A. A. J. de 'Sigmond and the Development of Soil Science

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A. A. J. DE 'SIGMOND had a prominent part in the development of soil science. His researches concerning the general problems of soil formation and classification as well as the genesis and amelioration of salt affected soils are still of profound importance and interest.

'SIGMOND concurred in DOKUCHAEV's opinion that soil formation is affected by a complex of several factors: parent rock, climate, relief, the activity of living organisms and age. He didn't accept the classification of soils on a geological basis developed by German scientists, RICHTOFEN and RAMANN, and always emphasized the close connection between soils and living organisms, especially the flora.

According to 'SIGMOND's opinion, soils are in continuous development. In his fundamental work [7] he stated: "The formation of the soil does not come to a standstill even if it is well developed: podsols for instance, may in time change into peat soils or steppe soils. It is quite impossible to ascertain which state of the soil is the end of the process of development."

'SIGMOND realized that human activity is one of the most effective factors in present soil forming processes.

'SIGMOND displayed intense interest in the investigations of DOKUCHAEV, SIBIRTZEV, GLINKA, GEDROIZ, KOSSOVICH, VISOTZKI, BOGDAN and NEUSTRUEV. Eminent personalities of Soviet soil science: D. N. PRIANISHNIKOV, K. D. GLINKA, L. I. PRASOLOV, B. B. POLYNOV, V. V. HEMMERLING, D. C. VILENSKY met him many times during their visit in Hungary or during international conferences. He introduced Russian terms into his scientific works like: "podsol", "chernozem", "gley" and in his researches he applied the genetic principles of the analysis of soil profiles according to horizons, elaborated by Russian soil scientists.

In a certain period 'SIGMOND and GEDROIZ considered the composition of exchangeable cations as the only basis for the classification of soils [1, 2, 6]. 'SIGMOND emphasized, however, unlike GEDROIZ, that the amount of exchangeable potassium is also a very important feature of classification. His opinion was based on analytical data indicating that high amounts of exchangeable potassium could be found in some Hungarian soils.

In his book "The Principles of Soil Science" [7] it is properly emphasized that soil classification has to be based on genetical and dynamical principles and on the characteristics of the soils themselves. For that very reason he didn't find the systems of RICHTOFEN and GLINKA satisfactory as a basis for the classification of soils formed under different climatic and geographical conditions.

'SIGMOND highly appreciated the scientific activity of MARBUT, the prominent American pedologist, who subdivided the soil types of the USA according to their Ca and Fe reserves and to the forms in which these compounds occurred. At the same time he found MARBUT's classification also not quite satisfactory because the conditions of soil formation were not properly taken into consideration in it. In 'SIGMOND's interpretation DOKUCHAEV's principle of classification involves both the concept of soil formation and the estimation of the relationship between the soil and soil forming factors. In 'SIGMOND's "General Soil System" [5] the "soil orders" deserve special attention. He remarked that these "soil orders" represented the most general grouping of soils formed under similar climatic and water regime conditions.

'SIGMOND observed that: "As a rule the H soils are spread over humid climates, the Ca soils in arid and semi-arid climates; the red earths in humid tropics or sub-tropics, the laterites in humid tropics with intermittent dry periods; the sphagnum turfs are of frequent occurrence in cold, humid climates". [7]

The so-called azonal and interzonal soils also display, according to 'SIGMOND, some characteristics of zonal soils and together with the latter they can be included in the "soil orders". It must be remarked that numerous Soviet soil scientists came to the same conclusion.

On the basis of his classification system, 'SIGMOND suggested the existence of soil types which were not yet known at that time, but which would be discovered sooner or later. He writes for example: "At present I do not know of any organic soil which has originated in salt water and constitutes a soil as really organic as the fresh water turf soils. Theoretically we may, however, assume that there may be conditions tending to produce this kind of soil . . . These soils occur in the deltas of rivers . . . We might theoretically expect the formation of saline low-moor land, not only in the tropics but also in cooler zones. It might be formed also in the interior of continents as a consequence of shallow salt lakes being grown over." [7]

Actually the above mentioned supposition has been confirmed by various recent investigations carried out on the alluvial plains of Ukraine, in the deltas of the Kuban, Volga, Kura and Amu-Darya rivers and on turf soils in West Siberia.

