western portion may well be divided into a northern and southern portion, the first of which comprises the great Willamette valley and a portion of the Coast mountains. Throughout the entire western portion of the State there is a multitude of small streams furnishing an ample flow of water during the entire season. The Willamette valley, embracing about 5,000,000 acres, is by far the largest valley in the State. It is about 130 miles in length by 60 in width and extends from a low range of hills on the south (Calipooias) to Portland on the north. To show how well watered is this valley it mey be stated that over 40 streams feed the Willamette in its course, and the stream is navigable for about 100 miles from its mouth.

The soils of this valley may be classified under two general heads, viz:—those of the foot hills and those of the bottom lands extending on each bank of the river. The former comprise a belt of rolling land extending nearly around the prairie and merging into the mountains. The prevailing soils are of basaltic origin mixed with more or less sandstone soil on the west side. The purely basaltic soils are mostly confined to the hill tops where they are generated. All the "bottom land" is of an alluvial nature and varies greatly in depth, from a few inches to many feet. It is made up of the washings from the hills and consists, as one would infer from the above, of a decomposed volcanic substance, somewhat basaltic in nature, mixed with sand and a large amount of alluvial deposit and vegetable mould or "humus," the last named substance being the more abundant in this portion of the State because of the larger rainfall.

It is a fact noticed in Italy long since, and borne out by experience in this northwest, that the soils of volcanic origin are of an unsurpassed fertility. The basalt from which much of the soil in Oregon is derived is not like most rocks in respect to its makeup for it contains, from the very nature of the case, the fertilizing ingredients of of a combination of rocks. Basalt is a complex mineral and a type of basic rocks. It is a very dark, almost black, rock, exceedingly hard and quite heavy; mineralogically it is made up of plagioclase (a soda-lime feldspar) augite, and olivine; it also nearly always contains more or less magnetic iron ore and other minerals. The coarser grained basalts are known as dolerytes and the fine grained anamesyte. Chemically the rock contains silica, lime, potash, soda, magnesia, oxides of iron and manganese, and alumina. There is one quite notable feature as to one of the mineral ingredients of basalt—augite—that it not infrequently contains considerable phosphoric anhydride (P_2O_5), occurring in a crystalline form as apatite. Of such an occurrence one writer has said, "While such crystals scattered in the soil may be somewhat refractory in dissolution, yet the mechanical and chemical process of soil formation must have supplied an abundance of finely pulverized mineral ('floats') available for the use of vegetation." The chemical composition of this rock from which has been derived the greater portion of our soils explains why the apparently barren soils of the eastern portion of the State, when supplied with the necessary moisture, are so very productive. In spite of the fact that some of the books published state that basalt forms soil very slowly, yet the rocks are really fragile and short-lived. They appear to be dense and lasting, but being complex in structure and containing a considerable amount of protoxide of iron, which is capable of further oxidation, and this quite rapidly, forming a sesqui-oxide, the bonds of the minerals are loosened and the rock breaks up. At the foot of every basaltic cliff is found a pile of debris and all over the basalt country this crumbling proceeds regularly and comparatively rapid. These rocks are of recent geological origin and doubltless represent the same time as those forming the Sierra Nevadas, the material being deposited in the Jura-Trias and elevated as mountains in the middle of the Mesozoic, while the formation of the Coast Range did not occur till about the end of the Middle Tertiary or Miocene, the place of the range having a marginal sea bottom and received sediment from the beginning of the Cretaceous. At the end of the Miocene this marginal sea bottom yielded to pressure and swelled up into the Coast Range of to-day. This inclosed between it and the Cascade Range an immense body of water which after a time became fresh giving fresh water sediment. These alluvial deposits were elevated and drained off, the Willamette valley being the latest to become land. These changes just mentioned, however, were not the ones which primarily gave us the immense quantities of basalt, but rather the great laval overflow, and the lesser and subsequent ones, which covered the whole of northern California, a great part of Oregon, Washington and Idaho, and extending into Nevada, the violence of this volcanic fire and molten lava destroying and blotting out all forms of vegetable and animal life. The entire northwest being covered from 25 to 100 feet deep in volcanic ashes. The lava beds where the great Columbia has made its cuts shows a depth of about 3000 feet. Over this entire field are found numerous extinct volcanoes, which for some time continued to belch forth their molten contents, those of the more recent activity being Mts. Hood, St. Helens, Pitt, Adams, Jefferson and Cowhorn Peak.

