SEDIMENTOLOGICAL INVESTIGATIONS OF UPPER PANNONIAN AND PLEISTOCENE DEPOSITS IN THE NORTHEASTERN GREAT HUNGARIAN PLAIN

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INTRODUCTION

The northern and northeastern border of the Great Plain's Pliocene basin is made up of Miocene volcanic rocks in most places. In the north the Mátra Mountains andesites, the Bükkalja (foreland of the Bükk Mountains) rhyolite tuff mantle and the complex eruptive mass of the Tokaj Mountains form this border, in the east it is constituted by the andesite volcanic range punctuated by the Vihorlát, the Kőhát, the

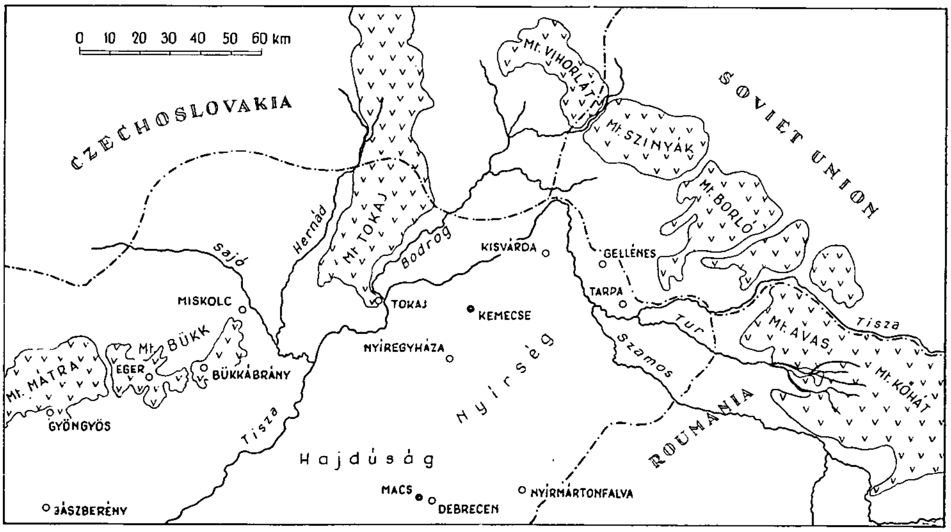

Fig. 1. Layout

Avas, and the Gutin Mountains *(Fig. 1)*. The volcanic formations continue towards the basin interior, as evidenced by gravimetric anomalies, by the andesite "islands" of Tarpa and Zemplén, and by the deep boreholes drilled in the Nyírség and Hajdúság areas.

The thickness of the volcanics decreases southwards. The Kisvárda borehole has penetrated into a 1050-m-thick rhyolite tuff complex after having traversed 1200 m of younger sedimentary deposits. The Nyíregyháza borehole, after crossing 1150 m of sediment, has cut 1425 m of Miocene volcanics without getting out of it. The Gelénes borehole has uncovered a volcanic complex of similar thickness [J. MOLNÁR, 1965]. Farther south, the borehole drilled at Nyírmártonfalva has found the same formations to be not thicker than 445 m [L. KŐRÖSSY, 1956, 1957, 1962].

In the northeastern part of the Great Hungarian Plain, inside the frontier, the Tortonian marine and Sarmatian brackwater sediments overlie volcanic products averaging 100 to 200 m in thickness. These may be intercalated by the afore-mentioned sediments or even be present in form of isolated patches only.

The total thickness of the Pliocene sediments, however, even exceeds 1000 m. Their stratigraphic subdivision has not been solved satisfactorily in all of the occurrences known. However, the general scheme adopted is to class their lower — thicker — part as Pannonian which is further subdivided into substages. The upper part is represented by the Upper Pliocene ("Levantine") sequence.

The Lower Pannonian oligohaline, lacustrine sediments are even known from outcrops in the Bükkalja and the Hernád valley. The Bükkalja Lower Pannonian sequence, transgressive on different members of the Miocene rhyolite tuffs, include in their basal layers the redeposited materials of their foot-wall, being represented by whitish, yellowish and greenish, tuffaceous sands and clays. However, the bulk of the sequence is constituted by yellow sands, sandstones, yellow and gray clays, calcareous clays, and clay-marls accompanied, in some places, by fine-grained gravels and granules as well as by thin lignite stringers. The Lower Pannonian outcrop of the Hernád valley consists of alternating sands and clays [Z. SCHRÉTER, 1939; K. BALOGH, 1964; K. BALOGH—A. RÓNAI, 1965].

