The Importance of 'Sigmond's Activity in Modern Soil Mineralogy

L. GEREI and M. REMÉNYI

National Institute for Agricultural Quality Testing, Budapest (Hungary)

Professor A. A. J. DE 'SIGMOND recognized the importance of the role that the colloid minerals play in the formation of soil properties [10, 11].

'SIGMOND used soil-mineralogical investigations for the characterization of soils and for the description of soil forming processes [14]. He designated the complexes having adsorption properties by the name of humus-zeolite complexes. Like GEDROIZ, he studied adsorption, the most important characteristic of the humus-zeolite complex, and its different types.

'SIGMOND attached a special, fundamental importance to the role of the humus-zeolite complex in the formation of salt affected soils [7]. He stated for example "The carbonate free 'szik' soils do not contain any carbonate of soda, as has sometimes been supposed; the alkali zeolites which they contain are responsible for the slight alkalinity. When treated with carbonic acid they yield an alkaline solution and therefore they may lead to the formation of sodium carbonate in the soil. These alkali zeolites actually accumulate in 'szik' soils, causing the peculiar physical properties of such soils. They can be recognized in the chemical composition by the great amount of soluble silica and of alkali metals."

'SIGMOND *considered the changes in the structure of the soil adsorption complexes as a very important part of soil dynamics* [14].

Following the directives of 'SIGMOND's scientific work, we investigated the changes in the structure of clay minerals during alkali soil formation in a strongly solonetzic meadow soil from Besenyszög, Hungary. The mineral composition of this soil is as follows:

In the clay fractions of the different horizons of the soil profile the quantity of primary minerals is roughly the same: about 5% of chlorite, feldspar, iron and aluminium hydroxide can be found in each horizon.

The highest quantity of quartz — about 20% — occurs in the A horizon and it decreases towards the deeper horizons; in the C horizon its amount is 8–10%.

As regards clay minerals, the quantity of illite is the highest — about 35% — in the A horizon, and it diminishes slightly towards the deeper horizons.

Montmorillonite in pure form could not be detected in the A horizon, but in the B horizon it occurs in a considerable quantity — about 20% — which slightly increases further — by a few per cent — in the C horizon.

Illite-montmorillonite interstratification is recognizable in each horizon. A small amount of the swelling component of the interstratification is present in the A horizon, and it becomes dominant — 70—80% — in the B horizon. The interstratification is random in each horizon (Table 1).

This mineralogical characterization clearly indicates that the amount of montmorillonite increases downwards in the profile, whereas the quantity of interstratified illite-montmorillonite, including that of the swelling component, has its maximum in the B horizon. This fact is in accordance with the former findings of the authors [2, 4] and it indicates that an illite-montmorillonite transformation, caused by and closely related to the alkalinization process takes place in the B horizon of solonetz soils.

Table 1

Mineralogical characterization of the strongly solonetzic meadow soil used in the experiment

Soil horizon	Depth, cm	Clay minerals
A	8— 16	I < Q < Cl = I—Cl = F = H
B_1	26— 37	I < Mo = Q < I—Mo < I—Cl = Cl = F = H
B_2	48— 55	I < Mo < Q < I—Mo < I—Cl = Cl = F = H
BC	75— 85	I < Mo < Q < Cl < I—Mo = I—Cl = F = H
C_1	97—105	I < Mo < Q < Cl = I—Mo = I—Cl = F = H
C_2	117—126	I < Mo < Q < Cl = I—Mo = I—Cl = F = H

I = illite
Mo = montmorillonite
Q = quartz
Cl = chlorite
F = feldspar
H = sesquioxide

'SIGMOND's other findings concerning soil formation as well as salinization and alkalinization also provide valuable help in soil mineralogical research. E.g. 'SIGMOND attached great importance to temporary water saturation and to desiccation in the formation of salt affected soils.

