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THE NEW SOIL SCIENCE[1]

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SOIL science or pedology, as it is now coming to be called, is not new. It is centuries old, as may be readily deduced from an examination of many old books and records. Recently, however, the study of soils has taken on a different aspect and we now have a new concept of soil science. It is this modern, rather recent development of the subject which is referred to as "the new soil science."

As is the case with many of our present-day sciences, the beginnings of soil science lie buried in the dim mists of antiquity. Just when and where it might be said to have originated can not be determined. Perhaps the first observations were made in the Garden of Eden. The writings of Moses indicate that agriculture is as old as man. Isaac and Jacob certainly knew how to grow good crops and they probably gathered many facts about soils. Observations on soils certainly have been made from the time man began to learn the art of using them for the production of crops.

According to Herbert Spencer, *use* is the underlying cause of the development of all science. In the early stages, the practical phases always receive the most attention, because of the struggle by man toward the utilization of nature. This has been particularly true, and naturally so, in the case of the various agricultural sciences.

But there is another force which is perhaps even more powerful than use in bringing about the evolution of sciences. It is the "unconscious struggle of our natures for the acquisition of abstract knowledge or for the discovery of the laws of phenomena." In any branch of science, this force soon becomes the more significant, and the present status of knowledge

[1] Address of the retiring president of the Iowa State Chapter of Sigma Xi.

along most lines is due primarily to the efforts of those who have attempted to formulate the laws of nature.

In the development of soil science these two causes have operated continuously and often along parallel lines. There is frequently much overlapping, as might be expected, and it is apt to be quite difficult if not absolutely impossible to determine whether this or that discovery or deduction has come from curiosity or from practical need.

How much knowledge of soils was accumulated in ancient times because of the motivation afforded by the need of the utilization of land for the best crop growth and by the desire of man to penetrate the mysteries of nature is a matter of pure speculation. The early records indicate considerable previous knowledge but throw little light on the extent of this knowledge.

According to Jariloff soil descriptions were already in existence in the seventh century before Christ, but for many succeeding years the study of soils centered mainly around utilization and the scientific aspects of the subject were largely overlooked.

The early Roman literature is filled with observations on soils and speculations on the significance of soil conditions. The works of Cato, Varro, Vergil and Columella are replete with discussions of soil management problems which are much the same to-day as then. Columella attempted to determine the value of soils by determining the sweetness and fatness of plants growing on them. Cato classified soils on their varying capacities for the production of certain plants, not on their characteristics. Many others among these early writers note the wide differences in soils and comment on the relationship of these variations to crop growth.

Not until the beginning of the nineteenth century was there any definite scientific curiosity manifested concerning the characteristics of the soil, and even at the close of that century there was a wide diversity of opinion regarding the field or object of soil science. There was still a tendency to consider the study of soils merely as an adjunct to a knowledge of plant growth and the production of crops. Soils were considered merely as media upon which plants grow or as geological formations with minor modifications.

In spite of the limitations placed upon the science by such fallible, irrational and unscientific bases for the study of soils, there has been a vast accumulation of facts which, in the light of our present knowledge and of the information which is now being secured, can be properly arranged and evaluated for the formulation of those definite laws which must form the basis of any true science.

The new concept of soils involves a consideration of them "in their genetic and geographic relationships." This means that they must be looked upon not merely as geological formations, as surface deposits, as crop producers or as nutrient media for plants, but as definite, distinct entities, recognizable and separable because of certain characteristics which are inherent in themselves. In other words it has been recognized that soils should be studied *as soils.* To do this there must be developed a systematic scheme of classification, for the first step necessary in the scientific study of the objects concerned in any science is to devise a grouping system. Like other objects, too, soils must be grouped or classified on the basis of some definite characteristics. Recent advances in knowledge and more especially changes in view-point have pointed the way toward a scientific grouping of soils, and it is now possible to classify them in what is believed to be a rather permanent way. The modern concept of soils emphasizes the soil type as the unit basis upon which all scientific study must be carried out.

The soil type, then, is now recognized as the final unit in soil classification. The term is not new, but the bases upon which types are differentiated are now more definite and more scientific. The study of the classification of soils and the establishment of more or less fixed criteria for distinguishing and describing soil characteristics and therefore defining soil types has made it possible now, for the first time in the history of soil science, to lay a solid foundation of fact upon which a permanent superstructure may be erected.

