Map of Clay Mineral Associations in Hungarian Soils

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The clay mineral associations in Hungary were studied during three periods. First, the soils belonging to the Corn Production System /Bábolna/ were sampled and analyzed between 1974 and 1981 in order to improve the national fertilization advisory service. Later, the mineral examination was extended to other parts of the country by the Ministry of Agriculture and Food /1981-1984/, using funds granted for basic research by the Hungarian Academy of Sciences, while between 1986 and 1988 a survey was made on soils developed on hard rock parent material under forest vegetation. The results of the field surveys and laboratory analyses, covering 500 representative soil profiles, have been reported in a number of publications /STEFANOVITS, 1985/1986 STEFANOVITS and DOMBÓVÁRI, 1985, 1986a, 1986b; STEFANOVITS, BODOR and VARJU, 1978; STEFANOVITS, KÁLMÁN and KÓNYA, 1985; STEFANOVITS et al., 1985/.

The present paper gives a summary of these reports, complemented with new results and with conclusions drawn from the data.

Methods

The examination system was compiled in accordance with the desire to improve the national advisory service on potassium and nitrogen fertilization. The investigations can be divided into three parts:

- Basic analyses /including the measurement of nutrient element content/ of the total soil material; determination of the mineral composition of the soils using the X-ray diffraction method;
- Mineral composition of the crystalline phase of the clay fraction separated from the soil, based on the X-ray diffraction curves of the oriented samples treated with magnesium, ethylene glycol, KCl and NH_4Cl;
- Measurement of the cation exchange capacity of the clay fraction; determination of the total potassium content of the clay fraction; thermal examination of the clay fraction, with the construction of DTA, DTG and TG curves.

Nine types of clay mineral associations were distinguished, based on the results of these examinations. These nine types are the mapping units used in the map of clay mineral associations. The map of clay mineral associ-

