Transformation and Destruction of Clay Minerals in Alkali Soils as Affected by Soil Forming Processes

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The interrelations between micro-mineralogical processes and soil dynamics should be considered in view of the following threefold aspect:

1. Destruction and synthesis of clay minerals and their correlations with soil forming processes;
2. The transformation of clay minerals in relation to the dynamics of the soil;
3. The role of the transformation of clay minerals in the process of soil alkalinization.

The soil mineralogical processes taking place during alkalinization were examined. It has been assumed that transformations of microminerals play an important role in the alkalinization process.

Materials and methods

In order to investigate the interrelations between alkalinization and micro-mineralogical processes occurring in the soil, the following soils have been studied:

a) A calcareous solonchak-solonetz on sandy silt
b) A bog solonchak on calcareous silty clay
c) A solonchak on calcareous silt
d) A solonchaky bog soil on calcareous silt

The following analyses were carried out: The total chemical analysis of the soil and of the colloidal fraction, the X-ray analysis, the DTA and the electron microscopic investigations.

Results, discussion and conclusions

The results obtained lead to the following conclusions:

I. In the colloidal fraction of horizon A and B_1 of solonchak-solonetz soils and of horizon A of solonchak soils the $SiO_2 : R_2O_3$ ratio changed for increasing of the ratio to a much greater extent than in deeper layers.

II. As regards the ratios of primary minerals to clay minerals and the shifts in these ratios in different horizons, significant interrelations were found between the mentioned feature and pedological processes. The ratios in question were calculated on the basis of characteristic line intensities noted in the course of X-ray investigations, as stated above they were in line with $SiO_2 : R_2O_3$-values pertaining to the colloidal fractions of the soil as well as with the DTA-curve. A visualization of the ratios of primary minerals to clay minerals clearly indicates that the colloidal fractions in the B_2 and deeper horizons of all soils comprise predominantly of clay minerals amounting to 60% or more of the total mineral content. Significantly different trends of the ratios of primary minerals to clay minerals can be observed in the upper

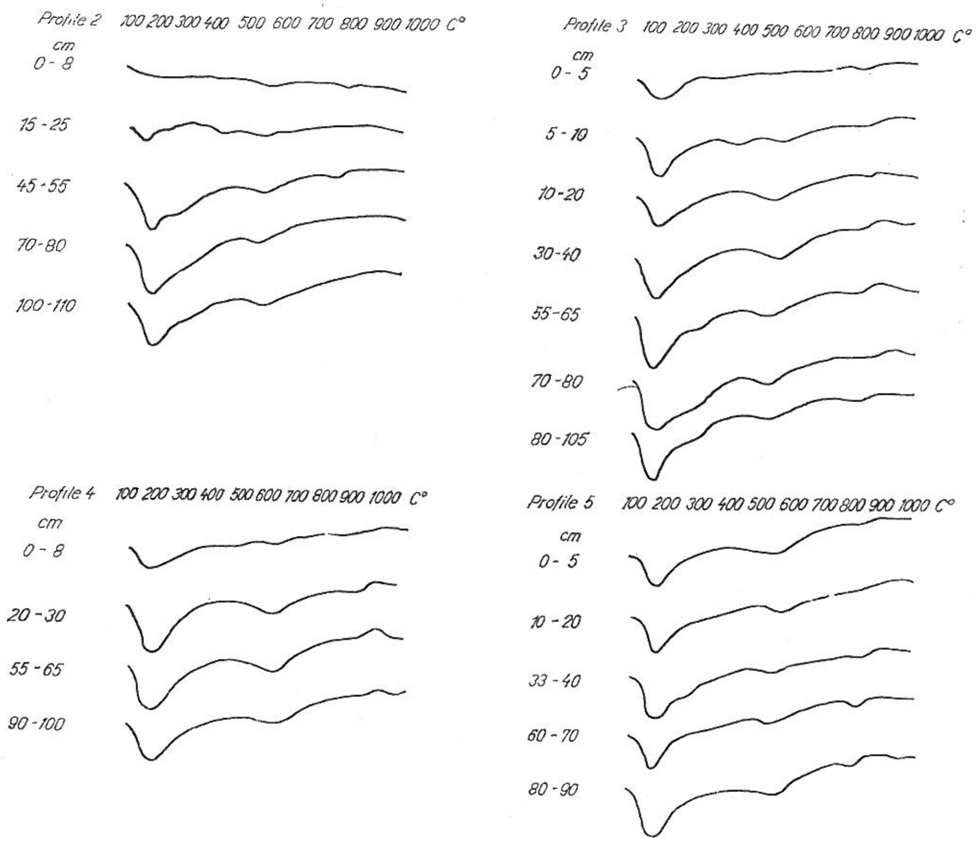

Figure 1

Thermograms of colloid fractions of soils in the vicinity of Lake Konyár. Profile 2: Calcareous solonchak-solonetz on sandy silt. Profile 3.: Bog solonchak, on calcareous silty clay. Profile 4.: Solonchak, on calcareous silt. Profile 5.: Solonchaky bog soil, on calcareous silt

horizons of the solonchak-solonetz and the solonchak soil and, also in the upper horizons of soils with bog-forming process, i.e. the bog solonchak and the solonchaky bog.

