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THE MINERAL COMPOSITION OF HUNGARIAN SOILS
II. SOILS OF THE BALATON REGION

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ABSTRACT

About 30 soil samples of the Balaton region (Hungary) have been investigated; all for their granulometric composition, 24 full chemical analyses were made and in 24 the mineral percentages have been determined by the diffractometer. The geographical position and the geological conditions are also sketched. — The method of determination gives also the amorphous (and poorly crystallized) content, the chemical and mineralogical composition of which has been evaluated on plausible assumptions.

In the preceeding communication of this series [1] we displayed the general points of view and purposes of our researches. Now the granulometric composition, the chemical and mineralogical composition of numerous soils from different regions of Hungary have been determined. We give in the following the results of our work on soils of the Balaton region.

I. SOILS OF BALATON-SZABADI

a) Geographical position

The cooperative "November 7" of B.-Szabadi lies along the southeastern shores of the Lake Balaton (German: Plattensee). Following the natural geography it belongs in part to Mezőföld and in part to the hilly land adherent to the Balaton. The greater part of the region lies on the comb of Enying in Mezőföld. This region is genetically and geologically much better known, than Zala County.

b) Geological conditions

The comb of Enying stretches from B.-Aliga as far as the juncture of the river Sió and the rivulet Kabóka. One has a good view of the complete section of the comb from the high banks of the Balaton near B-.Aliga where in the vertical or nearly vertical walls the upright layers show a horizontal direction. A study of these high walls — with the allowance of the eventual pinch out — reveals also the geological structure of the inner territories lying farther from the lake.

The northern part of the comb of Enying as far as the rivulet Kabóka is composed of very different layers. We find sandy and loamy layers with lignite seams alternating in thickness. The southern part of the comb, the region sinking toward the Sió is built of typical loess. One can draw the border between the two layers in the second third of the area between B.-Aliga and B.-Világos. SE of the high bank the loess sometimes reaches a substantial depth (10—15 m), since it has not been exposed to erosion as much as it was in the vicinity of the bank.

Sandy-loamy river loess and pleistocene loess, both from the Upper Pannon, are the components of the structure of the region. Under these lies the old-palaeozoic crystalline granitic slate of the Balaton region. Its today's facies has been built up as the consequence of mighthy sructural movements in the New Pleistocene.

On the top of the high bank we find also gravel tending towards SE in more or less thick layers, mainly in the higher levels, where it has shielded the sandy-loamy layers against erosion. Through erosion and deflation processes the later modification of the surface brought residues of the granitic shale to daylight.

The mineralogical examination of the bore holes set in this neighbourhood shows the prevalence of inactive minerals in the layers of the northern part of the comb of Enying; with quartz as the most common of them, felspars; calcite and dolomite are also present. Among the clay minerals illite is prevailant. In a few samples attapulgite could be detected, while others contained also montmorillonite (these two minerals have not been found in B.-Szabadi). Kaolinite was absent in all our samples. In the loess region mineralogical relations are more or less similar to the foregoing, with the important difference that there is on the whole less clay here than in the northern region.

P. STEFANOVITS [2] assings the vicinity of B.-Szabadi to the chernozem soils with chalk coating.

The third part of the area investigated by us belongs to the Sió valley, which is mostly composed of organic sediments and can be classified with the alluvial soils. The soils here are sandy—muddy alluvial formations.

c) Granulometric composition

This was determined by sedimentation of the samples formerly stripped from organic matter by hydrogen peroxide and dispersed with sodium diphosphate. It should be mentioned here that although the different dispersing materials and

TABLE I

Granulometric composition of the soils of the Balaton Region

Soil No.	Fraction μm						
	>50	20—50	10—20	5—10	2—5	<2	≦10
			I. Soil of Balaton-Szabadi				
1	24,1	29,1	9,2	6,3	12,1	19,2	37,6
2	27,0	33,0	10,0	6,0	9,0	15,0	30,0
3	23,6	33,0	7,8	5,8	8,0	21,8	35,6
4	23,9	33,6	7,7	5,2	10,0	19,6	34,8
5	22,6	36,7	6,2	5,4	7,8	21,2	34,4
6	20,7	31,8	8,2	4,0	12,3	23,0	39,3
7	18,0	39,3	6,2	4,1	11,2	21,2	36,5
8	14,0	37,0	9,0	6,0	10,0	24,0	40,0
9	33,6	30,5	4,5	1,4	7,5	22,5	31,4
10	50,1	17,5	2,6	2,6	3,5	23,7	29,8
11	40,0	18,6	5,4	4,1	8,1	23,8	36,0
12	33,9	27,5	4,8	3,1	10,6	20,1	33,8
13	33,0	22,5	7,5	7,4	8,0	21,6	37,0
14	40,0	18,9	6,3	2,8	7,4	24,6	34,8
15	30,8	30,8	5,1	3,5	9,1	20,7	33,3
16	38,6	24,1	4,0	1,9	6,3	25,1	33,3