In the Lower Pannonian, represented by basin facies, the predominant sediments are grey and bluish-grey clays and clay-marls with sand and sandstone lenses of different size, though commonly a few metres thick only. The thickness of the basin-facies Lower Pannonian attains 1000 m in the northern Great Hungarian Plain, along the Tisza river; farther east of this line, these sediments thin out to be reduced to 97 m at Nyíregyháza, to 68 m at Gelénes, and to 82 m at Nyírmártonfalva [E. R. SCHMIDT, 1939; L. KŐRÖSSY, 1957; L. DUBAI—K. JAMNICZKY, 1961; V. DANK, 1961].

The Mátra—Bükkalja sector of the Upper Pannonian freshwater (lacustrine, paludal) basin-filling sediments is constituted by greenish-grey and grey clays, clay-marls, grey to yellow sands as well as sandstones. Within these alternating sediments, the sandy members are predominant. The sequence is characterized by the intervention of numerous lignite seams which often attain several metres in thickness. The outcrop lying east of the Hernád valley shows similar lithological composition, the only difference being the absence of lignite.

On the basin border the Upper Pannonian formations transgress the Lower Pannonian and overlie directly the Miocene rhyolite tuffs.

The basin-facies Upper Pannonian of the northeastern Great Hungarian Plain is represented by a frequent alternation of sands and sandy clays locally interrupted by marls, lignite stringers, and calcareous concretions. The thickness varies between 500 and 1000 m.

Difficult to distinguish from the Upper Pannonian is the Upper Pliocene ("Levantine") fluviatile, paludal, continental sequence characterized by the scarcity or total absence of fossils, and lithologically by variegated (streaked, mottled), ill-stratified or fine-sandy clays and light grey, fine-grained sands with plenty of calcareous concretions [M. SZÉLES, 1965). According to some workers [M. ERDÉLYI,