The place of Hungarian black soils in the classification system has a particular interest for Soviet soil scientists. 'SIGMOND considered these soils as identical with Russian chernozems. Under Hungarian black soils, however, the water table is nearer to the surface and at a depth of 90—100 cm considerable amounts of exchangeable sodium (8—13% of the sum of cations), sometimes a certain amount of water soluble salts (below 0,4%) and considerably high alkalinity (pH 8—8,5—9) can be found. These soils seem to be similar to the solonetzic solonchak-like meadow chernozem soils in Tambol and in the West Siberian Plain. Hungarian black soils represent a pre-stage of typical steppe chernozems and this explains a certain degree of salinization and alkalinization and the considerably higher level of the groundwater.

The study of the problems of soil salinization and alkalinization represents a very important part of 'SIGMOND's scientific activity. Salt affected soils are widespread in Hungary and naturally they have drawn the attention of Hungarian scientists.

In his book, "Hungarian Alkali Soils and Methods of Their Reclamation" [3] 'SIGMOND discussed the history of the investigation and amelioration of salt affected soils and he described in detail their genesis as well as their physical, chemical and biological properties.

According to 'SIGMOND's opinion, the formation of salt affected soils is closely connected with the following natural environmental factors: arid climate, impermeable subsoil, periodically excessive moisture conditions caused by the groundwater rising near the surface, and the rapid evaporation of soil moisture.

'SIGMOND subdivided the Hungarian salt affected soils — just as we, Soviet soil scientists do — into two main groups: heavy clayey, alkaline soils — analogous with Russian solonetz soils, and saline soils — analogous with solonchaks. In Hungary soils belonging to the second group are mainly sodic solonchaks, while most solonchak soils of the steppe and prerie regions of the USSR belong to the sulphate-chloride type. The importance of different salts in the formation of saline soils and the importance of the composition of exchangeable cations in the formation of solonetz soils in particular was studied by 'SIGMOND in numerous experiments. He endorsed the theory of GEDROIZ about the three stages: — solonchak → solonetz → solod — in the formation of salt affected soils. He thought it necessary, however, to introduce the intermediate stage of solonchak-solonetz in the above mentioned scheme [4]. It is remarkable that both GEDROIZ and 'SIGMOND, though they considered this scheme the normal and usual way of the development of salt affected soils, spoke about the possibility of the transition taking place in the opposite direction, i.e. from solonetz to solonchak soils.

As is well known, in many of his publications V. P. VILIAMS stated, that solonetz soils represent a pre-stage of solonchaks. It is also well known that in continental climatic zones hydromorphic meadow soils very frequently show well expressed alkalinization due to the effect of slightly mineralized, soda containing groundwaters without the previous formation of solonchak soils.

In such a way solonetzic hydromorphic meadow soils constitute the pre-stage of solonchak soils, turning step by step into the latter, particularly as a result of over-pasturing and flood control.

This type of genetical relationship between solnetzic soils and solonchaks is widespread and it is possible that a great part of the salt affected soils in the Hungarian Plain has formed just this way. Under the arid climatic conditions of the Hungarian Plain, meadow and peat soils can turn step by step into solonetzes and then into solonchaks. Probably this process has been accelerated and has become more intensive due to the drainage works. Similar phenomena can be observed very frequently on plains and flooded areas in the arid regions. Only after the lowering of the water table below 5—7 m, may desalinization processes start turning hydromorphic solonetzic and salty meadow soils into solonetzic chernozems.

Decades have elapsed since 'SIGMOND's death, and during this time new findings have enriched soil science, new facts have come to light. These are, however, closely connected with past researches. It has been proved that alkalinization phenomena occur in the soil if the parent material is rich in clay minerals of the montmorillonite type. It has been found that the neosynthesis of montmorillonite type minerals and of the interstratified form of illite-montmorillonite itself takes place parallel with the soda salinization of hydromorphic soils. It is one form of the geochemical accumulation of mobile products of weathering and soil forming processes.

It has been proved that, although during desalinization and desalkalinization processes water soluble salts are leached out and exchangeable sodium is replaced by calcium, a considerable amount of clay minerals of swelling lattice remains in the soil. These soils are called: solonetz soils with a small amount of sodium (occasionally without sodium) because in spite of the columnar structure and the compact B horizon, no considerable amount of exchangeable sodium can be found in them.

The theory about the formation of the most typical forms of solonetz soils under hydromorphic meadow conditions (i.e. under the effect of upward capillary flow) and in the presence of groundwaters containing sodium carbonate and/or hydrocarbonate, has been generally accepted.