II. Soil of Kapospula

17	5,0	44,0	11,0	5,0	9,8	25,2	40,0
18	9,0	33,6	12,2	5,3	11,3	28,6	45,2

III. Soils of Kadarkut

19	94,2	1,4	1,1	0,6	0,8	1,9	3,3
20	89,7	1,6	2,2	1,2	0,8	4,5	6,5
21	80,7	4,1	3,0	3,0	4,6	4,6	12,2
22	79,3	3,3	3,3	2,5	5,0	6,6	14,1
23	91,2	3,7	0,6	0,2	1,3	3,0	4,5
24	87,5	3,7	1,1	2,6	1,9	3,2	7,7
25	89,2	1,9	1,0	0,1	3,5	4,3	7,9
26	90,4	3,0	1,8	0,6	1,1	3,1	4,8
27	90,9	2,2	0,8	0,9	1,4	3,8	6,1
28	89,4	1,2	1,4	1,0	2,8	4,2	8,0
29	93,4	2,2	1,3	0,2	0,5	2,4	3,1
30	87,2	3,3	2,7	1,1	2,2	3,5	6,8
31	92,1	3,1	1,0	0,7	2,0	1,0	3,7
32	94,1	2,1	0,7	0,5	1,1	1,5	3,1

TABLE I (continuation)

Soil samples investigated

I. Soils of Balaton-Szabadi

1. Virgin grass (pasture) 0—20 cm	
2. Virgin grass (pasture) 20—40 cm	
3. A/15, wheat, fertilizer 6 q/cadastral yoke	0—20 cm
4. A/15, wheat, fertilizer 8 q/cadastral yoke	20—40 cm
5. A/15, wheat, fertilizer 8 q/cadastral yoke	0—20 cm
6. A/15, wheat, fertilizet 8 q/cadastral yoke	20—40 cm
7. A/8 wheat, fertilizer 6 q/cadastral yoke	0—20 cm
8. A/8 wheat, fertilizer 6 q/cadastral yoke	20—40 cm
9. From 5 cad. yokes, wheat	0—20 cm
10. From 5 cad. yokes, peas	0—20 cm
11. From 5 cad. yokes, barley	0—20 cm
12. From 5 cad. yokes, spring barley (fert. 7,85 q/cad. yoke)	0—20 cm
13. From 5 cad. yokes, peas (5,14 q/cad. yoke)	0—20 cm
14. From 5 cad. yokes, maize (8 q/cad. yoke)	0—20 cm
15. From 20 cad. yokes, wheat	0—20 cm
16. From 20 cad. yokes, peas	0—20 cm

II. Soil of Kapospula

17. 0—20 cm
18. 20—40 cm

III. Soils of Kadarkut

19. From C 20/1, 5 cad. yokes, potatoes	0—20 cm
20. From C 20/2, 5 cad. yokes	0—20 cm
21. From C 20/2, 5 cad .yokes	20—40 cm
22. From C 21 5 cad. yokes, maize	0—20 cm
23. From C 22 5 cad. yokes	0—20 cm
24. From C 22 5 cad, yokes	20—40 cm
25. From C 20/1, 15 cad. yokes, potatoes	0—20 cm
26. From C 21, 15 cad. yokes, maize	0—20 cm
27. From C 20/2, 19 cad. yokes	0—20 cm

28. From C 20/2, 19 cad. yokes	20—40 cm
29. From C 22, 19 cad. yokes	0—20 cm
30. From C 22, 19 cad. yokes	20—40 cm
31. Control sample	0—20 cm
32 Control sample	20—40 cm

methods do not give quite the same results, still the latter are apt for practical purposes. Sixteen soil samples have been investigated; in 4 of the both layers 0—20 cm and 20—40 cm deep, in further 12 only the layer 0—20 cm. We see the results in Table I and on *Figs. 1—6*. The grading limits are: I <2 μm, II 2—5 μm, III 5—10 μm, IV 1—20 μm, V 20—50 μm, VI >50 μm.

One sees different typical distribution curves, which are easily discriminated on the diagrams. Still more instructive is the comparison with the diagrams of the soils of Kapospula and Kadarkut (see below, *Fig. 7—8*.)

The granulometric composition of the sandy loam soils of B.—Szabadi shows two maxima. The first of these is always the finest fraction, the second is either the coarsest or the next coarsest part. Sandy soils, of course, have a quite different granulometric composition. The minimum lies always with the fraction III (5—10 μm), it is sometimes very flat.

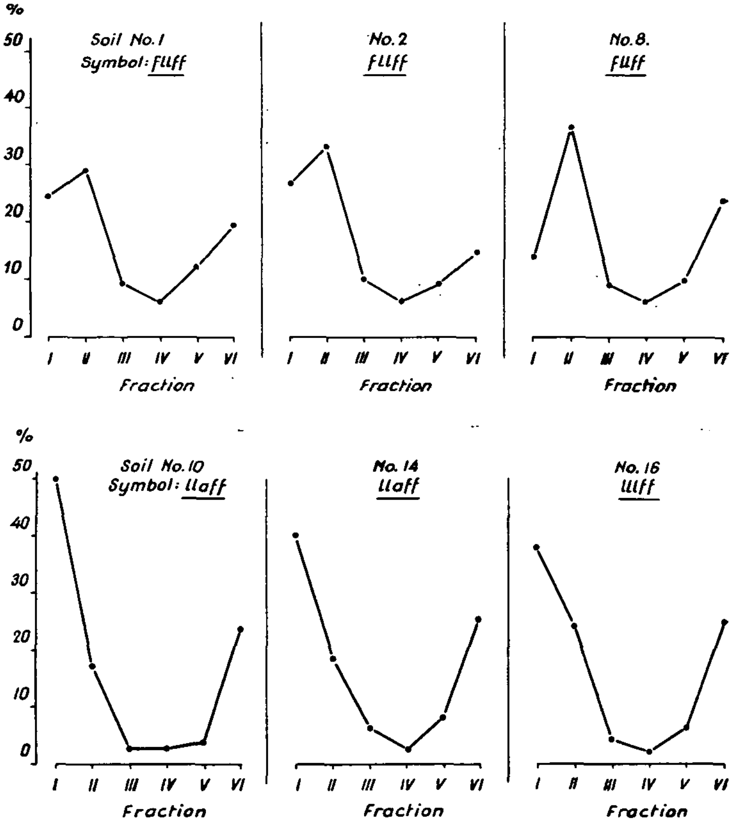

Fig. 1—6. Granulometric diagrams of the soils of B.—Szabadi

It is well known, that clay minerals are contained mainly in the finest fractions of the soil, they occur however — as will be later shown — also in the coarses fractions and in not insignificant quantities. Nevertheless the finest fractions seem to have special significance for the fertility of the soil.