The ratio of primary minerals to clay minerals is 70 : 30 in the A and B^I horizons of the solonchak-solonetz and in the A horizon of the solonchak. On the other hand it is 50 : 50 and 40 : 60 in the A horizons of bog solonchak and solonchaky bog, respectively. Thus, in the upper horizons of alkali soils

Table 1

Data of total chemical analysis of the colloid fraction in soils in the vicinity of lake Konyár

No. of profile and depth, cm	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	SiO_2/R_2O_3
	%								
2.									
0— 8	77,25	14,40	5,42	8,98	1,28	1,26	1,40	2,70	7,02
15— 25	77,97	15,60	7,41	8,19	1,23	0,36	1,50	1,40	6,85
45— 55	55,46	38,90	19,72	19,18	2,00	1,45	0,60	0,50	1,97
70— 80	50,36	44,00	15,60	28,40	1,37	1,70	1,42	3,00	1,49
100—110	49,00	34,00	10,30	23,70	1,61	1,33	1,70	3,00	1,84
3.									
5— 10	46,52	34,65	11,88	22,77	4,86	1,41	3,24	2,40	1,73
10— 20	51,96	32,15	8,98	23,17	2,55	1,77	3,16	2,56	2,02
30— 40	47,88	32,90	9,26	23,64	4,12	1,92	2,88	2,20	1,88
55— 65	49,08	34,30	9,64	24,66	4,17	1,34	2,96	2,12	1,81
70— 80	48,78	36,85	10,45	26,40	4,12	1,05	2,60	2,60	1,72
95—105	50,60	30,20	9,40	20,80	4,09	1,59	2,64	1,20	2,14
4.									
0— 8	63,92	19,60	5,51	14,09	4,40	2,91	2,25	2,10	4,10
20— 30	48,04	33,30	8,59	24,71	3,00	3,19	3,15	1,40	1,82
55— 65	47,66	37,05	7,77	29,28	3,23	3,08	3,00	1,03	1,58
90—100	47,49	33,25	9,19	24,06	4,73	3,19	2,45	1,20	1,80
5.									
0— 5	48,00	31,60	10,09	21,51	2,74	2,06	3,10	2,00	1,95
10— 20	53,90	27,35	8,12	19,23	2,74	2,35	2,80	1,60	2,51
33— 43	54,44	28,95	10,52	18,43	3,47	3,26	2,25	1,20	2,45
60— 70	55,15	28,30	8,74	19,56	2,35	3,26	3,40	1,57	2,48
80— 90	53,58	34,85	10,67	24,18	4,04	1,45	3,65	1,05	1,96

without bog forming processes, primary minerals are dominant, in the bog solonchak they are present in the same amounts as the clay minerals, whil.e the latter are preponderant in the solonchaky bog from the surface downwards. These trends observed in the upper horizons of the solonchak-solonetz and of the solonchak are related with te destruction of clay minerals. In the corresponding horizons of the bog solonchak and the solonchaky bog the destruction of clay minerals either does not occur at all, or to a much lesser degree.

The considerable differences in the proportion of primary to secondary minerals and in the $SiO_2 : R_2O_3$ ratios in the upper horizons in favour of the primary minerals and SiO_2 could be observed only in those soils where only alkalinization took place. Therefore, it may be assumed that the destruction of clay minerals in the upper horizons of these soils is the cause of the shift in the proportion of primary to secondary minerals in favour of the former as well as of the increase in the content of silica as compared to that of sesquioxides. Primary minerals in the colloidal fractions consist to a great extent of SiO_2 and oxides of iron and aluminium, which are probably decomposition products of soil colloids, mainly of clay minerals. This assumption is strongly supported by the fact that DTA-curves indicate the presence of much but slightly lcrystaline and amorphous substances in the colloidal fractions. On the

Table 2

Proportion of primary to secondary minerals in the colloid fractions of soils in the vicinity of lake Konyár

No. of the profile	Type	Horizon	Proportion of primary to secondary minerals
2.	Solonchak-solonetz soil	A	70/30
		B_1	70/30
		B_2	40/60
		C_2	20/80
3.	Bog solon-chak soil	A	50/50
		A	50/50
		B_1	40/60
		B_2	40/60
		BC	40/60
		C	40/60
4.	Solonchak soil	A	70/30
		B	40/60
		BC	40/60
		C	40/60
5.	Solonchak bog soil	A	40/60
		A	30/70
		B_1	20/80
		B_2	20/80
		C	20/80