The above all represent marine deposits, while in both the southern and eastern portions of the State there are numerous localities showing fresh water lake deposits. During the laying down of much of this alluvial soil the ocean extended up the Columbia river forming an immense sound which is shown not only by numerous beach marks but also from the successive terraces. An extensive bay, the deposits of which formed the present subsoils of the region of Forest Grove, Hillsboro, etc., covered these places to a considerable depth.

As we pass into the southern division of western Oregon Mesozoic strata are prominent, and during this time nearly all of southern Oregon was probably under water and not less than 3000 feet of sediment was deposited covering nearly all of the entire region of the Rogue, Coquille and Umpqua rivers, the water being drained off probably early in the Miocene, if not before. Between the Umpqua and Rogue rivers toward the south the formation is chiefly metamorphic slate and quartzite, while to the north there is much colngomerate and slate with more or less serpentine, the latter is very abundant on the south Umpqua. To shew the depth of these strata, a well bored 175 feet near Jacksonville failed to reach beyond the sediment of the Tertiary.

As the rocks, so the soils here are quite varied, and it is not uncommon to find a half dozen different soils on 160 acres. The predominating soil of this portion seems to be a red clay which terminates in the high plateaus. Black loams, with vegetable debris, are found along the principal valleys, where granitic soil is not uncommon.

The analysis of a characteristic black loam soil from the farm of J. D. Wilson, Yoncalla, Douglas county, is given below.

SOIL FROM DOUGLAS COUNTY.

J. D. Wilson. Yoncalla.	1X—Black Loam.
Coarse material > .6 mm	45.40
Fine earth	54.60
Moisture absorbed at 15 c	1.24
Capacity for water	42.00
ANALYSIS OF FINE EARTH.	
Insoluble matter	39 58
Soluble silica	10.43
Potash (K_2O)	.44
Soda (Na_2O)	.26
Lime (CaO)	2.05
Magnesia (MgO)	.42
Manganese (Mn_3O_4)	.08
Iron (Fe_2O_3) } Alumina (Al_2O_3) }	29.45
Sulphuric Acid (SO_4)	.01
Phosphoric Acid (P_2O_5)	.16
Carbonic Acid (CO_2)	
Water and organic matter	17.21
Total	100.09
Humus	1.3

The above soil, it will be noticed, is somewhat peculiar as it carries such a heavy amount of soluble silica as well as iron and alumina, yet a high percentage of soluble silica is not uncommonly found with high percentages of iron and alumina. The soil carries a large supply of phosphoric acid, especially is this true since the soil has an abundant supply of lime. There is a fair amount of potash, yet if we can judge from remarks on page 7 the soil will wear out first on that side, yet it will not be deficient for some time. It seems to have the elements of a good all around soil.

The foregoing points on the geology of the State have been given since it is more or less important in beginning work on the soils to have at least an outline of the geological nature of the State and it is hoped that the work along this line may be extended further in the near future.

The record of examination of a number of the soils is found below, and in connection with these analyses, it will be desirable for the reader to again refer to page 7.

Western Oregon Soils.

Most of the following soils represent quite an area and the analyses will no doubt be of interest and value to a large number in the vicinity whence the sample was taken, yet as stated before, *a large number* of analyses must be made before comparative results can be had.

SOILS FROM WASHINGTON COUNTY.

