A. A. J. de 'Sigmond and Modern Soil Science

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The first decades of the 20th century represent very significant stages in the development of sciences. As regards modern soil science, it was during this period that the basic principles of our present knowledge, views and, partly, methods were formulated, due to the activities and contributions of numerous outstanding soil scientists of whom ALEXIUS A. J. DE 'SIGMOND is considered as one of the greatest. It is to his memory that this volume is dedicated on the occasion of the centenary of his birth.

A. A. J. DE 'SIGMOND was born in Kolozsvár (Transylvania) in 1873. He studied chemistry at the Technical University of Budapest, graduating with the degree of chemical engineer in 1895. His professors, first of all L. ILOSVAY, the eminent expert on analytical chemistry, recognized 'SIGMOND's outstanding ability already in his early student years and invited him to participate in the scientific work carried on at the Faculty. 'SIGMOND received his doctor's degree in 1898 from the University of Kolozsvár. In addition to his scientific work, 'SIGMOND devoted much time to language studies; his knowledge in English, German and French was such, that he could lecture and write papers in these languages with complete ease.

In 1899 'SIGMOND became assistant chemist at the Agricultural Experiment Station at Magyaróvár where his interest in soil problems was stimulated by his chief, S. CSERHÁTI. He engaged in studying Hungarian salt affected soils and the methods of their utilization. During the years he spent at Magyaróvár, 'SIGMOND became familiarized with agronomical research, field experiments, as well as with the laboratory methods of soil analysis. He was charged with developing a method for the determination of available phosphorus compounds in soils. His report "The significance of available phosphoric acid and its determination for obtaining data on the nutrient requirement of soils" was awarded a prize by the Hungarian Academy of Sciences in 1905. One year earlier, in 1904, his book "Agricultural Chemistry" was published.

In 1905, he became privat-docent in agricultural chemistry at the University of Budapest.

In 1906 the decision to establish an Institute of Agricultural and Food Chemistry within the Technical University was reached and 'SIGMOND was entrusted with the important task of organization. To gain experiences in this field he was sent abroad for a 2 year study tour. He visited various agricultural

institutes in Western Europe and in the United States and familiarized himself with their work and set up.

'SIGMOND was appointed the Head and the first professor of the new Institute and he bore this responsibility during the rest of his life.

The 1st International Conference on Agrogeology (Budapest, 1909) had a decisive influence on 'SIGMOND's carrier. During this meeting he and his elder colleagues, P. TREITZ and I. TIMKÓ established closer contact and co-operation with other eminent soil scientists of the world.

At the 2nd International Conference on Agrogeology (Stockholm, 1910) 'SIGMOND was entrusted with the organization of the International Commission on Chemical Soil Analysis and was elected Chairman of this Commission.

In 1911 the Hungarian Ministry of Agriculture appointed 'SIGMOND a member of the High State Commission of Agriculture. The main task of this Commission was to control the quality of agricultural products.

Between 1916 and 1925 'SIGMOND became the member and served as officer of numerous Hungarian and foreign scientific bodies.

In recognition of his outstanding scientific achievements 'SIGMOND was made a member of the Hungarian Academy of Sciences in 1925. Next year he was appointed Director of the Hungarian Central Institute of Chemistry. In his new capacity 'SIGMOND's first action was the establishment of soil research laboratories not only in the Central Institute but also in its county departments.

In May 1924 the 4th International Conference on Agrogeology held in Rome adopted a resolution signifying a milestone in the progress of soil science: the International Society of Soil Science was founded. The International Commission for Soil Chemists was bodily incorporated as Commission II (Soil Chemistry) of which 'SIGMOND was elected president.

'SIGMOND devoted particular attention to the question of alkali soils. His book "Hungarian Alkali Soils and Their Reclamation" was published by the Hungarian Academy of Sciences in 1923. A few years later it was translated also into English and published by the University of California in 1927.

As one of the most eminent experts in this particular field, he was elected president of the Alkali Subcommission, which was established by the 1st International Congress of Soil Science (Washington, 1927). Within the framework of both Commission II and the Alkali Subcommission important meetings were organized and these exercised great influence partly by organizing and co-ordinating research at an international level, partly by providing a forum where the aims, results and problems of research work could be discussed.

In appreciation of his tireless and valuable activity, 'SIGMOND was elected honorary president of Commission II and honorary member of the ISSS at the 3rd International Congress of Soil Science in 1935.

In 1934 'SIGMOND published his "Handbook of Soil Science" in Hungarian in which he summarized not only the results of his investigations and his philosophy on the different branches of soil science but also all that was known about soils at that time. The somewhat shortened English version of this book entitled: "The Principles of Soil Science" was published in London in 1938. Notwithstanding the time that has elapsed since its publication, it is still quite modern in its outlook on nature, soils and practical aspects.