Many attempts to classify soils have been made in the past and various schemes have been suggested. One of the earliest was based on texture, differentiating clays, sands, loams and sandy loams. Humus soils and limy soils were also included in this grouping. The geological origin of soils has been used quite extensively as a grouping basis, distinguishing soils derived from limestone rocks, from feldspathic rocks or from granitic rocks. The location or origin of the soil was the basis for another grouping, residual, alluvial and "occasional" soils being separated. There was also a chemical classification, silicate, carbonate and sulphate soils being differentiated. More recently classifications have been suggested on the basis of color, vegetation (*e.g.,* forest, and prairie soils), temperature (recognizing tropic, temperate and arctic soils) and moisture (separating arid, semiarid and humid soils).

The Russian pedologists have contributed much to our knowledge of the classification of soils. Glinka has summarized the earlier work, much of which was inaccessible to us until his book appeared. The names of Thaer, Fallou, Dokutschajeff, Von Richthofen, Sibirceff and Wyssotzkie stand out prominently among the many who have attempted to classify soils. Glinka himself purposed a classification based mainly on moisture conditions under which the soils have developed. He distinguished Endodynamomorphic soils, or transition soils, in which the influence of the properties of the parent rock predominate and which may change independently of external conditions, and Ektodynamomorphic soils, in which the climatic factors exert the most effect. This latter group he subdivides into six subgroups, depending upon the moisture conditions under which the soils are developed.

More important, however, than any of the other ideas put forth by the Russians was that of examining soils by horizons and profiles, in other words, of studying the characteristics of the soil itself, by layers. The soil profile is the vertical section of the soil from the surface to the underlying unweathered material. The soil horizon is the layer or section of the soil profile more or less well defined, occupying a position parallel to the soil surface. Three definite layers or horizons are recognized, called the A, B and C horizons. The A horizon is the surface soil, the B horizon the subsoil and the C horizon the substratum. Subdivisions are made in these horizons when necessary, calling them A_1, B_2, etc.

Marbut, of the Bureau of Soils of the U. S. Department of Agriculture, utilizing many of the Russian suggestions and profiting by the mass of other work on soils which is extant, has developed a system of classification which permits of a rational, scientific and permanent grouping—a grouping of objects which is comparable to those followed in other sciences.

According to this plan the soil type is separated on the basis of the profile characteristics, and this includes, of course, the characteristics of the various horizons. The following features are determined for a type separation:

(1) Number of horizons in the soil profile.
(2) Color of the various horizons.
(3) Texture of the horizons.
(4) Structure of the horizons.
(5) Relative arrangement of the horizons.
(6) Chemical composition of the horizons.
(7) Thickness of the horizons.
(8) Thickness of the true soil.
(9) Character of the soil material.
(10) Geology of the soil material.

It may be noted how all the earlier ideas on soil classification have been embodied in the present system but have been subordinated to the more important idea of determining the characteristics of the soil horizon.

A soil type may then be defined as a soil which, wherever it occurs, has a relatively uniform texture of the surface soil and relatively uniform profile characteristics.

The soil type is the species.

Soil types are grouped into *series* when all the characteristics are the same except the texture of the surface soil.

The soil series is the *genus*.

Soil series having certain similar profile characteristics are further grouped into *families*.

A final grouping of *families* into soil *orders* is indicated as a future possibility, perhaps based on the occurrence or absence of a zone of carbonate accumulation.

Soil types are given a compound name, one part of which indicates the profile characteristics, the other the texture of the surface soil. The first is the series name. Thus there is the Carrington loam, the Webster loam, the O'Neill loam, each belonging to different series but having the same surface texture. There are also the Carrington sandy loam, the Carrington fine sandy loam, the Carrington sand, and so on, all belonging to the same series but differing in texture of the surface soil.

The series name is an arbitrary designation, it is true, but that can hardly be objected to, inasmuch as arbitrary terms have been fixed for the objects involved in all branches of science.

Names have not been devised, as yet, for the various soil families or for the soil orders. Undoubtedly, in the future, arbitrary terms will be selected for these soil groups.