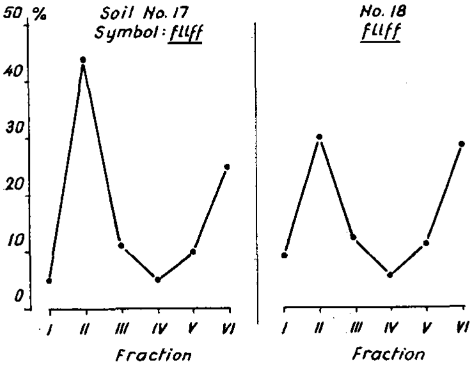

Fig. 7. Granulometric diagrams of the soil of Kapospula

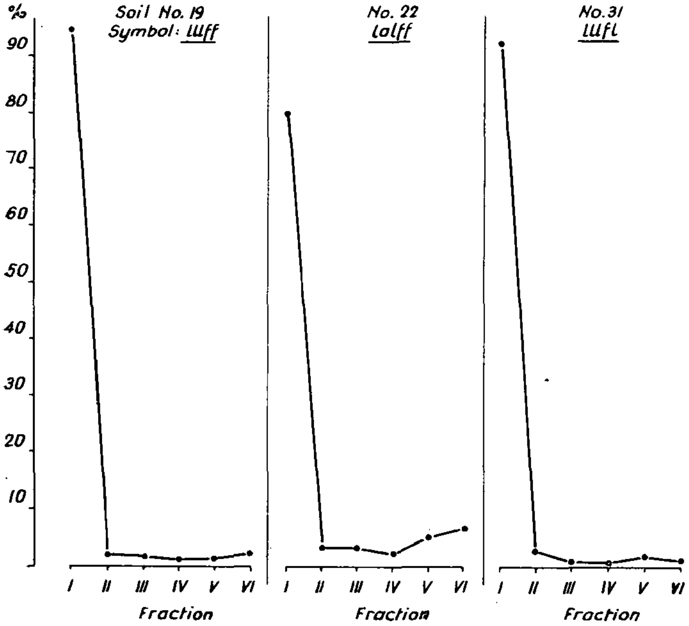

Fig. 8. Granulometric diagrams of the soils of Kadarkút

Studying the combined percentage of the fractions under 10 μm, one can see that in the soils of B.-Szabadi it amounts to 30—40,8%. There is even more in the soil of Kapospula, i. e. 40—45%, which is the most fertile among the soils inves-

TABLE II

Chemical analysis of the soils of Balaton-Szabadi and Kapospula
(Analyst: *G. Csajághy*)

Soil No.	1	2	3	4	5	6	7	8	9
SiO_2	64,20	61,82	64,70	59,73	65,08	63,37	63,96	63,34	59,36
TiO_2	0,70	0,67	0,74	0,68	0,74	0,70	0,77	0,74	0,62
Al_2O_3	10,04	9,68	10,29	9,82	9,69	9,79	10,46	10,39	9,49
Fe_2O_3	1,88	2,08	2,21	2,29	2,27	2,32	2,25	2,36	2,21
FeO	1,28	1,10	1,17	1,00	1,02	0,92	1,22	1,12	0,94
MnO	0,08	0,09	0,09	0,09	0,09	0,09	0,09	0,09	0,07
MgO	1,62	1,69	1,90	2,24	1,94	1,94	2,01	2,01	2,29
CaO	3,65	6,55	4,20	7,60	4,10	5,50	4,60	5,60	6,66
Na_2O	0,89	0,88	0,79	0,82	0,89	0,82	0,90	0,89	0,77
K_2O	1,66	1,64	1,58	1,65	1,51	1,64	1,56	1,73	1,50
H_2O-	2,71	2,29	2,22	2,23	2,21	2,17	2,15	2,25	2,47
H_2O+	2,84	3,11	3,73	2,97	3,10	3,13	3,23	3,24	3,35
P_2O_5	0,16	0,14	0,21	0,17	0,21	0,21	0,22	0,20	0,21
Carbonate CO_2	2,21	4,55	2,46	5,98	2,78	4,06	3,26	3,98	5,62
Organic matter	5,98	3,68	3,53	2,78	3,95	3,44	3,20	2,96	4,09
Whole	99,90	99,97	99,82	100,05	99,85	100,10	99,89	99,90	99,65
Fe as Fe_2O_3	3,30	3,30	3,53	3,40	3,40	3,34	3,60	3,60	3,25
Soil No.	10	11	12	13	14	15	16	17	18
SiO_2	59,99	65,73	66,66	61,67	66,78	59,49	57,99	67,92	67,71
TiO_2	0,72	0,74	0,72	0,72	0,74	0,68	0,74	0,90	0,94
Al_2O_3	9,10	11,49	11,01	10,56	11,58	9,86	9,29	13,04	13,57
Fe_2O_3	2,17	2,55	2,51	2,11	2,28	2,44	2,12	3,27	3,61
FeO	0,99	1,01	1,14	1,16	1,19	0,80	1,16	1,19	1,08
MnO	0,08	0,08	0,08	0,10	0,09	0,07	0,07	0,09	0,09
MgO	2,30	1,08	1,72	2,08	1,72	2,26	2,44	1,33	1,44
CaO	7,30	2,40	2,60	5,60	2,40	6,35	6,96	1,15	1,20
Na_2O	0,83	0,80	0,82	0,79	0,79	0,80	0,80	1,03	0,96
K_2O	1,41	1,71	1,65	1,53	1,53	1,50	1,50	1,99	1,98
H_2O-	2,06	2,90	2,52	2,44	2,72	2,54	2,46	2,38	2,52
H_2O+	4,20	3,97	3,25	3,17	3,28	3,18	3,96	2,91	3,24
P_2O_5	0,17	0,20	0,18	0,21	0,18	0,21	0,21	0,18	0,13
Carbonate CO_2	5,24	0,62	1,49	4,40	1,24	5,27	5,79	0,35	0,25
Organic matter	3,22	4,43	3,35	3,33	3,19	4,12	4,09	2,15	1,43
Whole	99,78	99,71	99,70	99,87	99,71	99,57	99,58	99,88	100,15
Fe as Fe_2O_3	3,27	3,67	3,77	3,40	3,60	3,33	3,41	4,58	4,81