GEREI et al. [4] came to the conclusion that the following three conditions were necessary to the destruction of clay minerals in the course of the formation of carbonate-hydrocarbonate solonchak-solonetz and carbonate-hydrocarbonate solonchak:

a. The presence of sodium salts (especially hydrocarbonate and carbonate)
b. Temporary waterlogging (reduction process)
c. Temporary desiccation (oxidation process).

The fact, that identical factors play important roles both in soil formation processes and in the destruction of clay minerals, indicates that 'SIGMOND's theory on the importance of the adsorption complex saturated with sodium and its changes in the formation of salt affected soils can be proved by up-to-date methods, as well. 'SIGMOND attached great importance to model experiments in soil mineralogy, too. [6] He deserves great credit for the production of artification aluminium silicates on which he studied the properties of the inorganic adsorption complex in vitro. These compounds, named by him as artificial zeolites, were produced by boiling pure hydrate of silicic acid and aluminium-oxihydrate in sodium hydroxide solution. The artificial aluminium silicates were chemically and mineralogically analysed. He found that the more SiO_2 molecules were linked to the Al_2O_3 molecules, the higher was the initial ratio of the two components and the less was the excess Na_2O in the original solution. He carried out base exchange investigations with 10% ammonium nitrate solution. His statement, that the nutrient status of the soil is considerably affected by the amount of zeolites and by the quality of the adsorbed bases, has set an important course for research work. He recognized that the salt affected soil remains salt affected even after the leaching of sodium salts if the sodium zeolites remain in it. In a very important experiment that he conducted with his coworkers, TELEGDY-KOVÁTS and ZUCKER [12] they produced artificial zeolites (permutite) saturated or unsaturated with calcium or sodium and investigated their effect on the activity of the different nitrificating bacteria.