	No. 1 C Forest Grove H. Buxton.	No. 1 D Ditto.	No. 1 F Gales Creek A. Powell.	No. 1 G Ditto.	No. 1 H Ditto.	No 1 L Fir B. M. Collins.
Coarse material > .6 mm	1.00	3.00	51.94	34.00	19.00	33.00
Fine earth	99.00	97.00	48.06	66.00	81.00	67.00
Capacity for water	53.40	8.00	50.80	40.80	50.00	45.00
Hygroscopic moisture [15° C]	5.00	1.42	3.30	6.50	4.72	8.30
ANALYSIS OF FINE EARTH.						
Insoluble matter	76.19	75.06	65.89	67.40	67.99	63.62
Soluble silica	4.49	3.76	5.82	5.18	3.22	9.74
Potash [K_2O]	.03	.16	.12	.28	.26	.11
Soda [Na_2O]	.01	.00	.06	.05	.07	.08
Lime [CaO]	.34	.63	.75	.13	.76	1.47
Magnesia [MgO]	1.71	1.18	.71	.90	.71	1.27
Manganese [Mn_3O_4]	.22	.21	.04	.04		.22
Iron Fe_2O_3] / Alumina [Al_2O_3]	8.76	7.58	17.50	17.68	18.13	12.88
Sulphuric Acid [SO_3]		.05		.08	.08	.04
Phosphoric Acid [P_2O_5]	.03	.32	.09	.34	.34	.30
Water and organic matter	8.51	11.62	9.81	7.99	8.74	9.80
Totai	100.29	100.57	100.79	100.07	100.30	99.54
Humus		.20	1.87	1.76		.32
Soluble Phosphoric acid		.19	.05			.02

1 C.—The average depth of the soil is about 3 feet. It is a mixture of decomposed soap-stone with some sand and feldspar. It is a gray loam which darkens considerably on wetting and becomes fairly plastic on kneading. In looking at the analysis of the soil the most striking feature is the very low percentage of potash and phosphoric acid and were these not in a very available form and that it was well supplied with lime, it would be considered deficient in these ingredients. That these ingredients are in an available form is shown by the fact that soil from the same general locality has produced good crops for a long series of years. The high percentage of magnesia is consistent with the soil's origin.

1 D.—This is a stiff red clay and very waxy. The dry lumps are almost impossible to crush and darken only slightly on moistening.

1 F., 1 G., 1 H.—These soils are of a reddish color and are quite lumpy. They do not blacken to any extent when wet but become very sticky. There is considerable iron oxide in the soil together with quartz and feldspar, with some hornblende. These soils are commonly called "shot-lands" since the iron oxide with particles of clay have formed small nodules which to some extent resemble shot, which by continued wear in cultivation disappear. This so-called "shot-land" covers quite an area of hill country and as the bottom-lands are approached the shot become less. The natural growth on this soil is fir, alder and maple. It is a soil which produces well and one which is easily worked.

1 L.—This soil is somewhat similar to the last three described but contains less "shot," belonging to the same class of soils, however. The soil in this part of Washington county is nearly all of this character in the foothills. It has a range of from 10 to 20 feet in depth. In general the water is soft and in many places are found springs which contain more or less iron. From the depth and porosity the soil would not be called deficient in potash, but this is the ingredient which is likely to need the most careful attention.

SOILS FROM BENTON COUNTY.

The soils of Benton county in general resemble those of the other portions of the Willamette valley, especially those of Polk county. The prairie bottoms are of a rich dark loam for the most part. There is quite a body of what is called "white land," which is found in various lowlands of the valley. It is a heavy whitish clay destitute of natural drainage. The great trouble with the land is excessive moisture, but where well drained it seems to give fairly good results.

The hill lands are of a reddish soil of excellent physical condition for working and offer most excellent soils for fruit. The bottom soils are made up of the washing from the hills added to the clays and loams from the former sedimentary deposits.

The analysis of the Benton county soils given below are from representative samples and may be taken as showing in general the composition of their respective kinds. The first two were taken from the College farm and their analysis is as follows;

SOILS FROM COLLEGE FARM, CORVALLIS.