tigated here. It is, on the other hand, fundamentally less in the sandy soils of Kadarkut, which give, of course, by far less good yields.

We have used the following abbreviations to mark the different granulometric types: The decreases in percentage from Fraction I to Fraction II and any further decrease is denoted *l*. The rise in percentage of a fraction is marked *f* and if it remains the same, it is denoted *a*. In this way the granulometric composition e. g. of the soil No. *14* is designated *lllff* and that of the soils No. *1* and *2* (virgin grass of B.-Szabadi) *fllff*. The formula *lllff* is very common. There occurs also *llaff*, in sandy soils, and other similar formulae. The deeper meaning of these diagrams can be understood only after further widespread determinations.

d) Chemical composition

The analyses have been performed in the Hungarian Geological Institute of Geology with the methods evolved by one of us (G. Csajáhgy); we can see the results in Table II together with the results for the soil of Kapospula. From these analyses one can learn naturally very important facts also concerning the mineral composition: the calcite and dolomite content, the content of P_2O_5 and apatite resp., the organic matter and trace elements. One can also draw indirect conclusions regarding the content of clay minerals, quartz and felspars. The analytical results are, however, not sufficient for the quantitative and complete determination of the mineral composition.

e) Mineralogical composition

We determined with our modified inner standard method [3] the complete mineral composition of all soils investigated. In addition to the skeleton*), carbonate and clay minerals, also the amorphous and poorly crystallized part could be determined.

We take the composition of certain soil minerals granted; this is so in quartz (100% SiO_2), calcite (100% $CaCO_3$) and dolomite (100% $CaMg[CO_3]_2$). The case is different with felspars. Owing to isomorphism, albite, plagioclases, orthoclase and microcline can be determined only with less accuracy. It is necessary to take different compositions for the different isomorphous mixed crystals and use them in appropriate cases. The accuracy of the analysis will diminish through this procedure, but it remains still very valuable for practical uses.

Table III gives the chemical composition of the most important soils minerals.

Table III

Chemical composition of soil minerals

	SiO_2	Al_2O_3	Na_2O	K_2O	MgO	CaO	CO_2	H_2O+	
Quartz	100	—	—	—	—	—	—	—	
Calcite	—	—	—	—	—	56	44	—	
Dolomite	—	—	—	—	21,8	30,2	48	—	
Ca-Montmorillonite	52	19	—	—	4	3	—	7.5	H_2O^-:15
Prochlorite	24	21	—	—	18	3	—	7	FeO:26
Klinochlor	40	22	—	—	22	—	—	16	
Muskovite	45,2	38,4	—	11,8	—	—	—	4,5	
Illite	46,5	39,5	—	6	—	—	—	7	
Kaolinite	46,5	39,6	—	—	—	—	—	—	
Albite	68,7	19,5	11,8	—	—	—	—	—	
Anorthite	43,1	36,7	—	—	—	20,1	—	—	
Orthoclase	64,7	18,4	—	—	—	—	—	—	
K-Na-Felspar 1:1	66,7	19	6	8,4	—	—	—	—	
Plagioclase 1:1	56	28	6	—	—	10	—	—	
Plagioclase 2:1	60,2	25,2	7,9	—	—	6,7	—	—	
Limonite	—	—	—	—	—	—	—	10	Fe_2O_3:90
Fluorapatite	—	—	—	—	—	54,7	P_2O_5:41,6		F:3,7

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* In our notation, quartz and felspars are called skeleton minerals, although the latter are also nutrients by the virtue of their potassium content.

In the amorphous and poorly crystallized part (which contains also minerals present in small amount, like apatite, anatase etc.) we find limonite, amorphous silicic acid, amorphous aluminum oxides and hydroxides resp., the whole organic matter and also the poorly crystallized clay minerals. There are ways for the calculation of their percentages and though this calculation is by no means exact, since it accumulates the faults of chemical analysis and the diffractometric determination, it gives notwithstanding very interesting results, e. g. concerning the amount of aluminium (III)- and iron(III)-hydroxides, which make phosphoric acid insoluble. Unfortunately, the actual composition of clay minerals, namely of montmorillonite and chlorites is not accurately known.