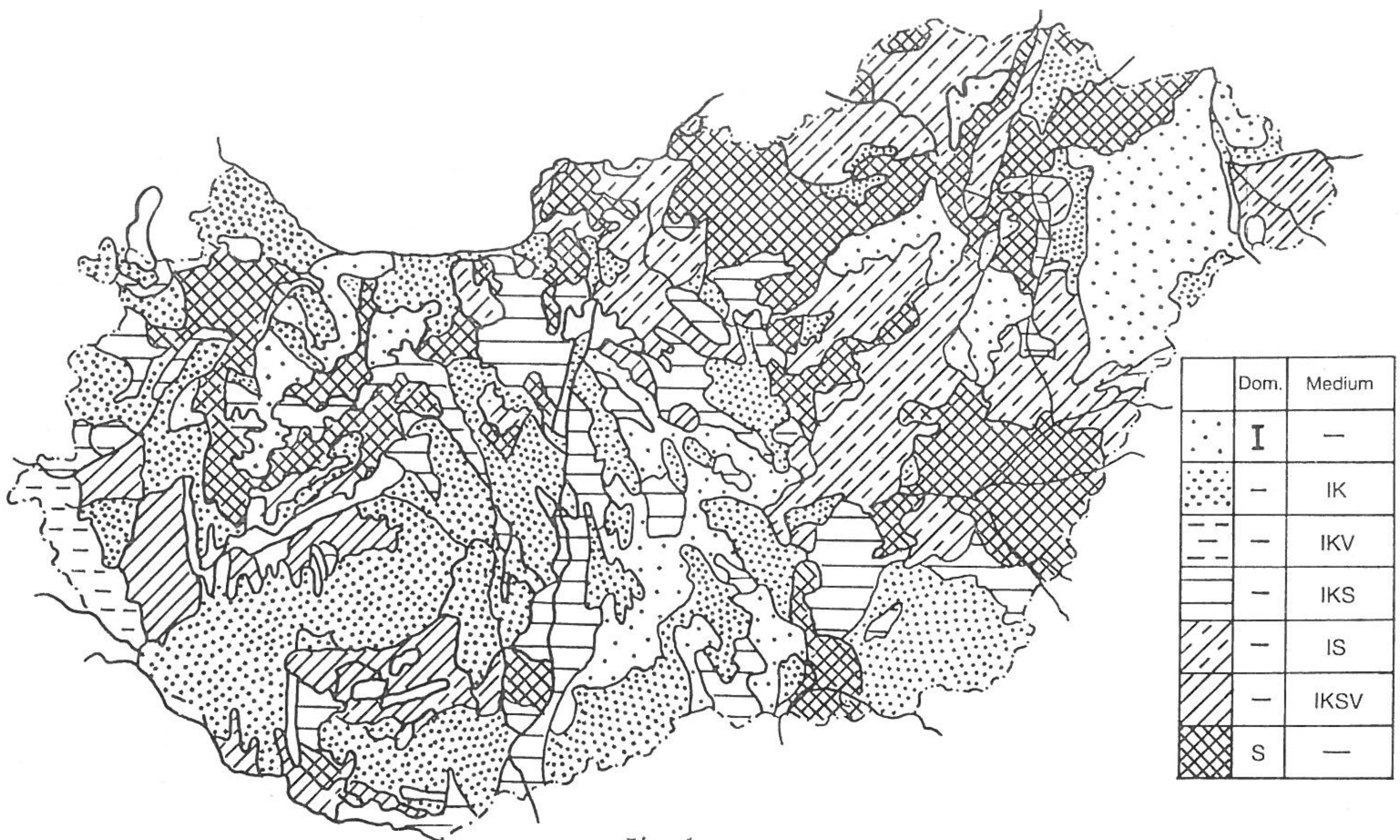

Fig. 1

The soil clay mineral associations in Hungary. A reduced and simplified form of the original map in the scale of 1:500 000. I: illite; K: chlorite and kaolinite; S: smectite; V: vermiculite

Table

The total mineral composition, clay content and the minerals of the content of the clay

Depth of sampling, cm	Minerals in the soil, %									Clay %
	Illite +Mica	Chlorite +Kaolinite	Montmorillonite	Quartz	Plagioclase	Orthoclase	Calcite	Dolomite	Amorphous	
1. Bicsérd										
0- 25	10	7	1	54	5	4	1	1	17	26
25- 53	13	8	3	57	9	5	–	–	5	26
75-100	8	6	–	47	7	1	13	7	11	13
100-130	11	7	–	44	7	2	13	14	2	9
2. Martonvásár										
0- 30	18	10	6	43	8	4	1	1	9	21
30- 60	17	10	5	42	8	4	9	4	1	16
50- 90	10	5	3	49	6	3	14	7	3	13
90-120	19	10	6	42	2	2	10	7	2	13
120-150	18	12	4	42	2	3	10	7	2	12
3. Sátorhely										
0- 35	9	6	2	51	10	5	2	1	14	22
35- 70	9	5	2	49	4	1	4	3	23	21
120-150	8	5	2	47	6	1	15	9	7	15
4. Nagyhegyes										
0- 35	11	3	4	52	9	4	–	–	17	27
35- 65	10	4	6	51	10	2	–	–	17	38
65- 95	11	5	8	58	11	3	–	–	4	23
95-130	10	6	5	51	6	3	7	1	11	22

ations for Hungary's agricultural land was constructed on a scale of 1:500 000. Fig. 1 shows a reduced, simplified version of the map.

On the basis of the map, samples were collected from 30 soil types characteristic of the larger territories. Nutrient adsorption and desorption as well as acidification were studied to show the changes caused by fertilizers added to the soils. Electro-ultrafiltration /VARJU and STEFANOVITS, 1979, 1980/, continuous desorption /STEFANOVITS and JÁKI, 1985; STEFANOVITS, FÜLEKY and JÁKI, 1987/ and fractionate desorption /STEFANOVITS and DOMBÓVÁRI, 1987/ were applied. Pot experiments were carried out to analyse the utilization of the added nutrients. In some places where the clay mineral composition of the soil was characteristic of a larger area, small plot fertilization experiments were conducted under field conditions to reveal the relationship between the clay mineral composition and the effect of fertilization. The clay mineral studies were extended to the plots of long-term fertilization experiments in order to determine the relationship between the mineral composition and the effect of fertilization /DOMBÓVÁRI, 1986/.

1
crystalline phase of the clay fraction; CEC value and total potassium fraction in chernozem soils

Minerals in the clay, %						Clay	
Illite	Kao-linite	Chlo-rite	Smec-tite	Vermi-culite	Mixed layer clay minerals	CEC me/100 g	K_2O %
45	-	19	17	6	13	35	2.4
39	-	24	18	5	14	40	2.0
31	-	29	26	2	12	47	1.8
30	-	27	31	-	12	22	1.2
48	-	13	21	13	11	46	2.7
36	-	16	30	5	13	72	1.8
27	-	17	38	7	11	56	1.7
16	-	11	65	-	8	57	2.0
16	-	16	61	-	7	44	2.0
41	-	20	16	10	13	36	4.0
44	-	25	13	5	13	36	2.0
33	-	34	21	3	9	26	2.1
38	-	9	16	7	30	56	2.6
43	-	9	20	9	19	54	2.6
32	-	12	18	22	16	53	2.7
27	-	15	19	25	14	61	2.0

Simultaneously, determinations of the clay mineral and total mineral composition of soils developed on hard rock were carried out for each parent material typical of larger territories.