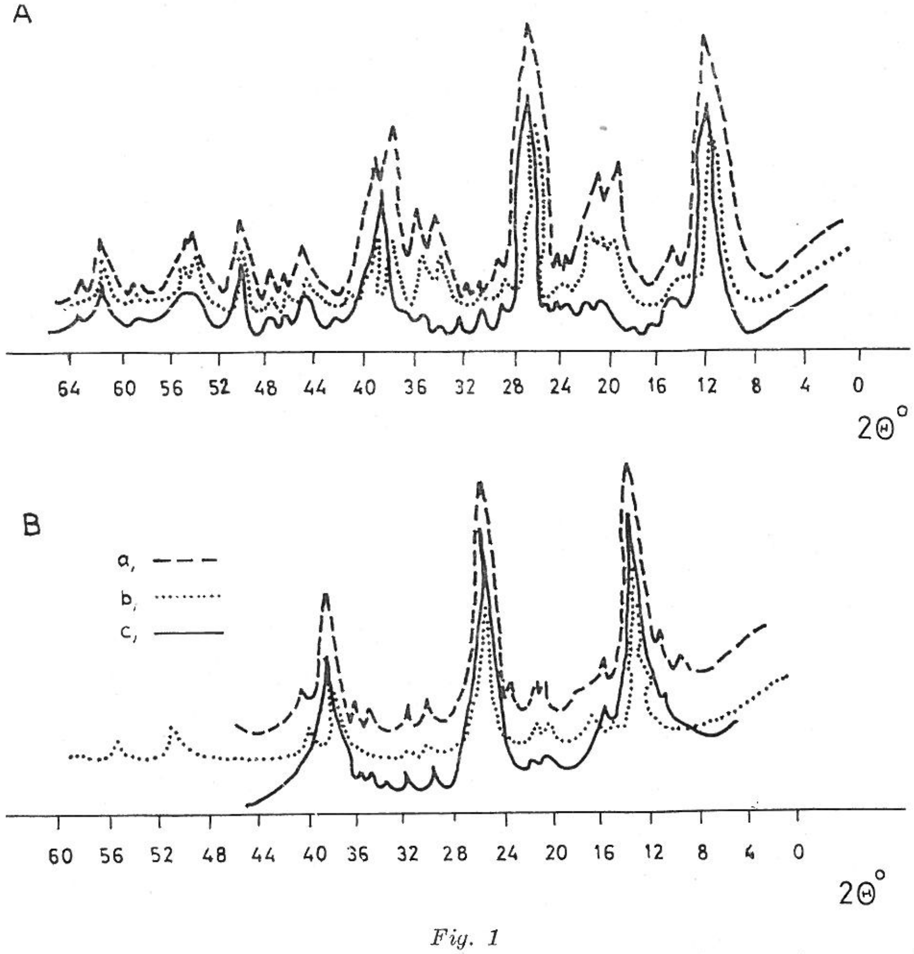

Fig. 1

Diffractograms of kaolinite. A. After treatments with 2 N Na_2SO_4 solution, repeated 70 times. B. After treatments with 2 N Na_2CO_3 solution, repeated 70 times. a. dried — frozen; b. dried; c. untreated

They proved the decrease of nitrite production under the influence of permutite treated with sodium, an increase due to the effect of calcium saturated permutite and the absence of nitrite production in the case of unsaturated permutite. In vitro experiments are important in modern soil minerology, as well. The authors [3] studied the effect of sodium salt solutions on clay minerals (kaolinite, illite, bentonite), as well as on the colloid fraction separated from the A horizon of a strongly solonetzic meadow soil. The treatments were carried out with 2 N sodium carbonate and 2 N sodium sulphate solutions. The method was as follows: 10 ml solution was added to 2 g soil. The samples were left standing for a week, then they were dried at 105 °C, or frozen at —4 °C, or alternately dried and frozen. After desiccation the samples were filled up with distilled water; the salt concentration of solutions in contact with the substance was kept unchanged during the treatments. The filtrate analysis was carried out after 70 treatments. After a thorough washing of the samples by distilled water, the original salt content was reset for the further treatments. Based on the results of the treatments the following conclusions can be drawn:

1. The changes refer to the beginning of a slight opening of the crystal-lattice after the destruction of weakly crystallized oxides and hydroxides.

2. After the treatments of kaolinite, well crystallized aluminium hydroxide developed from amorphous substances. (Fig. 1).

3. After the treatments of bentonite a *hydromica-like interstratification formed* in the crystal-lattice of bentonite. (Fig. 2.)

4. After the treatments of the clay fraction of alkali soils *the amount of the interstratified form of illite-montmorillonite increased in the samples.* (Fig. 3.)

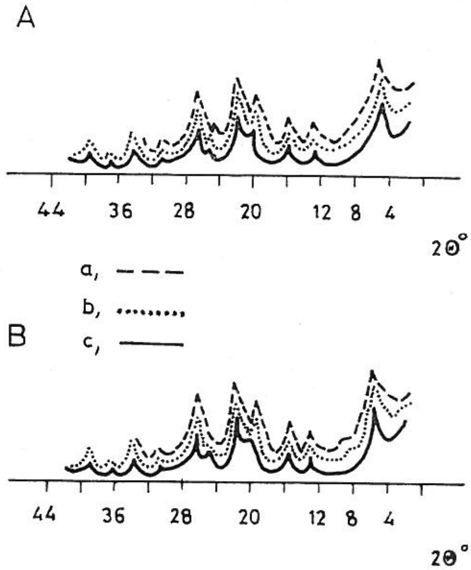

Fig. 2
Diffractograms of montmorillonite saturated with glycerol. A.—B. and a.—c.: See Fig. 1