The mineralogical composition of the soils of B.-Szabadi shows not unimportant differences. Depending on differences of the percentage of amorphous matter this variety arises from two sources, namely from the carbonate content which may be greater or lesser. Samples from the same point but of unequal depths are also somewhat divergent.

Table IV gives the results of our diffractometric determinations on 16 soil samples of B.-Szabadi. We see from the above, that quartz occurs in the amount of 34—45%, felspars 11—16%, hydromuscovite and illite together 18—27%, chlorite 5—9%, calcite 1—9%, dolomite 2—6% and the amorphous and poorly crystallized part makes 9—21%. Table 4 gives calculations of the oxide composition of the amorphous part of a number of samples. The method of calculation is expounded later under "Concluding remarks".

We also performed the calculation of the mineral composition of the amorphous part the method of which can be found also in the section mentioned; the results are compiled in Table V.

The granulometric fractions of the samples have been also analyzed with the diffractometer concerning their mineral composition; we find these results in Table VI. One may see that the mineral composition of the different granulometric fractions of the same soil sample shows characteristic differences. Here we cannot give a full discussion of facts, we allude only to our finding that also the coarser fractions (over 10 µm) contain substantial amount of clay minerals. The quartz content diminishes with the diameter of the grains, but there is still a considerable part in the fraction <2 µm. Felspars, on the other hand, appear only exceptionally in the finest fraction.

II. SOIL OF KAPOSPULA

We obtained only two samples of this very fertile soil from the same point, but of two different depths.

a) Geographic position

Kapospula is lying on the border of two landscapes. It is customary to draw the border between the landscape of Outer Somogy and the Tolna-Baranya hilly country with the Dombóvár—Kaposvár railway line. It is, of course, not possible to exactly separate the two regions by such an artificial line, since the transition is continuous. The region of Kapospula rather belongs to Outer Somogy morphologically and geologically.

b) Geological conditions

The area of Outer Somogy is covered with loess and sand. The loess is of the same age as the younger layers of the Pleistocene loess, which covers part of Trans-

TABLE IV

Mineral composition of the soils of the Balaton region

Mineral		*Balaton Region*											
	Soil No.	1	2	3	4	5	6	7	8	9	10	13	14
Quartz		39	44	36	34	45	36	41	35	37	40	34	40
Felspar		14	15	11	12	11	12	16	13	14	13	12	13
Muskovite + illite		19	19	27	22	22	18	18	22	23	20	24	23
Chlorite		6	5	5	5	6	5	5	6	5	6	6	7
Calcite		3	8	2	9	2	5	4	5	5	6	5	5
Dolomite		2	3	3	3	3	3	3	4	6	6	4	3
Amorphous		17	6	16	15	11	21	13	15	10	9	15	9
In the amorphous part:													
SiO_2		5	—	7	6	1	9	8	7	—	—	6	
Al_2O_3		1	—	—	1	2	3	2	1	—	—	1	
Fe_2O_3		3	3	3	3	3	3	3	3	3	3	3	
Organic matter		6	3	4	3	4	3	3	3	4	3	3	
Sum of clay minerals + organic matter		31	27	36	30	32	26	26	31	32	29	33	
Fraction $\leqq 10\mu m$		37,6	30,0	35,6	34,8	34,4	39,3	36,5	40,0	31,4	29,8	37,0	34,8

TABLE IV (continuation)

	Balaton-Szabadi				Kapospula		Kadarkút					
Mineral / Boden No.	15	16	16a	16b	17	18	20	23	24	29	30	31
Quartz	38	41	37	39	41	38	66	56	63	62	64	65
Feldspar	13	12	13	14	15	13	10	11	12	10	14	13
Muskovite + Illite	24	26	24	25	24	24	7	10	4	8	3	1
Chlorite	6	6	9	6	5	9	2	1	1	2	2	1
Calcite	5	4	2	1	—	—	—	—	—	—	—	—
Dolomite	5	4	3	2	—	—	—	—	—	—	—	—
Amorphous	9	12	12	13	15	16	15	22	20	18	17	20
In the amorphous Part:												
SiO_2	—	1	5	4	4	7	14	22	17	17	15	17
Al_2O_3	—	—	—	1	3	3	—	—	1	—	—	1
Fe_2O_3	3	3	3	4	2	4	1	—	1	—	1	1
Organic matter	4	4	4	3	4	2	—	1	1	1	1	1
Sum of clay minerals + organic matter	34	36	37	34	33	35	9	12	6	11	6	3
Fraction $\leq 10 \mu m$	33,3	33,3	—	—	40,0	45,2	6,5	4,5	7,7	3,1	6,8	3,7

danubia. According to the investigations of A. VENDL [4] the youngest loess layers of Hungary can be classified with the second glaciation of the Würm time range; this statement has been secured by newer investigations. We can find in the young loess a number of buried soil niveaus on grounds of the explorations and determinations of P. STEFANOVITS [5]; these show the climatic changes characterizing the interglacial periods. In this way we can detect these buried soil niveaus also in the area of the Outer Somogy landscape unit.