Results

Up till now loess has been considered to be uniform, however, it has now been proved that its mineral composition differs in various parts of the country. The difference stems from the mineral composition of the material the loess originates from. Loess sedimented from the clay transported from the deposits of the Alps and the Eastern Carpathians contains more chlorite than other types. If the weathered material of the andezites is mixed with the loess, there is in a higher proportion of smectites. The theory that in the temperate zone the sole clay mineral of loess is illite has not been confirmed; smectites and their mixed-layer minerals were in the majority /STEFANOVITS, 1985a/.

Table

The total mineral composition, clay content and the minerals of the crystalline clay fraction in forest soils /Karád, Putnok/

Depth of samp-ling, cm	Minerals in the soil, %									Clay %
	Illite +Mica	Chlo-rite +Kao-linite	Mont-moril-lonite	Quartz	Plagio-clase	Ortho-clase	Cal-cite	Dolo-mite	Amor-phous	
5. Karád /Orthic luvisol/										
0- 10	6	3	3	60	9	4	–	–	15	9
10- 30	6	4	2	62	9	3	–	–	14	14
30- 70	10	5	5	51	7	3	–	–	19	28
70-120	13	8	3	57	8	3	–	–	8	22
120-140	15	8	3	50	7	2	9	6	–	11
6. Putnok /Humic luvisol/										
0- 35	3	2	6	67	9	5	–	–	8	30
35- 70	6	2	8	57	8	4	–	–	15	50
70-100	5	2	10	60	5	5	–	–	13	50
100-120	6	2	11	65	6	3	–	–	7	50
7. Abádszalók /Gleyic solonetz/										
0- 30	11	2	4	53	9	2	–	–	19	17
30- 60	13	6	1	45	10	2	6	1	16	38
60- 85	16	6	1	45	10	2	11	2	7	29
8. Pázmánd /Gleyic solonetz/										
0- 35	17	7	1	53	10	5	3	–	4	32
35- 75	18	10	1	48	6	7	4	–	6	31
75-100	16	6	1	44	7	4	11	–	11	21

Due to the formation processes taking place in chernozem soils the smectites of the parent material are mostly transformed into illite-like clay minerals /Table 1 and Fig. 2/. The double maximum found in the desorption curves indicate that that some parts of these are potassium smectite /STEFANOVITS, 1989a, b/.

Due to lessivation and salinization processes chiefly smectites migrate from the topsoil into the accumulation horizon, leading to significant differences in the clay mineral compositions of the leaching and accumulation horizons /Table 2/.

Potassium and ammonium ions are adsorbed to a similar extent in illite-type soils, while in smectite-type soils more potassium than ammonium is adsorbed /STEFANOVITS, 1989a, b/.

In fertilization experiments under field conditions it was proved that in illite-type chernozems - where easily soluble or desorbable potassium was present in large quantities - the yield was higher without potassium fertilization. In these soils potassium fertilization can thus be suspended till the mobilizable potassium values decrease to the average level. In soils containing less than 15% clay, the importance of clay minerals depends on the aim of fertilization.

2
phase of the clay fraction; CEC value and total potassium content of the
and solonetz soils /Abádszalók and Pázmánd/

Minerals in the clay, %						Clay	
Illite	Kao-linite	Chlo-rite	Smec-tite	Vermi-culite	Mixed layer clay minerals	CEC me/100 g	K_2O %
37	-	25	7	5	26	34	2.8
34	-	25	7	9	25	45	2.8
30	-	19	15	15	21	57	2.7
32	-	22	19	9	18	52	2.5
26	-	29	28	3	14	39	2.2
33	14	-	27	-	26	62	2.2
24	8	-	40	5	23	60	1.6
20	16	-	32	14	18	61	1.6
19	15	-	38	9	19	63	1.9
43	-	6	31	7	13	52	3.4
37	-	10	37	2	14	37	2.9
33	-	12	37	7	11	39	2.4
60	10	22	3	1	4	44	3.3
53	-	33	6	-	8	49	3.2
35	-	30	27	-	8	28	2.0

