LABORATORY METHODS OF VALUE TO SOIL SURVEY.

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Any laboratory method that may be utilized to provide us with information relative to the fundamental properties of soils should be of value to the soil surveyor. We are forced to admit that many phases of our knowledge of soil science are in reality very meager, thus there is much to be accomplished.

The physico-chemical studies may afford us much information that would be of really great value to the soil surveyor. The water relationship, for example, is probably one of the most fundamental and far reaching that could be studied because of the tremendous importance of water in so many different ways. By means of the water relations of soils we may study such problems as the weathering of soils, the structural relationships and also the size of particles. I am referring here to the investigation of different forms of water; and in addition the heat of wetting of soils may be used to great advantage in connection with the soil survey. The determination of the hygroscopic coefficient and moisture equivalent of soils has in the past revealed valuable information and probably is yet to be used to advantage yet it seems that they are not sufficient.

We need to know more about the weathering of soils, that is the formation of various horizons, their composition relative to the different elements that go to make them up. Then, too, there is the question of soil coloration. There are several phases of this to be settled. Have we gone too far with it in our investigations of soils or have we considered it sufficiently? Again, we need to know more about the constitution of the soil, not merely the per cent of the nitrogen, phosphorus, potassium and others but the combinations in which they go into solution, reactions that take place when various substances are added to them and others. The degree of acidity and basicity are important in the classification of soils.

In some of the northern states where the acreage of organic soils is high we are forced to make advancements in our present methods of classification and not merely to show on the maps whether such deposits are deep or shallow. Such questions as the nature of the materials that go to make up the surface and sub-soil and also the total mineral, lime content, moisture relationship, the descriptive properties and others are important. Such is not only desirable from the agricultural viewpoint but also from the industrial standpoint.

Those who have worked in this field probably realize that there is much that can be done from the laboratory standpoint to aid in the classification of these soils.

When we consider these various aspects we are forced to conclude that the soil surveyor should have the view point of the scientist and when he goes into an area to classify the soils therein he is really taking up a piece of research work that is worthy of his most serious consideration and study. He has much more to do than merely to locate the boundaries between different types of soil and report to the inspector. He has opportunities almost daily to make note of conditions that are of fundamental value to the soil survey as a whole. Many of these conditions he should not only make note of but also should attempt to account for them. This is true because the inspector usually can not spend

sufficient time in the area and go over it in sufficient detail to note many of these. The point that we wish to make is that the soil surveyor should fully realize and appreciate that he has a great work to perform in each area and that the work is not merely a mechanical proposition but entails keenness of observation, thought and careful attention to details as well as to the broad relationships.

Physico-Chemical Methods.

At our last meeting in Chicago we stated that probably no other relationship tells us as much about the soil as does the moisture. We still believe that this is one of the best means of studying many properties of the soil. It may be utilized to investigate such subjects as weathering, solubility of the soil, structure of the soil, size of particles and others.

The Dilatometer Method. I shall discuss first the dilatometer method which may be utilized to advantage. This hinges on or makes use of the fact that water expands upon freezing. If one knows the coefficient of expansion of water upon freezing and also the total water content of the soil he can calculate the amount of water which freezes and that which does not freeze at a given temperature. I need not discuss the technique at this time inasmuch as it is probably familiar to all of you.

It has been shown that appreciable quantities of water in the soil may fail to freeze. It must be of great significance inasmuch as it is different from that water which readily solidifies. There may be a difference of opinion relative to the causes of this phenomenon and the form in which this water exists in the soil, that is whether it is liquid, solid, water of hydration, capillary adsorbed and etc., but the fact still remains that this is a characteristic of many soils and must be an important property. We believe it may be made use of to decided advantage in connection with the soil survey, pointing out the fundamental relationships so that the surveyor may be on the look out for various properties and characteristics.