G. BIDLÓ [unpublished researches] investigated the mineral composition of three sections. The lines obtained with a simple Debye-Scherrer camera and Fe K_α radiation show quartz to be the principal component, while also calcite and felspar are present. Illite is the main clay mineral and in the upper layers also kaolinite may be detected (Nagyberek 0—10 cm). In the lower layers kaolinite disappears and in the loess of the mother rock only illite lines are present. All these three sections lie on the railway line Dombóvár-Kaposvár; in the two outer ones the upper layer contains kaolinite, in the middle one (from Báté) it is absent. All these results are qualitative.

c) Granulometric composition

This is similar in both samples of the same point (0—20 cm and 20—40 cm) and is of the type *fllff;* the percentual figures are given in *Fig. 7.* The finest fraction <2 µm amounts in the upper layer to 25,2 % and in the lower to 28,6 %; both are very substantial and the latter is the highest among the soils of the Balaton region investigated by us. The second-finest fraction (2—5 µm) is also relatively high (9,8 and 11,3 % resp.). Therefore the soil contains little amount of sand >50 µm.

e) Mineralogical composition

One can draw the conclusion already from the chemical analysis — but also from the exterior of the soil samples — that the soils of Kadarkut are typical sandy

TABLE V

Calculated mineral composition of „amorphous" part of the soils of the Balaton Region, % of the soil

Soil No.	Amorphous $SiO_2 \cdot H_2O$	Limonite FeOOH	Anatase, TiO_2	Organ. matter	Moisture, H_2O-	Sum	Dt. diffractometr.
1	5,6	2,1	0,7	6,0	2,7	17,1	17
2	—	2,3	0,7	3,7	2,3	9,0	6
3	8,3	2,4	0,7	3,5	2,2	17,1	16
4	8,4	2,5	0,7	2,8	2,2	16,6	15
5	1,2	2,5	0,7	4,0	2,2	9,4	11
6	10,6	2,5	0,7	3,4	2,2	19,4	21
7	3,8	2,5	0,8	3,2	2,2	12,5	13
8	8,3	2,6	0,7	3,0	2,2	16,8	15
9	2,0	2,4	0,6	4,1	2,5	11,6	10
10	—	2,4	0,7	3,2	2,1	8,4	9
13	7,1	2,4	0,7	3,3	2,4	15,6	15
14	5,7	2,5	0,7	3,2	2,7	14,8	9
15	0,3	2,7	0,7	4,1	2,5	10,3	9
16	—	2,4	0,7	4,1	2,5	9,7	12
17	4,9	3,6	0,9	2,1	2,4	13,9	15
18	7,1	4,0	0,9	1,4	2,5	15,9	16
20	12,8	0,4	0,3	0,9	0,4	14,8	15
23	22,4	0,2	0,4	0,8	0,3	24,1	22
29	16,9	0,9	0,4	1,0	0,5	19,7	18
31	17,3	0,4	0,2	0,7	0,4	19,0	20

Table VI

Mineral composition of the different granulometric fractions of the soils of the Balaton Region, weight %

Fraction µm	Quartz					Felspar					H. musk.+ Illite					Chlorite					Calcite					Dolomite					Amorphous				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
>50	67	57	47	44	59	12	22	15	22	14	4	11	5	5	3	—	—	2	1	1	1	—	2	2	1	3	—	4	4	1	13	10	25	22	21
20—50	49	50	49	43	55	23	18	14	15	13	6	13	13	14	7	3	3	3	2	2	1	1	2	2	—	3	3	4	4	3	15	12	15	20	20
10—20	40	42	42	49	42	16	15	16	14	17	17	15	26	22	18	6	9	11	8	8	1	4	2	5	2	3	2	3	4	4	17	13	—	—	9
5—10	33	36	28	30	34	15	12	21	15	19	20	33	34	28	26	12	11	13	15	11	1	6	2	10	2	2	2	2	2	3	17	—	—	—	5
2—5	28	22	28	18	29	17	13	10	13	16	32	24	42	30	26	13	10	15	15	16	1	18	5	22	3	1	2	—	2	1	8	—	—	—	9
<2	15	28	23	15	26	7	—	—	—	—	43	26	55	50	48	15	13	13	11	15	5	33	4	26	7	—	—	15	—	4	15	—	—	—	—
	6	7	8	9	10	6	7	8	9	10	6	7	8	9	0	6	7	8	9	10	6	7	8	9	10	6	7	8	9	10	6	7	8	9	10
<50	49	62	52	48	49	15	14	17	10	16	8	—	—	16	12	2	3	2	3	1	2	2	3	3	4	7	4	6	9	10	17	15	20	11	8
20—50	45	60	44	46	44	17	17	15	14	16	11	6	16	15	12	2	2	5	3	5	1	2	2	3	4	3	3	6	11	12	21	10	9	8	7
10—20	35	39	39	36	33	9	16	16	18	14	22	19	24	20	28	10	6	6	7	9	3	3	2	5	7	5	4	5	6	5	16	13	8	8	4
5—10	36	34	35	39	26	17	14	14	13	13	33	23	23	23	30	8	14	8	9	10	3	2	5	3	6	3	3	2	4	6	—	9	13	9	9
2—5	26	24	33	23	16	10	19	13	10	—	31	35	22	37	50	12	13	14	15	15	8	4	7	6	17	3	—	3	4	2	10	5	8	5	—
<2	18	17	17	10	13	10	—	—	—	—	22	51	46	62	42	7	15	13	16	11	15	8	13	8	4	7	—	—	4	3	21	9	11	—	27
	15	16	17	18		15	16	17	18		15	16	17	18		15	16	17	18		15	16	17	18		15	16	17	18		15	16	17	18	
>50	44	47	63	53		15	12	20	20		12	15	3	5		1	3	1	—		4	3	—	—		8	8	—	—		16	12	13	22	
20—50	37	41	61	51		21	15	20	22		14	14	3	5		3	3	1	2		2	3	—	—		8	15	—	—		15	9	15	20	
10—20	35	32	45	51		16	19	17	20		20	19	16	11		7	11	4	5		3	5	—	—		7	5	—	—		12	9	18	13	
5—10	31	28	—	—		12	11	—	—		28	38	—	—		9	9	—	—		2	4	—	—		5	5	—	—		13	5	—	—	
2—5	22	13	19	21		10	8	10	—		40	61	48	45		10	13	16	24		5	3	—	—		2	2	—	—		11	—	7	10	
<2	9	11	13	10		—	—	—	—		58	70	55	51		15	12	14	22		5	7	—	—		3	—	—	—		10	—	18	17	