The desalinization of sodic saline soils (i.e. saline soils containing sodium carbonate and bicarbonate besides chlorides and sulphates) usually brings about the formation of characteristic solonetz soils.

As regards the formation of soda-saline soils, the GEDROIZ—'SIGMOND—KELLEY theory is still considered as valid.

The same can be said about sodium-chloride saline soils without any gypsum content. In the arid regions, however, the greater part of saline soils is gypsipherous (soils containing sulphate, sulphate-chloride and gypsum). The desalinization of these soils does not result in the development of well-expressed solonetz horizons and high alkalinity, and this makes their amelioration and utilization much easier.

In the last 25—30 years it has been found that alkalinization phenomena (high alkalinity: pH 9—10; the relative amount of exchangeable sodium is more than 20—25% of the CEC; montmorillonite character of the colloid and silt fraction, swelling, crust formation and cementation) are characteristic of some crusty soils in the deserts of Asia and Africa. These so called "takyrs", having an impermeable, crusty surface of polygonal structure, may be found on ancient alluvial plains. On the other hand, some "smolnica" soils, the heavy compact horizons of "regurs", frequently some heavy structured meadow soils of Southern Europe and the vertisols of the Western Hemisphere display a montmorillonite type mineralogical character together with high alkalinity and a low quantity of residual salts and exchangeable sodium. In both cases (takyrs and compact vertisols) we have to infer the past existence of a hydromorphic regime and of some forms of salinization and desalinization processes.

Our knowledge about the role of the flora in the formation of saline, alkali and "normal" soils has become more exact, too. Due to some halophytes (Salicornia, Halocharis, Halostachis and others) up to 1000 kg/ha/year of salts may get into the upper soil horizons through biogenic ways. The evaporation of salt containing groundwaters, however, accumulates thousands of tons of salts in hydromorphic soils. The role of biogenic and evaporation salt accumulation changes if the water table is situated deeper than 7—8 m. Groundwaters do not evaporate from that depth and, consequently, do not cause any salinization processes in the soils.

The ionic composition of the ash content of gramineae and legumes is characterised by a slight excess of Ca^{2+} over sodium. Under the above mentioned flora therefore, a progressive replacement of sodium by biogenic calcium accompanied by the accumulation of humus, phosphorus and nitrogen may take place due to the decomposition and mineralization of the litter in every vegetation period. The transformation of alkali soils into so-called "alkali soils turning into stepp formation" and the development of "normal" soils may take place, too.

This theory was advanced by the author of the present paper in a lecture held at the meeting of the Alkali Subcommission during the 3rd Congress of ISSS in Oxford. The chairman of the meeting, Prof. 'SIGMOND, supported this theory though he remarked that if the plant litter contains alkalis, as it is characteristic of some steppe xerophytes (wormwoods and especially of Sacsauls (Haloxylons)), a biogenic alkalinization of soils may also take place. The sodium and potassium content of the decomposited litter of these plants makes the appearence of alkalinity possible.

Concerning the question of the amelioration and utilization of salt affected soils, 'SIGMOND was absolutely right in emphasizing that there is no general amelioration method. For each type of salt affected soils a particular method and system of amelioration and agrotechnics, selected on the basis of preliminary, detailed investigations of the given soils, have to be used. This fundamental thesis is even more valid in the case of soda-saline soils since their amelioration and utilization require complex measures.

The absolute necessity of the neutralization of the free soda content and the replacement of exchangeable sodium during the amelioration and utilization of alkaline sodic soils was proved by 'SIGMOND's laboratory and field experiments. For the amelioration of these soils an original method, the application of alum and the so-called "acifer" preparatum — a powder soaked with sulphuric acid — was tested.

Soviet, Hungarian and Romanian scientists have proved the importance of combining the chemical amelioration of alkali soils with deep ploughing and manuring.

For the amelioration of saline soils the lowering of the water table by drainage, leaching to remove the salts and subsequent ley-farming were recommended by 'SIGMOND as basic methods.

The above mentioned theories have been proved everywhere by the experiences gained in the amelioration of irrigated salt affected soils as well.

A. A. J. DE 'SIGMOND is one of the founders of modern soil science. In Hungarian and international scientific life his invaluable merits are rightly remembered and appreciated.

References

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