Empirical methods are not sufficient. Not only is the fineness of particles important in governing the activities of the soil as measured by the dilatometer method but also the composition or state of the material. We know that crystalline materials may be rather inert and those that are in the amorphous condition much more active. We may pulverize or grind a large number of minerals, as Dr. Bouyoucos has done, that we know go to make up a soil and mix them together and make determinations of their activity relative to this phenomenon and they will be found to be quite inert, yet when they are in the soil they may be exceedingly active. Carbon black is known to be very finely divided material but it is inert. If it is heated to a certain temperature it is known that its properties are markedly altered and it becomes exceedingly active yet the surface exposure or fineness of particles probably has not been altered to any great extent. Clay when ignited largely loses its power to take water from the easily freezable form and place it in a difficultly freezable class. In other words the active material in the clay is destroyed by the treatment. Colloids seem to play a very important role in governing the activity of the soil. Bouyoucos has shown that there is no definite and consistent correlation between the factor of the unfrozen water and the class determined by mechanical analysis. It is undoubtedly true that there is a general tendency for the quantity of unfrozen water to increase from sand to clay and from clay to organic soils but

there may be exceptions. Some sandy loams, for example, may be as active in this respect as clay loams as determined by mechanical analyses.

That the nature of the material is extremely important in governing the activity of the soil may be strikingly shown by our studies on organic soils. The amount of organic matter may not be so important as other things. The following may serve as an illustration. Samples were taken from different deposits, the ash content determined and the amount of water that they cause to go into an unfreezable condition found to be as follows:

Organic matter

Unfree Water

92.6	46.2
90.4	49.2
89.7	41.2
85.8	62.5
84.2	79.0
78.2	70.0
71.8	55.2

If as we believe to be the case the seat of most of the reaction that takes place in the soil is at the surface of the particles, or solid material and if the larger particles are coated with colloidal material in some cases and are not in others there should be differences in the properties of such soils. Such conditions are not revealed by mechanical analyses of soils. It is true that the mechanical analyses have been of a great deal of value to the soil surveyor yet we believe that it is not sufficient in itself.

Soil Structure. This raises the question of soil structure. I suppose all agriculturists agree that the activity of the soil with respect to structure is of tremendous importance. It is our judgment that the future will see a great deal of energy expended on this subject. We are forced to admit that our knowledge of soil structure and what really causes the changes in it is greatly limited. We believe that by means of moisture studies that much information will be derived. This question is under investigation but we are not ready to publish results that have been obtained thus far.

Usually the activities of the soil do not involve the individual particles but very often these function as groups, and if such is the case it would seem that further investigations on this question are indeed necessary and essential. Not only the various activities of the soil in connection with water relationships but others should be governed by the mechanical condition of the soil.

Chemical Studies.

There are possibilities along analytical lines as these have not been exploited to the fullest extent. We are now speaking and writing of profiles or horizons of soils and describing them with respect to color, texture and structure so far as can be done. What differences are there in these layers that are described, that is with regard to the effect that weathering has produced? Analytical work, we take it, should point out the effect of these forces and should not necessarily be done with the point in view of determining the number of pounds per acre of nitrogen, phosphorus, potassium, calcium and others, although this may be desirable in another connection. I am speaking from the

viewpoint of the work that will be of value to the soil surveyor or that which will cause him to pay, if possible, more attention or be on the look out for differences in the surface as well as the subsoil to a greater extent than has been done in the past. The unpublished work of the Bureau of Soils and associates and that of Dr. Alway of Minnesota is especially significant as well as that of others. Wheeling of this department has done considerable work on the weathering of glacial material to produce Miami and other soils.

As Mr. Veatch has brought out, there are certain characteristics of the soil horizons in the northern part of Michigan, especially in the Upper Peninsula. Now what differences are there in these various colored layers? Are they measurable? What causes these? What do they signify? Was the grayish material caused by the leaching of organic compounds from the forest floor and the removal of certain constituents and their deposition lower down and was organic matter transported in the solid state, such as the colloidal form? What effect, if any, has heat had upon this condition? Would the burning of the forest floor and the resulting high temperature of the surface layer of soil bring about sufficient changes relative to the amount and nature of the materials that go into solution and thence into the soil effect it in addition to the ways just mentioned? We are using colorimetric methods in part in the identification of soil types and in other ways. Have we gone far enough or too far in the use of color characteristics in the classification of soil? It is probable that there is considerable to discover in this field.