TABLE VI (cont.)

Fraction µm	Quartz						Felspar						H. musk. + Illite						Chlorite					
	20	23	24	29	30	31	20	23	24	29	30	31	20	23	24	29	30	31	20	23	24	29	30	31
>50	64	52	69	62	69	66	16	12	14	11	13	11	—	11	—	5	—	—	1	1	—	2	—	—
20—50	52	54	52	42	51	52	18	17	22	27	19	23	13	8	10	13	14	6	2	2	2	3	3	2
10—20	48	52	53	43	50	48	20	19	18	24	23	17	17	18	11	17	14	12	3	4	5	6	4	3
5—10	48	50	53	42	53	55	35	10	14	21	17	15	12	19	16	19	15	10	5	5	3	8	5	2
2—5	47	52	53	40	56	58	22	13	20	17	16	21	16	16	10	20	13	11	15	4	7	10	3	3
<2	35	29	27	17	38	29	12	14	13	—	13	—	15	40	41	28	21	20	7	7	7	15	3	15
	Calcite						Dolomite						Amorphous											
>50	—	—	—	—	—	—	—	—	—	—	—	—	19	24	17	20	18	23						
20—50	—	—	—	—	—	—	—	—	—	—	—	—	15	19	14	15	13	17						
10—20	—	—	—	—	—	—	—	—	—	—	—	—	12	7	13	10	9	20						
5—10	—	—	—	—	—	—	—	—	—	—	—	—	—	6	14	10	10	18						
2—5	—	—	—	—	—	—	—	—	—	—	—	—	—	16	10	13	12	7						
<2	—	—	—	—	—	—	—	—	—	—	—	—	31	—	12	40	21	36						

Since the soil of Kapospula is the most fertile among our samples, we point to the connection between the amounts of the finest fractions regarding the fertility; one can that see, naturally, in other cases too.

d) Chemical composition

These data are shown (together with the results for the soils of B.—Szabadi) in Table II. The high content of Al_2O_3, K_2O and H_2O+ is conspicuous; there is, however, only a small amount of carbonate — CO_2 present. It is, of course, impossible to determine quantitatively the amounts of the said minerals by chemical analysis. Organic matter as well as P_2O_5 is present in moderate percentage.

e) Mineral composition

This is, on the whole, very similar to that of the soils of B.—Szabadi, only the clay mineral part is higher and also the finely divided amorphous part ($<10\,\mu m$). Carbonates could not be detected with the diffractometer, although a very small amount can be present. The full data are contained in Table IV.

III. SOILS OF KADARKUT

a) Geographical position

The soils investigated lie in the sediments of the rivulet Rinya. The mother rock is pleistocene river sand, with a few pleistocene loess patches. The pleistocene sand is composed of sharp-edged grains. Also the degradation area of the rivulet is derived from sedimentary rocks, so the mineral composition is very versatile.

b) Geological conditions

Based on the above composition we draw the conlusion that the minerals mentioned consist mainly of the detrimental products of the Mecsek Mountains. The group of minerals originating from the loess completes them; the latter contain in the first line quartz, also calcite, which, however, is often dissolved and dissappears during the formation of the soil.

c) Granulometric composition

This is fairly similar in the soils of Kadarkút, at least qualitatively. In all the relevant soils the grain size of the largest fraction, i. e. 79,3—94,2 % is over 50 μm. Therefore the other fractions can amount to only a few percent; so 20—50 μm 1,4—4,1 %, 10—20 μm 0,8—3 %, 5—10 μm 0,1—3,0 %, 2—5 μm 0,5—5,0 % and $<2\,\mu m$ 1,9—6,6 %. The symbols as expounded above are *IIIff, IIflf, IIfff* etc. Oving to the very small deviations there is hardly any difference between them. Some of these distribution diagrams are shown in *Fig. 8.*

d) Chemical composition

As seen in Table VII these soils are very rich in silica (89,18—91,12 %). Alumina amounts to 4,09—5,03 %; $FeO+Fe_2O_3$ to 0,92—1,27 %; MgO to 0,14—0,32 %; CaO to 0,40—0,65 %; Na_2O to 0,67—0,85 %; K_2O to 0,78—0,94 %; carbonate-CO_2 is absent. Organic matter makes 0,21—0,92 %, total iron as Fe_2O_3 amounts to 1,00—1,34 %; H_2O+ to 0,62—0,83 %, TiO_2 to 0,18—0,40 %; MnO to 0,03—0,07 % and P_2O_5 to 0,03—0,11 %. It is clear that we have mostly quartz and felspar particles with very little clay and organic matter; the natural fertility must be very low. soils. As a matter of fact, we have found 56—66 % quartz and 10—14 % felspars in them; carbonates are missing. The total of the clay minerals is 2—11 %; organic matter is present only in small quantity, 0—1 %; see Table IV. The sum of clay minerals and organic matter makes 3—12 %, there is 15—22 % of amorphous part.