His intense and many-sided scientific activity did not prevent 'SIGMOND from playing an active role also in public life. He received various honors from the Hungarian government and from foreign countries as well.

In the late thirties 'SIGMOND's health, which had always been fragile, rapidly deteriorated and he died on 30th September 1939. His passing away meant a heavy loss to Hungarian and international scientific life.

In the first years of this century, — the actual beginning of the scientific activity of A. A. J. DE 'SIGMOND —, soil science, that developed mostly from geology to become an independent science, looked back upon a past of barely 25 years. Although the fundamental aims and theoretical concepts, as well as the tasks of practical importance were elaborated, adopted and recognized by the beginning of the 20th century and soil scientists displayed intense activity in many countries, the approach and methods of soil science still resembled closely those of geology.

If we study now a soil map prepared around the turn of the century, on the basis of our more advanced knowledge we find it to resemble geological or climatic maps more than present-day soil maps. At that time the methods of soil science were nearly identical with those of geology both in field survey and laboratory techniques. It is quite understandable that this situation impeded, in many respects, the rapid development of soil science as an independent discipline. Thus, although DOKUCHAEV (Russia), HILGARD (USA), RAMANN (Germany), RUSSEL (UK) and others deserve credit for laying the foundations of an independent soil science, the creation of really modern soil science was accomplished by the second generation of great pedologists, who carried out their activity mainly in the first third of the 20th century. During this period revolutionary development was attained in physics and chemistry, as well as in other exact and applied sciences. On the basis of modern physics and chemistry a new, scientific conception of Nature was formed, determining the development of practically all sciences of our epoch. The new concepts made it possible for the scientists to get a more up-to-date and exact knowledge of the Laws of Nature and they considerably contributed also to the more practical and efficient application of the scientific achievements in the different fields of everyday life. All this affected pedology as well, because at that time the interest of eminent soil scientists such as GEDROIZ, GAPON, KOSSOVICH, POLINOV and TYURIN in Russia, i.e. in the USSR, KELLEY and MARBUT in the USA, KAPPEN in Germany, RUSSEL in England, HISSINK in the Netherlands, WIEGNER and PALMAN in Switzerland, MATSON in Sweden and last but not least that of 'SIGMOND in Hungary centered on the exact sciences. Applying the new results achieved in those fields they developed the up-to-date methods of their own branch of science.

'SIGMOND never ceased to emphasize the importance of close contact with the other natural sciences, as is indicated by the following quotation from his book "The Principles of Soil Science" (p. 3):

"The fact that pedology has risen to the dignity of an independent natural science has in no way impaired its connection with the other natural sciences. On the contrary, all kindred sciences have gained by the concentration in a scientific system of all our pedological knowledge. Previously this knowledge was scattered about the whole field of scientific literature, a fact which made it extremely difficult to find references."

'SIGMOND and his colleagues were very much impressed by the rapidly developing colloid chemistry. Still intent on separating soil science from geology he wrote in his book "The Principles of Soil Sciences" (p. 1.):

"Yet petrographers investigate the weathering process from a different point of view from pedologists, who are interested in those transitory states and changes of rock which cannot be defined by petrographic or mineralogical methods. Rocks may be classified according to their component minerals, whereas the clearly definable minerals in soils are mostly of no importance for the purpose of determining the soil type. This is due to the soil-forming rock being only one, and very often by no means the dominant factor in soil formation.... (p. 86) For that reason purely mineralogical analyses can usually be employed only to a restricted extent for characterising the various soil types. The case is quite different with the recent investigations of the colloidal fractions, which cannot be regarded as original minerals, but as the results of chemical reactions occurring during the weathering process. From some of the investigations we may conclude also that the same secondary minerals contribute actively to the reactive capacity of the colloidal fractions."

Now, in the light of our more thorough and advanced knowledge, we would express this in slightly different terms, yet it shows clearly that 'SIGMOND's attention was drawn to the most active, most mobile compounds in soil formation. Simultaneously with searching for the way to find new methods for the better characterization of the soil forming processes, he devoted, just like GEDROIZ, KELLEY and others, close attention to the soil's adsorbing complex, the thorough study of which started at that time. 'SIGMOND was of the opinion that the investigation of the adsorbing complex of soils would make the subtle interpretation of the soil forming processes possible. He expressed this idea in "The Principles . . ." (p. 111):

"The fact that the characteristics of the adsorbing complex — which are easily definable chemically — reproduce what are practically the past and the present dynamic conditions of the soil and allow us to foresee phenomena to be expected in the near future has made the adsorbing complex a very important medium in soil dynamic researches — so important as to have led certain soil students to base their whole soil system on it."

'SIGMOND and his contemporaries were the pioneers of modern soil colloid chemistry and they laid the foundations of our present knowledge in this subject.

