Marshall's Volume 1 On Soil Materials

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THE CLAY OF THE MUDDY MISSOURI RIVER; or of the "gumbo" soils of its flood plains; or of the troublesome "clay-pan" subsoils of the level—once less-productive—area of nearly a quarter of Missouri's arable acres would scarcely suggest itself for scrutinizing research by science. But yet for more than a half-century it has been the object of decided concern for study by the Missouri Agricultural Experiment Station. That was initiated by Merritt F. Miller, originally professor of soils and later dean and director of the station. Others followed in the clay studies—Huddleson, Duley, Albrecht, Bradfield, Jenny, and Baver, in the earlier years, and C. Edmund Marshall since 1936. That says nothing of the host of other faculty members, and their graduate students, who were also interested in studying the clay. From their tabulations of the many properties of that minute separate of the soil in relation to the nutrition of microbes, plants and animals grown thereon, the knowledge of the chemodynamics of the clay has been organized into principles for technological application to improved soil management. There has come, thereby, a trebling of the productivity of that extensive agricultural area. Prof. C. Edmund Marshall has now made available that organization of the basic facts about the clay of the soil in his book, "The Physical Chemistry and Mineralogy of Soils. Volume I. Soil Materials" John Wiley & Sons, Inc. New York, London, Sydney.

This volume applies the general field of physical chemistry to soil systems, via thermodynamic and non-thermodynamic knowledge, by which the soil is active in both decomposition and synthesis of clay minerals. Those are given special attention. The mineralogy of the soil is introduced and given decided clarification through the modern molecular structural classification of the alumino-silicates, which were for years the natural objects of studies in colloidal chemistry.

After outlining the application of physical chemistry to soil systems in the first near-sixty pages, then the soil separates, viz: sand, silt and clay are each given individual consideration with respect to chemistry, mineralogy, colloidal nature and characterizing physico-chemical properties. The latter given to the humic matter of the soil should be of interest when it brings the long-baffling properties of this organic soil separate into order corresponding more nearly with that of the inorganic clay.

Almost the second half of the book is given

to the chemo- and electro-dynamics. Those include molecular adsorption by the soil materials, electrochemical properties of the clays, and their ionic exchange, adsorption, and fixation-reactions with special reference to them in suspensions and pastes. Through all this discussion there is the prominence of natural surface properties and associated phenomena of matter which transcend those of its mass more and more according as the particles become smaller, or by which fact many materials are classified as colloidal.

By the reported studies of the clay as a "membrane," that term envisions the clay's connection molecularly, ionically and dynamically with the membranous cell-wall of the plant's root-hair. It points to those two membranes in contact within the moist soil as the minute area for study and explanations of how the soil can be nutrition for both microbial and root cells through such contact. With adsorption of nutrient cations on the soil's clay-humus colloid explained in chapter **5**; electrochemical behaviors of those colloids codified in chapter **6**; and the characteristics of ionic exchange listed in chapter **7**; the small surface areas of the animate roots (or microbial cells) matched up with those inanimate ones of the clay-humus become most extensive for vision of how they represent the vivo-dynamics by which the roots within the soil spell plant growth above it.

Such information connects the first stage of soil development in the weathering of the rock with the living soil microbes and the production of all plants. It suggests the clay as the minute mid-link in the long chain of natural phenomena from the lifeless beginning of rock disintegration through to the perpetuation of all life. It makes the soil the real power of creation in its own science as well as in ancient allegory.

This first one of two volumes has nine chapters dealing with the materials of the soil. It assembles the thinking, not only of the author during his decades of research, but also of nearly five hundred others in the science of soil and the contributing sciences. They represent the author's familiarity with the nearly six hundred references cited relatedly at the close of the chapters. That familiarity makes the book an excellent reference to the extensive bases of soil science. It is a fitting foundation for the second volume bringing discussion of "Natural Soils" and his interpretation of them in their respective geo-climatic settings, different degrees of development, and varied nutrient potential for crop production as we can now measure it technically by soil, crop and animal tests.

While the rapid strides were taking place in the evolution of soil science, of which so much is already recorded in this volume, the separate facts were moving out into practices in fertility treatments and management of the soil for improved plant nutrition. Guided by progressively improved soil tests, these have demonstrated their reliability by increased production of crops and livestock. The refined clay in colloidal suspensions was a medium for establishing the laboratory-grown cultures of nodule-producing bacteria, distributed to farmers for inoculating their seedings of new legumes. The clay, as a paste mixed with quartz sand, made possible the establishment of the ratios of the cations; viz: calcium, magnesium, potassium, sodium, and hydrogen (a non-nutrient), adsorbed on the clay in a "balanced" plant diet for legumes of higher protein and mineral contents representing higher nutritional values. It was via the refined clay techniques of accurate nutrient control of microbe and plant nutrition that the nodule bacteria and leguminous plants were brought into understanding of their symbiosis for nitrogen fixation according to required nutrition of both by the calcareous and more fertile soils.

Better balanced diets, including the soil's organic matter, for the non-legume plants establishing their mycorrhizal symbiotic root connection with soil fungi, is a challenge to research ahead to comprehend and to manage that microbial section of the soil flora (now of antibiotic fame) for increased biotic surface in soil contact mobilizing chelated nutrient elements and organo-inorganic molecules according to the organic matter of the soil. Therein the anions, phosphorus, sulfur, nitrogen and others serving plants from that non-elucidated, colloidal soil separate, may bring about our understanding of its chemodynamics on a par of that for the nutrient cations connected with clay.

When our understanding of the molecular structure of the sand and silt showed that "the mineral nature of this skeletal part of the soil exerts an important and often preponderant influence on processes of soil formation and development and on the resultant fertility"; and when that structural approach also gave much wider interpretation of the chemo- and electro-dynamics of the clay which drapes that skeleton much as living tissue does in the warm-blooded body; can we not envision soil science as a future clarification of the factors in species' distribution on the face of the earth, and in the acceptance of the soil as the basic one in the science of ecology? If fuller techniques as a sequel to atomic energy will push our concepts in soil science forward to a par with the push given it by atomic structure applied to soil mineralogy, there should come great help toward wiser management of soils for support of more and healthier life-forms over wider extent of the earth's surfaces of both land and sea.