TABLE VII

Chemical Analysis of the soils of Kadarkut
(Analyst: *G. Csajághy*)

Soil No.	19	20	23	29	31	32
SiO_2	90,11	89,77	90,04	89,69	90,77	91,12
TiO_2	0,30	0,30	0,40	0,42	0,20	0,18
Al_2O_3	4,56	4,53	4,27	4,45	4,09	4,10
Fe_2O_3	0,52	0,40	0,20	0,76	0,37	0,55
FeO	0,43	0,68	0,72	0,22	0,57	0,55
MnO	0,04	0,06	0,04	0,04	0,03	0,03
MgO	0,29	0,21	0,22	0,25	0,14	0,18
CaO	0,50	0,55	0,50	0,50	0,50	0,55
Na_2O	0,69	0,74	0,68	0,72	0,72	0,67
K_2O	0,90	0,87	0,82	0,85	0,78	0,79
H_2O-	0,23	0,37	0,27	0,27	0,35	0,23
H_2O+	0,71	0,77	0,83	0,76	0,67	0,73
P_2O_5	0,05	0,07	0,11	0,06	0,05	0,04
Carbonate CO_2	0,00	0,00	0,00	0,00	0,00	0,00
Organic matter	0,75	0,89	0,83	0,71	0,72	0,21
	100,08	100,21	99,93	99,70	99,96	99,82
Total Fe as Fe_2O_3	1,00	1,15	1,00	1,00	1,00	1,05

Through a microscope it is possible to detect very small quantities of zircon magnetite, kyanite, garnets, amphibol and apatite. The fertility of these soils is in accord with this mineral composition. In spite of this, they can give still agriculturally satisfactory crops if properly cultivated.

IV. CONCLUDING REMARKS ON THE MINERAL AND AMORPHOUS COMPOSITION

Our first communication [1] alludes already to the known role of the different soil minerals. In our opinion the knowledge of the mineral composition of a soil is of vital importance in its assessment, although it is mostly very little appraised.

All soils investigated contain quartz in great proportion (34—66 % *i. e.* from one to two thirds). Felspars are always present in amounts of 10—16 % and this is often overlooked in works on soil science. But the most valuable in the soil are the clay minerals, in the first line hydromuscovite-illite and chlorites, sometimes together with montmorillonite and kaolinite; the latter two mostly in moderate amounts. It is very important, whether carbonates are present or not, since the plant needs calcium as well as magnesium. Too much carbonates is of course not desired, neither are clay minerals over 50—60 %, since in this case the rootlets of the plant cannot grow unresistedly during the dry period.

Besides the minerals treated above, there are others present in very small amounts (see above, III *e*); their role, although slighter, is still important.

The soil minerals are often poorly crystallized and there are also really amorphous parts of the soil, which are exceedingly important. Up to now no method has been employed for the determination of the amorphous content of the soil. With our modified inner standard method [3] this content can easily be determined; in our soil samples it amounts to 6—22 %. But it is also possible to make calculations concerning the composition of this amorphous and poorly crystallized part; these conclusions are naturally somewhat less reliable than the direct determinations, since they are founded on certain assumptions.

Two kinds of calculations can be made; one can determine the oxide composition and the mineral composition of the amorphous and poorly crystallized part. In the first case, one adds the SiO_2 amounts calculated from the diffractometrically determined percentages with the aid of their known chemical composition and subtracts the SiO_2 sum obtained in this way from the result of the chemical analysis (which, of course, must be exact); the difference is contained in the amorphous part. We get so the composition of the latter and the sum of oxides calculated so must give the amount of the amorphous and poorly crystallized part determined diffractometrically (there is of course some experimental error). Organic matter belongs also to the amorphous part. We see the data so obtained in Table IV.

Concerning the mineral composition of the amorphous part we made the assumption in this work that all Fe_2O_3 is contained in it in the form of limonite, FeOOH; therefore we add an eighth of the Fe_2O_3 percentage to it from the chemically bound water, H_2O+ and we obtain so the limonite percentage (which is wholly amorphous). Now we add the SiO_2 content of the diffractometrically determined minerals and subtract the sum from the result of the chemical analysis; the difference got is amorphous, combined with the rest of the surplus water obtained in the same way from the calculated and the chemically found H_2O+ it gives silicagel, its formula being $SiO_2 \cdot xH_2O$. It is not clear if the surplus Al_2O_3 should be treated in this way or it should — at least partly — be considered as belonging to a poorly crystallized clay mineral. But the amorphous silica, the limonite, the chemically found TiO_2 which we consider to be anatase, the organic matter and the moisture, i. e. H_2O-, constitute in our analyses the amorphous part, the mean difference being about 2 % abs. One cannot expect a more exact coincidence because errors of the same sign may add. By the way we used here for the composition of the felspar albite (or plagioclase) the proportion albite: anorthite = 2:1, which is also an approximation only. The calculation process could be, of course, refined or altered.

It is well known that the knowledge of limonite and aluminium hydroxide content is very important, since these minerals make phosphoric acid and its salts insoluble.

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