	No. 1 I College Farm "Adobe."	No. 1 J Ditto Clay.
Coarse matter > .6 mm	2.25	1.75
Fine earth	97.75	98.25
Capacity for water	56.00	44.20
Hygroscopic moisture [15 C]		3.94
ANALYSIS OF FINE EARTH.		
Insoluble matter	38.91	
Soluble silica	16.74	72.70
Potash [K_2O]	.11	5.93
Soda [Na_2O]	.03	.47
Lime [CaO]	1.60	.24
Magnesia [MgO]	1.78	1.60
Manganese [Mn_3O_4]	.08	1.03
Iron [Fe_2O_3] } Alumina [Al_2O_3 }	23.21	.10
		9.23
Sulphuric acid [SO_3]	.01	.03
Phosphoric Acid [P_2O_5]	.09	.05
Water and organic matter	17.44	8.00
Total	100.00	99.38
Humus	1.80	.76
Soluble Phosphoric acid	.02	.03

For the sake of comparison the analysis of a California "adobe soil" is placed alongside that from the College farm.

	No. 1 I College Farm "Adobe."	Valley Adobe Soil, Touloume Co., Cal.
Coarse material > .6 mm.	2.25	
Fine earth	97.75	
Capacity for water	56.00	
Hygroscopic moisture(15C)		15.42
ANALYSIS OF FINE EARSH.		
Insoluble mrtter	38.91	56.61
Soluble silica	16.74	
Potash [K_2O]	.11	.19
Soda [Na_2O]	.03	.14
Lime [CaO]	1.60	.68
Magnesia	1.78	13.74
Manganese	.08	.08
Iron [Fe_2O_3] } Alumina [Al_2O_3 }	23.21	18.43
Sulphuric Acid	.01	.01
Phosphoric Acid	.09	.07
Water and organic matter	17.44	9.84
Total	100.00	99.79
Humus	1.80	1.61
Soluble Phosphoric acid	.02	.40

Of the Toulome county soil the California report says: "The adobe soil is quite remarkable for its unusually low contents of potash and a most extraordinary proportion of magnesia............The soil has a fair proportion of lime and phosphoric acid, as well as a high one of humus, and while the potash holds out it should produce well, but should have the most thorough tillage."

The "adobe" soils become exceedingly sticky when wet, and are difficult to work, in fact it is impossible to work them unless taken just at the right point of moisture. It is underlaid by a heavy stiff clay. If the soil is thoroughly tilled it retains moisture well. The main difficulty with this land lies in its poor drainage. If some inert material could in some way be worked into the soil it would render it materially easier to work. The tillability of the soil would be greatly improved by as much lime as could be afforded. It is for this use that large quantities of gypsum could be used could the supply be had at reasonable rates. Anyone finding any indication of gypsum would not only benefit himself but also largely aid our agricultural interests by reporting and investigating the same. The Station is always ready to assist so far as possible in any such line of work.

Improvement of the physical condition of the "adobe" soils is a question for experiment. Underdrainage, so important in all such lands, would probably correct to a large extent, and green manuring would be an aid.

While soil 1 I has even less phosphoric acid than the California soil it also carries a heavier percentage of humus and of lime. From the greater amount of lime a less amount of phosphoric acid would suffice yet it would seem that this ingredient should receive careful attention. It is intended to conduct experiments during the year as to the relation of "adobe" soil to moisture.

1 B.—This is an alluvial soil sent by Mr. C. J. Bishop, of Tidewater. The soil is about four feet deep and of a brownish color. As is shown by the mechanical analysis, the soil is of fine texture, the coarse material consists almost entirely of organic matter, sticks, etc. The soil shows a considerable portion of decomposed feldspar. The lumps crush easily between the fingers. The natural growth of trees is cedar, red and yellow fir, alder, and maple ; for shrubs and grasses, the vine maple, salmon berry, and native clovers. On account of depth and physical condition it seems to be an excellent soil for root crops, but the supply of potash is limited.

1 M and 1 N.—Except so far as the difference in chemical composition is concerned these soils are described as in 1 B. They carry less lime and phosphoric acid, which should be present in at least .10 per cent. to give the most satisfactory results.