In the short time which has elapsed since soils have been classified, named and mapped on this basis, there has developed a wide-spread appreciation of the value of the system. Not only has it come into use scientifically but it is also proving to be of much practical value. The new concept of soils, then, is not a mere scientific curiosity; it is of practical importance.

Time will not permit of an extended consideration of the significance of the modern concept of soils to all phases of soil investigations or to practical agriculture.

Sufficient information is available, however, to show that any study on soils must be carried out by types or the results will be of little value. Any systems of management, to be of practical importance, must be worked out for soil types. The conclusion drawn from the results secured on one soil type may not be at all applicable to another type. The system of treatment found to give increased crop yields on one type may fail utterly to benefit the crop on another type. Field experiments in Iowa have shown that even the most common fertilizing materials will have varying effects on the different soil types.

Much of the work of the past has been carried out with a complete disregard of the particular soil conditions; the results of field experiments, greenhouse tests and laboratory investigations have been quite generally interpreted as applicable to all soils. While extreme differences in soils, such as occur between sands and clays, were recognized, there was a decided tendency to look upon "any soil as soil." An examination of the voluminous soils literature of the past will bear out this statement. For example, the results secured by one investigator may not be checked by another, and each, then, may privately suspect the other of inaccurate work, even if they do not go as far as to engage in a polemical dispute in some scientific journal. The Bureau of Soils' toxic theory of soil fertility, the acid phosphate-rock phosphate dispute, the character of soil acidity, the cause of soil infertility, the protozoal theory of the Rothamsted investigators, the plant disease theory of Bolley and a host of other interesting and important questions have not been settled because it has been attempted to dispose of them without regard to the soil types involved.

There are, of course, certain principles which may be found to be applicable to all soil types, to all soil series, to all soil families or to all soil orders, but they can not be accepted as applicable by mere assumption. Investigations must be carried out on each type. Obviously, such principles can not be enunciated, therefore, for many years to come. Not even for a limited area will it be possible to lay down laws until investigations have been continued over a long period of time. There are over two hundred soil types now mapped in Iowa, and before the survey of the state is completed there will be many more. In the United States there will undoubtedly be many thousands of types.

But soil investigators are not at all alarmed by the amount of work which is thus indicated to be ahead of them. Rather are they enthusiastically accepting the "new soil science" and planning and carrying out their work on the modern basis, knowing that their results will not be misinterpreted, will not be discarded because of being inapplicable to all soils and will not be merely an evidence of wasted effort. They can be confident that they are adding to the sum total of human knowledge and eventually in the distant future they will have played their part, contributed their quota toward the establishment of the principles and laws of soil science.

While the investigations of the past have added much to the present-day knowledge of soils, the studies of the present are accumulating facts upon which laws can be formulated. The modern concept of soil science has literally brought all soils work "down to earth," and the future can be faced with confidence. No more will there be any question of whether or not soil science is a real science. No more will investigations be criticized on the basis of being inapplicable to all soils. Work on one soil type will be recognized as of value. The "new soil science" is scientific; it is distinct; it is permanent, and, finally, it is definitely and undisputably agriculturally practical.

RECENT PROGRESS IN THE HISTORY OF ANCIENT MATHEMATICS[1]

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NOT much more than one hundred years ago the united efforts of a large group of European scholars unraveled the mysteries of the Egyptian hieroglyphics and hieratic characters, and only a little while thereafter in a somewhat analogous manner the mysteries of the Babylonian cuneiform writing were revealed. By these efforts two absolutely dead languages were placed among the living languages of the world of scholarship. These achievements must always be accounted among the greatest accomplishments of the human intellect, restoring Egypt and Babylon to participation in the telling of the history of by-gone ages.

In the early days of Egyptology the Rhind mathematical papyrus was discovered and translated, based upon the recently deciphered hieratic writing. In Babylon the tablets of Senkereh, with tables of squares and cubes, gave a significant bit of material about Babylonian mathematics. In both instances these were accidental documents whose preservation and discovery were somewhat a matter of chance.

Concerning certain developments of Greek mathematics particularly with respect to the development of arithmetic and algebraic ideas the information available has long been fragmentary and to some ex-

[1] Address delivered before the Michigan Education Association Institute, Ninth District, Mathematics Section, October 28, 1929.