The work of Bouyoucos is suggestive in this respect. Here we have the mineral orthoclase that was ground sufficiently fine to pass a 200 mesh sieve, treated with different salt solutions and let stand in a moist condition. We find that very striking changes have taken place as measured by colorimetric methods. As you may observe the color changes are striking and variable. The rate of change was observed to vary markedly with the different treatments. Many other minerals and rocks have been powdered and studied in this manner. Although there remains much analytical work to be done here is some food for thought it seems to us in connection with soil coloration and I again raise the question--have we gone too far or not far enough in the use of color characteristics--in soil classification?

Much is to be done on organic soils. In this state we are being called upon to classify organic soils in far greater detail than has been done in the past, and are attempting to do so. We have come to the conclusion that there are about as striking differences in this group as occur in the mineral soils. Those who have made field observations realize that there are vast differences in the rate of drainage of different deposits; in some cases these soils are almost impervious to water and are wet or boggy at relatively short distances from open ditches, whereas in other cases a ditch takes care of the drainage over a distance of many rods. Some of the highly colloidal ones become extremely intractable upon drying and several properties are greatly altered thereby.

Again the activity, that is the rate of decomposition and solution of the surface and different layers or horizons that occur in these deposits may vary tremendously. Some are practically inert even at room temperature while others are very active. In some instances we have found that the upper layers are more active than those lower down while in others the reverse is true. Some have very high fixing power for phosphorus and potassium when they are added to them in solution, while in case of others it is feeble. The acidity as measured by different methods including the Ph varies widely. Thus we believe that laboratory

studies which will show correlations between the various properties of muck and peat soils will be very useful, assisting in the classification of them.

Solubility

The solubility of the soil may be studied to advantage. The solubility of minerals does not depend solely on the size of the particles. If minerals are ground very finely so that they will pass a 200 mesh sieve or finer and are brought in contact with water considerable material goes into solution in a relatively short time, the amount varying with the kind of mineral. When these powdered materials are leached or the soluble constituents or the products of the reaction are removed and they are again left in contact with water, the rate at which soluble materials usually form is very slow. If the various components are isolated from soils and studies made on the relative solubility of each, our investigations show, on soils that we have studied, that the finer particles account for much of the activity of the soil in this respect. If the sands or coarser particles are ground so that they will pass through a 200 mesh screen and brought in contact with water their initial solubility is appreciable but if this is removed as in case of minerals or rocks cited above, the formation of the soluble constituents is very slow. Temperature is important.

The investigations of Bouyoucos show that if minerals are brought into contact with water and maintained at high temperatures, they are quite stable. For example, if they are placed in a temperature bath of 53° C they are far more unstable yet their solubility does not increase very much until after they have been under this condition many days. After having been exposed for a considerable length of time they proceed to decompose rapidly and their appearance changes to a very great extent as illustrated by these samples.

Usually soils are strikingly affected by higher temperatures. Thus temperature relationships of soils under field conditions may be of great significance. The rate of formation of soluble constituents and the change in their composition must be increased markedly when the temperature is high. We have determined the rate of formation of soluble constituents on a large number of samples sent to us by Professor Marbut. Several were collected in Africa and a large number in the southern states. Those that are considered to represent the very old soils on the whole were found to be much less active in this respect than others that we have investigated. Such results are suggestive to the soil surveyor in his attempt to account for the variations in the soil. Since the temperature of the soil is controlled largely by its water content those that are poorly drained should weather relatively more slowly than those that are well drained. The parent material should lie somewhat nearer the surface under the former than under the latter conditions.