1 O and 1 P.—These run very closely together, 1 P however, being a little the heavier soil, and having, as would be expected, the greater moisture co-efficient. The supply of potash in each is fair and of phosphoric is good.

BENTON COUNTY COAST SOILS.

	BOTTOM LANDS.				HILL LAND.		TIDE LAND.		BENCH LAND.
	No. 1 B Tidewater C. J. Bishop.	No. 1 M Toledo G H Rosebrook	No. 1 N Ditto.	No. 1 Q Higher Ditto.	No. 1 O Ditto.	No. 1 P Ditto.	No. 1 T Ditto.	No. 1 U Ditto.	No. 1 S Toledo G H Rosebrook
Coarse material > .6 mm	1.01	3.40		20.00	7.40	16.31	None	2.90	
Fine earth	98.99	96.60		80.00	92.60	83.69	All	97.10	
Capacity for water	67.00	24.00		36.00	70.00	76.00		60.00	
Hygroscopic moisture	10.00	4.99		6.94	7.08	11.74	2.55	9.95	5.00
ANALYSIS OF FINE EARTH.									
Insoluble Matter	63.43	63.38	60.00	52.72	59.98	50.96	64.43	63.09	57.01
Soluble Silica	8.60	8.15	9.40	14.54	9.74	9.52	7.44	6.37	11.43
Potash (K_2O)	.10	.12	.19	.33	.29	.38	.22	.33	.16
Soda (Na_2O)		.22	.10	.09	.09	.04	.31	.53	.10
Lime ($Ca O$)	1.40	.53	.43	.27	.31	.30	.45	.27	.42
Magnesia (MgO)	1.65	.82	1.54	.25	.52	.40	2.04	.52	.98
Manganese (Mn_3O_4)	.09	.06	.08	.20	.08	.10	.10	.08	.06
Iron (Fe_2O_3) } Aluminum (Al_2O_3) }	13.44	14.96	15.94	18.31	16.50	23.37	14.69	11.25	14.70
Sulphuric Acid [SO_3]		.02	.03	.03	.02	.04	.02	.01	.01
Phosphoric Acid [P_2O_5]	.27	.08	.06	.12	.21	.33	.12	.11	.18
Carbonic Acid (CO_2)									
Water and Organic Matter	10.62	12.00	12.53	12.90	12.15	14.17	10.32	18.07	14.60
Total	99.60	100.34	100.30	99.76	99.89	99.61	100.14	100.63	99.64
Humus	1.74	.91	1.26	1.17	1.61		1.89	1.98	.88
Soluble Phosphoric Acid		.01	.05	.07	.06		.09	.08	.13

SOILS OF LANE COUNTY.

This county has an area of about 7,000 square miles, with an average breadth of about 50 miles and being about three times this distance in length. About three-fourths of this county is hilly and mountainous. The table or hill lands bordering the valleys seem to be quite fertile, and produce well when brought under cultivation. A sample of this soil is the only one yet examined from this county and whether all will show as low percentages in potash as this is somewhat doubtful.

NO. IV—SOIL FROM LANE COUNTY.

Coarse material > .6 mm	5.70
Fine earth	94.30
Capacity for water	50.00
Hygroscopic moisture	2.00

ANALYSIS OF FINE EARTH.

Insoluble matter	63.02
Soluble silica	8.77
Potash [K_2O]	.09
Soda [Na_2O]	.07
Lime [CaO]	.60
Magnesia [MgO]	.27
Manganese [Mn_3O_4]	.02
Iron [Fe_2O_3] } Alumina [Al_2O_3] }	15.90
Sulphuric Acid [SO_3]	.02
Phosphoric Acid [P_2O_5]	.16
Water and organic matter	10.57
Total	99.43
Humus	1.21
Ash	1.12
Soluble Phosphoric Acid	.04

The mechanical separation of the soil by an elutriating apparatus gave the following result: (See page 6, No. 2.)