'SIGMOND attempted to explain soil formation processes on the basis of physical, chemical and physico-chemical reactions of both colloidal and molecular magnitudes. He studied not only these processes but also the interrelationships existing among them during soil formation. His conceptions in this field met with world-wide appreciation and his methods were introduced into laboratory-, field- and model experimental techniques used in the study of soil forming processes.

It is still perfectly up-to-date what he wrote in his book "The Principles . . ." on the main soil forming reactions, on the grouping of processes playing a decisive role in soil formation, as well as on their dialectical interrelations with each other and with the environmental conditions (pp. 67—68):

"The main reactions taking place in the soil may be grouped under the following heads:

a) Dissolution and precipitation.

b) Leaching and accumulation.
c) Oxidation and reduction.
d) Humus formation and decomposition.
e) Formation and behaviour of the adsorption complex.

I have grouped these general reactions in pairs; for the several pairs are interdependent, though being phenomena of opposing character. Dissolution must always precede precipitation. It is dissolution that brings into being what is called the leaching process — the migration of matter in soil formation — while accumulation is the result of precipitation. There is no accumulation without leaching, the only exception being the accumulation of organic matter in the upper soil horizon. Oxidation and reduction are very frequent and sometimes characteristic soil reactions.

Among the most important and most characteristic processes of soil formation are humus formation and decomposition. In the foregoing pages I have already spoken repeatedly of these processes; indeed, in dealing with the micro-organisms taking part in soil formation we familiarised ourselves with the principal kinds of natural humus formation. What we have to do now is to gather together into an organic whole the material scattered about in the several chapters dealing with the different factors. For despite the fact that the process is contributed to by the higher plants and animals, by micro-organisms, and to some extent indeed also by man — these being all factors differing in themselves and more or less independent of one another — humus formation is nevertheless to be described as the result of a harmoniously coherent co-operation (biocoenosis)."

Although our knowledge has been considerably enlarged since that time, and the techniques used have become much more subtle, we have not much to add to the foregoing, at least as far as basic principles are concerned.

The development of pedological methods raised soil science, as a whole, to a higher level, it has become more and more suitable to cope with practical tasks. 'SIGMOND also recognized the importance of the unity of theory and practice in the field of research. He was well-aware of the fact that science can ward off making errors, and can find the right answers to practical problems only if the unity and the joint development of theory and practice are achieved. In "The Principles . . ." he underlines the importance of theory in approaching the practical problems on an up-to-date level (p. 3):

"Soil science, however, deals with the phenomena on a much wider and purely scientific basis, and . . . (this) has already led to important practical results — enabling us, for instance, to ascertain the origin, possibilities and methods of reclamation of alkali soils."

In an other part of the same book, he emphasizes the absolute necessity of field studies and practical knowledge (p. 80):

"A pedologist — whether chemist, physicist or biologist — should never confine his investigations to the laboratory. Soils must be examined in detail in their natural environment, otherwise there is every likelihood of drawing false conclusions."

The unity of theory and practice has remained very significant in soil science. Neglecting or underestimating the importance of either of them would prevent the drawing of rational and satisfactory conclusions, as well as the application of scientific results in practice.

'SIGMOND and his generation still considered it necessary to emphasize

the differences between pedology and other earth sciences. Today, when soil science has a past of more than a hundred years, and no one questions its importance as an independent discipline, we are faced with a different necessity. We have to do our best to promote the integration of the achievements of all natural sciences on a high level in order to meet the requirements of agriculture, soil mechanics, and, last but not least, of the conservation and protection of the natural environment. In this respect the precise definition of soil science as an independent discipline as well as of its sphere of activity and contacts with other sciences is just as important as it was in the past, and SIGMOND's relevant definitions are still valid and correct ("The Principles..." p. 5):

"Soil is a discrete natural product differing from both the dead mineral world and the living organic world, lying on the boundaries of the lithosphere and the biosphere and connected with both uniting them and obtaining its raw materials from them; it is the product of special genetic factors which determine and continuously direct the physical, chemical and biological phenomena and characteristic properties of the soils, thus making them the cradle of continuous organic life and the burial-place of dead organic matter. The soil is the scene of constant changes and transformations."