Table 3

Distribution of the readily soluble iron in soil profiles in the vicinity of lake Konyár

No. of the profile	Depth	Total soluble iron mg/100 g
2.	0— 8	59,43
	10— 15	49,66
	45— 55	39,89
	70— 80	19,58
	100—110	22,28
3.	0— 3	49,62
	5— 10	103,32
	10— 20	120,31
	30— 40	70,81
	55— 65	53,94
	70— 80	57,38
	95—105	76,70
4.	0— 8	81,70
	20— 30	80,60
	55— 65	57,00
	90—100	52,28
5.	0— 5	161,76
	10— 20	132,44
	33— 43	76,61
	60— 70	43,61
	80— 90	45,72

basis of these observations together with the chemical composition of the colloidal fractions, it can be stated that the upper soil horizons contain considerable amounts of amorphous hydroxides of iron and aluminium. According to GORBUNOV [1] these amorphous substances are products of mineral decomposition in solonetz soils. Yet another fact seems to support the assumed relation of alkalinization to micro-mineral destruction, viz.:

III. Clay mineral destruction is directly related to the alkalinization process and inversely related to bog formation.

Data on the water extract and the exchangeable cations indicate considerable amounts of sodium salts in the upper horizons of all four soils. An excess of moisture was prevalent in the upper horizons of all the profiles temporarily in the solonchak-solonetz and in the solonchak and permanently in the solonchaky bog and the bog solonchak. It could be stated that the destruction of clay minerals in the upper horizons of the former two soils was much more intensive than in corresponding horizons of the other soils. It is striking that in the B_2 and deeper horizons of all four profiles the destruction of clay and of microminerals does not take place. Thus, among the prevailing circumstances, the decomposition of the clay minerals was brought about by 3 factors, viz.: 1. The presence of sodium salts; 2. Temporary excess of moisture; 3. Temporary drying up.

These factors strongly point towards the statements made by GORBUNOV according to which the decomposition of minerals may be affected by the following external factors:

a) The bioclimatical environment;

b) The reaction of the medium;

c) The oxidation-reduction conditions.

It is evident that the bioclimatical environment and oxidation-reduction are in close connection with the factors No. 2 and 3 cited above while soil reaction is related to factor No. 1. 'SIGMOND [2] considered the "temporary moisture excess" to be one of the main factors of soil alkalinization. This factor plays a role also in the case investigated by us (No. 2 and 3 above). The first factor, i.e. hydrocarbonate and carbonate of sodium, acts with certain types of the alkalinization process. After all it may be assumed that the destruction of clay minerals is brought about by the three mentioned factors, in special cases of alkalinization, i.e. with the processes leading to the formation of hydrocarbonate- and carbonate-containing solonchak-solonetz and of carbonate- and hydrocarbonate-containing solonchak soils.

IV. In the solonchak-solonetz a transformation of illite into montmorillonite may be assumed to have taken place. This view is supported by the increases in montmorillonite content with depth in the profile, by the lower potassium content of the colloidal fraction as compared to other soils, by the presence of calcium and magnesium which are indispensable for the transformation dealt with, and finally by the values of T which are higher in comparison to other profiles and rise depth wise.

V. With respect to readily soluble iron it could be stated that dynamics operate in opposite directions, i.e. soluble iron compounds migrate downwards in the A horizon and upwards, under the effect of ground water, in the C horizon. In the soils under study total soluble amounts of iron are generally higher in the upper than in the deeper horizons.

The samples were collected in summer, when the upper horizons of alkali soils were drier than those of the bog soils. This fact explains that why the upper horizons of the bog solonchak and of the solonchaky bog contained considerably more soluble iron than the corresponding horizons of the alkali soils.

In bog soils there is much soluble iron during the whole year because these soils are permanently moist and reduction processes prevail accordingly. The dynamics of soluble iron compounds in alkali soils are, on the contrary, distinctly season-dependent. Thus, due to drying and oxidation during summer, the upper horizons of alkali soils contained less soluble iron than those of bog soils.

Summary

a) The intensity of the clay mineral destruction in the upper horizons of alkali soils was directly related to the process of alkalinization and inversely related to that of bog formation.

b) It may be assumed that in certain cases of soil alkalinization, the following three factors are indispensable:

1. The presence of sodium salts (mainly hydrocarbonate and carbonate);
2. Temporary excess of moisture (reduction processes);
3. Temporary drying up (oxidation processes);

c) Oxidation-reduction processes exert a decisive influence on the destruction of clay minerals as well as on the accumulation of readily soluble iron.

d) In the solonchak-solonetz soil the transformation of illite into montmorillonite may be assumed to be in process.

References

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[2] 'Sigmond, E.: General Soil Science. (Általános talajtan). Publ. by author. Budapest. 1934. (In Hung.).