IV.—The soil is a sandy loam and covers several sections in the foothills south of Eugene. Farther up the hills the soil becomes coarser and is underlaid with soft sandstone, which crumbles on short exposure. The vegetation is oak and wild grasses. The soil evidently has a good natural drainage and is easily worked. The dry lumps crush easily between the fingers and the soil does not become very sticky when wet. It is a soil that has been planted to fruit considerably of late. The physical condition of the soil would seem to warrant this, but the low percentage of potash would indicate that for the best results this ingredient will be needed in a few years.

The county is abundantly supplied with streams and springs. Considerable swale land is found in some parts of the county, mainly white land, but with good drainage this can be made productive. Taking Eugene as a starting point then going west about 6 miles is a low range of hills. From here we can look north for about 24 miles over a rich prairie through which flows the Willamette river, the course of which is rendered the more visible by the groves of balm, maple and shrubs. The hill land of the principal portion begins about 20 miles west from Eugene and is is largely covered with fir timber—in fact the whole region abounds in forests of fir, hemlock and cedar.

Further analyses from this rich section will shortly be made.

SOILS OF LINN COUNTY.

Of Linn county there are only about 1300 square miles that is suitable for agricultural purposes. "The arable portion of the county is about evenly divided into prairie and rolling land. The prairie is not a dead level, but slightly undulating, affording plenty of slope for good drainage to the Willamette river which bounds the county on the west along its whole length. The soil of the prairie lands is a rich, dark, clayey loam, of the general character of that of the whole Willamette valley." For the most part the soils are sandstone and basaltic. About the Santiam country the formations are porphyritic and granitic which are a contiuation of similar rocks to the north and south—a part of the same that outcrops on the west of the Cascades. Only one soil has been analyzed from this county.

IW—SOIL FROM LINN COUNTY.

Coarse material > .6 mm	22.90
Fine material	77.10
Capacity for water	44.00
Hygroscopic moisture	7.55

ANALYSIS OF FINE EARTH.

Insoluble matter	57.82
Soluble silica	7.23
Potash [K_2O]	.15
Soda [Na_2O]	.07
Lime [CaO]	3.51
Magnesia [MgO]	.21
Manganese [Mn_3O_4]	.12
Iron [Fe_2O_3] / Alumina [Al_2O_3]	16.89
Sulphuric Acid [SO_3]	.02
Phosphoric Acid [P_2O_5]	.11
Water and organic matter	13.07
Total	99.20
Humus	1.88
Soluble Phosphoric Acid	.09

1W.—This is a light loam, black in color, sent from Lebanon by Mr. John Withers. The soil to change of color, is from 18 to 24 inches, and the subsoil is about 2 feet deep. The soil grows fir, maple, oak and ash. As will be seen it carries a high percentage of lime and clearly shows a lime vegetation. It has a high moisture coefficient and evidently has good natural drainage. The soil should be easily worked and though the potash is not high, yet with the heavy percentage of lime it is fairly supplied and with thorough tillage is not apt to be deficient in this quarter. It is an excellent all around soil.

Soils From Eastern Oregon.

Only two soils have been as yet analyzed from this portion of the State. The nature of the rocks and soils has been mentioned on previous pages of this Bulletin to which the readers attention is invited. The following table gives the analysis:

EASTERN OREGON SOILS.

	No. 1Y Cross Keys Crook Co. Linton.	No. 1Z Meacham Union Co. A. H. Todd.
Coarse material > .6 mm	4.40	.40
Fine earth	95.60	99.60
Capacity for water	36.00	61.00
Hygroscopic moisture	3.85	4.70
ANALYSIS OF FINE EARTH.		
Insoluble Matter	76.69	65.75
Soluble Silica	8.47	8.95
Potash (K_2O)	.83	.84
Soda (Na_2O)	.20	.23
Lime ($Ca\,O$)	1.21	.76
Magnesia (MgO)	1.11	.24
Manganese (Mn_3O_4)	.04	.02
Iron (Fe_2O_3) Aluminum (Al_2O_3)	9.11	14.85
Sulphuric Acid [SO_3]		trace
Phosphoric Acid [P_2O_5]	.08	.07
Water and Organic Matter	3.35	8.09
Total	101.09	99.80
Humus	.41	1.10
Soluble Phosphoric Acid	.11	.02