At the same place in the book the interrelations of soil with the living and non-living world are even more precisely defined (p. 4):

"We are, indeed, entitled to say that soils belong to the biosphere (pedospere) — i.e., to that outer layer of the earth in and on which organic life exists — in contrast to the lifeless lithosphere, the outermost but dead crust of the earth. But the biosphere includes also fresh and salt water and the mud of lakes and seas. This latter is physically very closely related to, and in many cases hardly distinguishable from soil, being rich also in living organisms; but it differs from soil in that it is covered with water, whereas soils are in immediate contact with the atmosphere. . . . In volume and quantity the pedosphere is relatively insignificant when compared with the other spheres of the earth, but it is the source of all living existence. Soils are thus intermediate between the dead and the living world, being the prime source and carrier of all life. As natural products, they constitute an integral component of the solid part of the earth; and therefore — and for that reason only — come within the sphere of geology, as may also the atmosphere. . . . The formation and existence of soils depend upon special circumstances and factors which may be called collectively soil-forming factors. These factors are so characteristic of the several soil types that if we desire to obtain an exact idea of what soils are, the best way is to study soil genetics — i.e., the origin and formation factors of soils. Upon these soil-forming factors depend the peculiar structure of the soil and the physical, chemical and biological properties which differentiate it from both the dead and the living worlds. In the same way as the pedosphere lies between the lithosphere and the atmosphere, so also it may be said to be wedged between the living and the dead mineral worlds, which it connects and links together. It is in the soil that inorganic substances are transformed into living organisms, and dead organic matter also changes back into organic compounds. The soil is the cradle and the burial-place of all life."

These definitions may still serve as our guidelines and as the basis on which the co-operation with other earth sciences on the one hand, and with biological sciences and biosphere research on the other hand, may develop to the benefit of mankind.

'SIGMOND's scientific activity was not confined to one particular field in soil science. His constructive research work was concerned with so many different topics (e.g. soil classification, soil fertility, soil mineralogy, soil mapping, soil physico-chemistry, etc.) that it is simply impossible to delineate even a sketchy picture of all of them within a short paper dedicated to his memory.

There is, however, a part of his activity I should like to touch upon briefly. This is his research work concerning salt affected soils. His achievements in this field are the ones most closely related to his image preserved in the scientific world.

"Hungarian Alkali Soils and Methods of Their Reclamation", the first book by 'SIGMOND that was published also in English, dealt exclusively with salt affected soils, and the second one ("The Principles of Soil Science") was partly related to these soils.

'SIGMOND deserves the fullest credit for having studied all the problems posed by salt affected soils and for having achieved outstanding results in the investigation of the physics and chemistry of these soils as well as in their classification and utilization. The scope of his investigations was never limited to a particular area, nor was his interest focused only on the Hungarian salt affected soils: he studied these problems on a world-wide scale. He was among the first scientists who found and described salt affected soils in humid areas; he investigated and elucidated the rules governing their genetics. At the same time he paid due attention to the salt affected soils of arid regions, particularly to those occurring under irrigated conditions. 'SIGMOND was one of those who first adopted and applied the modern methods of colloid chemistry in the study of salt affected soils, and, contemporaneously with GEDROIZ and KELLEY, he called the attention to the importance of mineralogy in investigating the processes of soil salinity and alkalinity. These works of his have shown the way to the modern approaches used now in the surface chemistry and mineralogy of alkali soils.

Research carried on during the time that has elapsed since 'SIGMOND's death has proved his grouping system elaborated for salt affected soils correct. This grouping system (in a simplified form: *a)* saline soils; *b)* saline-alkali soils; *c)* alkali soils) characterizes well both the basic chemical properties and the different formation processes of salt affected soils. The same grouping is suitable when the recommendations for the reclamation and the utilization of salt affected soils are elaborated.

The Subcommission on Salt Affected Soils of the International Society of Soil Science is co-ordinating the programme for the preparation of the World Map of Salt Affected Soils, and within the framework of this project 'SIGMOND's grouping system has been revived and in a somewhat modified form served as the basis for an international classification of salt affected soils:

A) A class dominated by chlorides and sulphates. This class is to be called: *saline.*

B) A class dominated by exchangeable sodium and/or by sodium bicarbonate and/or sodium carbonate. This class is to be called: *alkali.* It is subdivided in:
   a) a sub-class without structural *B* horizon
   b) a sub-class with structural *B* horizon
      1. Solonchak-solonetz and calcareous solonetz
      2. Non calcareous solonetz with *A* horizon < 15 cm

3. Solodized and/or deeply leached solonetz and solod
4. Solonized and slightly salt affected soils with minor structure formation.

This classification is corresponding well to other grouping systems used in different parts of the world; the correlations are quite satisfactory for general maps from the practical point of view, clearly showing the soundness of 'SIGMOND's conceptions also in this field.

The work and achievements of 'SIGMOND raising soil science to altogether higher levels has earned him — already during his life and ever since — international fame and appreciation.

One of our most celebrated poets, J. ARANY, dedicated a poem to the memory of another great son of Hungary, who earned the everlasting gratitude of the nation. The words of the poem may apply also to 'SIGMOND, just as they relate to all men and scientists who dedicated their lives and work to the benefit of mankind, and whose achievements have stood the test of time:

"... it survives diffusing ever brighter light
as he recedes farther in space and time."