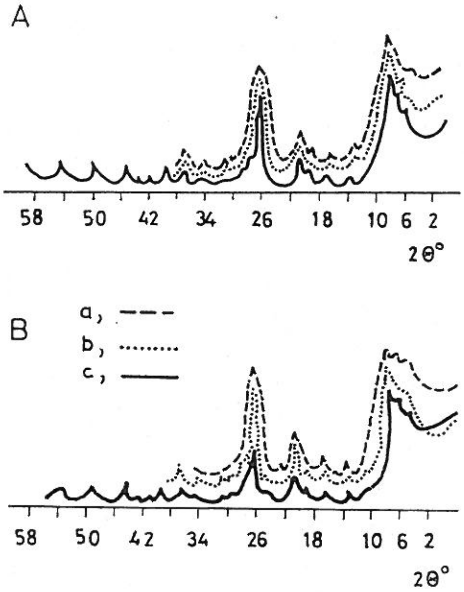

Fig. 3
Diffractograms of the clay fraction from the A horizon of a solonetz soil. A.—B. and a.—c.: See Fig. 1

'SIGMOND attached great importance to the investigation of the weathered part of soils. He made the following statement, which is still acceptable as a directive idea: "Since soil formation starts when the parent material chemically or minerologically decomposes, it is evident that the method used by the mineralogist or petrologist as a subsidiary means to recognize the weatherability of minerals and rocks becomes the most important means of the scientist dealing with soil investigations. From the point of view of soil evaluation generally it is not the remaining unweathered mineral that is important but the composition of the weathered part which cannot be determined mineralogically" [14].

'SIGMOND considered the concentrated hydrochloric acid extraction as the most suitable method for the analysis of the unweathered part. Also in the investigation of podzolization and the accompanying eluviation processes he considered indispensable the analysis of the hydrochloric extract besides the determination of adsorbed cations and hydrogen ions, pH and water soluble salts [8]. As president of Commission II (Soil Chemistry) of the International Soil Science Society he carried out comparative methodological investigations. The analysis of the hydrochloric acid extracts was also among the compared methods. The results of these investigations were presented and discussed at the Commission meating [9].

According to the present view, the transformability and weatherability of soil minerals depend on their grain size. To elucidate the existing relationships, the macro- and micro mineralogical compositions of the different grain size fractions of three soil profiles (meadow soil on calcareous clay, meadow solonetz on calcareous clay, solonchak-like meadow solonetz on calcareous sand) were investigated by DARAB et al. [1]. It was pointed out, that the effect of soil forming processes is the most noticeable in the fine dispersed fraction. The high amount of hydromica in the fine dispersed fractions of the A and B horizons of the examined soils and its abrupt decrease in the $1-5\mu$ size fraction are at least partly related with soil formation. The influence of soil formation is reflected in the mineralogical composition and colloid chemical state of the fine dispersed fractions, as well as in the quality and the absolute and relative quantities of the mobile components. The fine dispersed fraction of soils should be studied extensively because this fraction is the most liable to change and it is in the closest relation to the soil forming processes.

'SIGMOND carried out a complex investigation on the adsorption complex of soils. He studied its role in the nutrient balance of soils, as well as in soil reclamation and he attached great importance to the adsorption complex even in soil classification [3, 5, 13, 14].

Professor 'SIGMOND's initiatives and achivements in the field of soil mineralogy are still up-to-date in their essential conception and inspire generations of soil mineralogists.

Summary

1. 'SIGMOND considered the changes (destruction, transformation) of the adsorption complex as one of the most important factors of soil dynamics. He attached great importance to the role of the humus-zeolite complex in the formation of salt affected soils. Following 'SIGMOND's directives, the authors

investigated the transformation, formation and destruction of clay minerals in salt affected soils. They studied, among other things, the transformation of illite-montmorillonite in the B horizon of salt affected soils.

2. 'SIGMOND attached great importance to model experiments. He prepared artificial zeolites and determined their properties. Following his line the authors treated clay minerals originating from rocks and separated from soils with sodium salt solutions. The treatments resulted in the opening of the crystal-lattice, in the crystallization of aluminium hydroxide and in the increase of illite-montmorillonite interstratification.

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