1Y.—As will be seen from the above data this is a soil of very fine texture. It is a light gray soil which darkens slightly on moistening. It is abundantly supplied with potash but phosphoric acid is deficient. The main growth is bunch grass and sage brush, and to one unacquainted with its peculiarities the soil would not be considered favorably, although experience shows that the soils of this same character produce well provided they are given moisture.

1Z.—This soil in appearance is much like the one mentioned just above. It does not, however, contain so much inert matter, and the supply of humus is better. Like the above the phosphoric acid is present only to a very limited extent. Yet since these soils have a good supply of lime the conditions are the more favorable on that account.

In conclusion of this the first of a series of Bulletins on this important subject of soils it should be said that in the present state of our knowledge on this subject and the data in hand, it is often impossible to go beyond conjecture on some questions, yet by multiplying the results on the one hand, and by careful observation on the other the future work and benefit to be derived will be very much aided, and the results will be all the more helpful to the agricultural industry of the State.

APPENDIX.

Since the Station receives so many inquiries as to what it is prepared to do, and also that the Chemical Department may be of the greatest possible use to citizens of the State and come in closer contact with them these few pages are added. The department also takes this means to answer in a general way a few standing questions which are continually being asked. The Chemical Department of the Station is prepared to analyze and test soils, waters, butter, milk, cattle-foods, fertilizers, gypsum, and other agricultural products, and to make such mineral analyses as may be of interest to the State, and as we may have time. Also to give information on such subjects of agricultural science as may fall within its province.

All analyses are made *free of charge*, but are subject to the following conditions: 1.—All samples for analysis must be taken according to the directions of the Station. 2.—All questions concerning the sample will be answered truthfully by the person sending the samples. 3.—That the Station is free to publish all results of analyses made for the benefit of the public.

The Station will not undertake work the results of which are not at its disposal to publish.

The laboratory of the Station is complete in all particulars, although not so large as that of many stations. For that reason it is not possible to turn out work as rapidly. It must be borne in mind that to correctly analyze a substance is not a matter of a few minutes, but more often it is a matter of several days work; and that there is always regular experimental work being carried on which as a rule cannot be interfered with, hence all who send samples must be patient and bide their time. *All samples received are numbered in the order they are received and so analyzed*, the analysis then being reported to the party sending the sample.

In all cases where samples are sent to the Station for analysis *all charges must be prepaid.*

DIRECTIONS FOR SAMPLING.

For ordinary water analysis, one gallon of water should be sent; for mineral water analysis two gallons. The water should be put in clean glass bottles, filled completely full, and corked with *clean, new corks.*

Samples of milk should not be less than a pint, and the milk should be thoroughly mixed before a sample is taken, and the bottle completely filled.

Samples of rock, coal, etc., should be so taken as to be a fair average sample, invariably taken from below the surface.

Fertilizers are sampled by taking a quantity from the top middle and bottom, intimately mixing on paper. They should be sent in *clean, dry bottles well corked.*

It is essential that the fertilizer samples be certified to and certificates for this purpose will be furnished by the Station. Each sample of fertilizer must be accompanied by the following data:

1.—Sampler's name. 2.—Brand. 3.—Name and address of the manufacturer. 4.—Name and address of the dealer. 5.—Date of taking sample. 6.—Price per pound, ton or package. 7.—For what purpose used. 8.—Percentage of valuable ingredients claimed by manufacturer or dealer. 9.—Such other information as the Station may require.

Directions for sampling soil will be sent on application.

The department is ever ready to give any information within the province of its work, and solicits the co-operation of those interested in the welfare of the State. All communications relative to analyses and matters pertaining to chemical work should be addressed to

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Corvallis, Oregon.