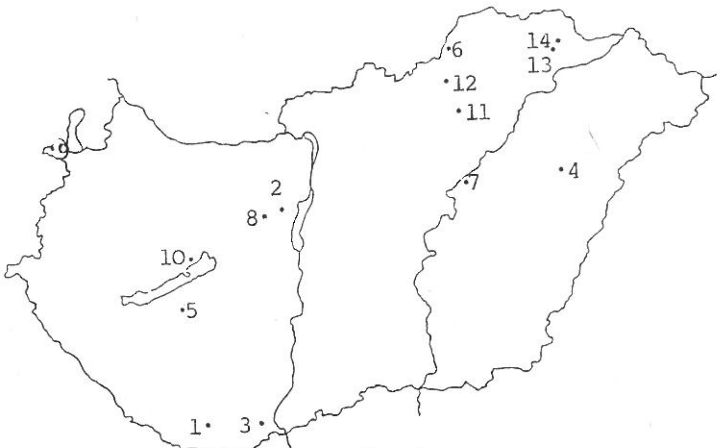

Fig. 2
The location of soil sampling sites /the numbering is according to Tables 1-4.

Table

The mineral composition of Luvisols developed on clay shale with reference

Depth of samp-ling, cm	Minerals in the soil, %							
	Illite +Mica	Chlo-rite +Kao-linite	Mont-moril-lonite	Quartz	Albite	Ortho-clase	Other feld-spars	Amor-phous
9. Sopron								
3- 15	12	8	-	46	-	-	4	30
15- 40	24	19	-	59	-	2	5	-9*
40- 80	30	16	-	37	-	-	6	11
80-100	33	17	-	52	-	-	8	-10*
10. Lovas								
0- 15	10	7	-	37	8	-	-	38
15- 40	32	16	-	19	8	3	1	21
40- 80	40	18	-	55	9	3	-	-25*
11. Oszla II.								
0- 25	6	2	1	56	4	2	-	29
25- 60	6	5	-	65	6	4	-	14
60-110	8	5	-	14	-	6	-	67
12. Tótfaluvereje								
0- 20	6	6	-	50	11	2	-	25
20- 70	8	8	-	63	10	3	-	8

* Negative values are the result of differences between the investigated and standard minerals.

In soils formed on hard rock parent material, among the clay minerals originating from clay shale the mica-like minerals are more easily reactivated than chlorites /Table 3/. In soils developed on rhiolite tuff containing zeolites the zeolite ratio of the rock is changed and, due to soil dynamic processes, the mordenite mostly remains. /Table 4/.

Summary

The map of clay mineral associations in Hungarian soils shows significant differences due to the mineral compositions of soils formed on rocks and to differences in soil dynamic processes.

There are great differences in the mineral compositions of different horizons in the soil profiles of soils developed either on hard rock parent material or on sedimentary rock. The explanation of these facts has thrown new light on the soil dynamics of chernozems, luvisols and solonetzes.

3
to the total soil and to the crystalline phase of their clay fraction

Minerals as a % of the crystalline phase in the clay fraction						
Illite +Mica	Chlo-rite +Kao-linite	Mont-moril-lonite	Quartz	Albite	Ortho-clase	Other feldspars
16	12	-	66	-	-	6
22	17	-	54	-	2	5
33	18	-	42	-	-	7
30	16	-	47	-	-	7
17	12	-	58	13	-	-
40	20	-	20	10	4	2
32	14	-	44	7	3	-
8	3	1	79	6	3	-
7	5	-	76	7	5	-
25	14	-	44	-	17	-
8	8	-	66	15	3	-
9	9	-	67	11	4	-

The differences in the mineral composition, and especially in the clay mineral associations, must be taken into consideration in the course of potassium and nitrogen fertilization of soils.

Table 4

The mineral composition of Luvisols developed on zeolite containing rhiolite tuff with reference to the total soil and to the crystalline phase of their clay fraction

Depth of samp-ling, cm	Minerals in the soil, %							Minerals as a % of the crystalline phase in the clay fraction					
	Illite + Mica	Quartz	Cris-tobal-ite	Albite	Clino-ptilo-lite	Mor-den-ite	Amor-phous	Illite + Mica	Quartz	Cris-tobàl-ite	Albite	Clino-ptilo-lite	Mor-den-ite
13. Flórika													
0- 25	1	14	2	2	3	17	61	2	37	5	4	8	44
25- 70	1	16	2	5	7	19	50	2	32	4	10	15	37
70-100	1	1	-	-	30	12	56	3	3	1	-	66	27
14. Gerendás													
3- 50	1	25	4	8	-	10	52	3	51	9	17	-	20
50- 80	3	28	7	13	-	13	36	5	43	11	21	-	20
80-130	2	18	4	5	7	17	47	4	34	8	10	13	31
130-160	4	-	-	-	60	28	8	5	-	-	-	65	30

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