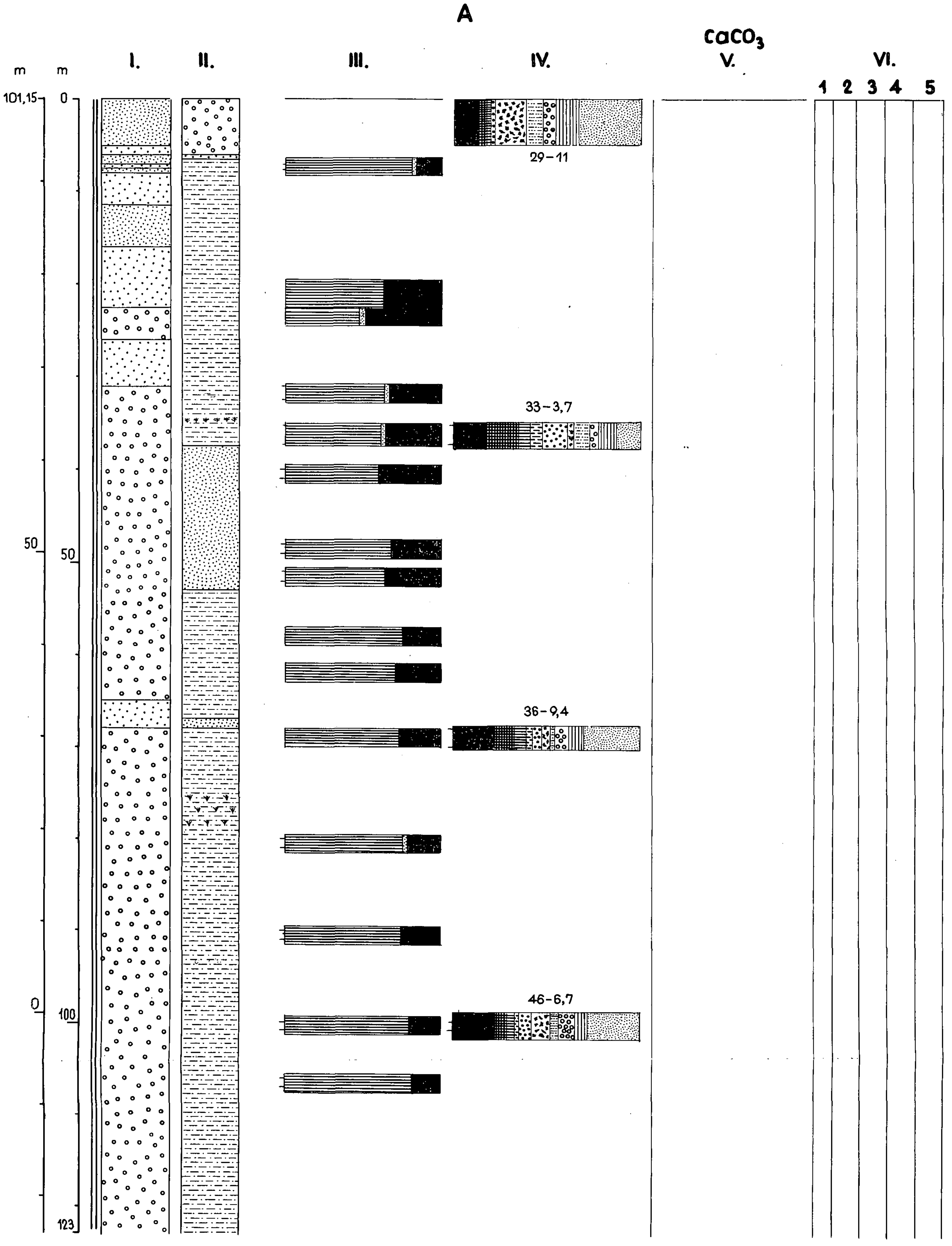

Fig. 2. Lithologic log of the Kemecse borehole, interval of 0 to 123 m.

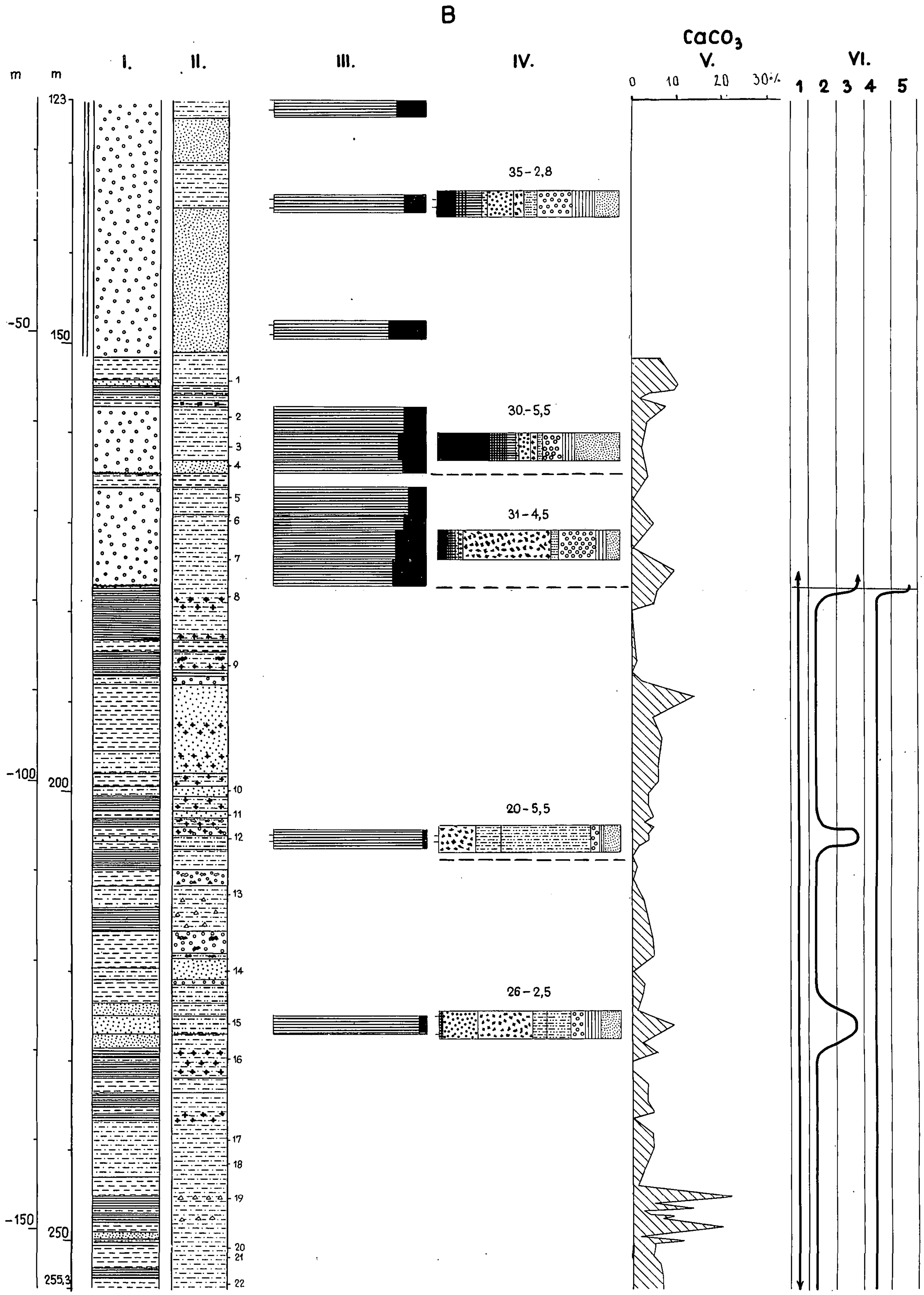

Fig. 3. Lithologic log of the Kemecse borehole, interval log of 123—253,5 m.

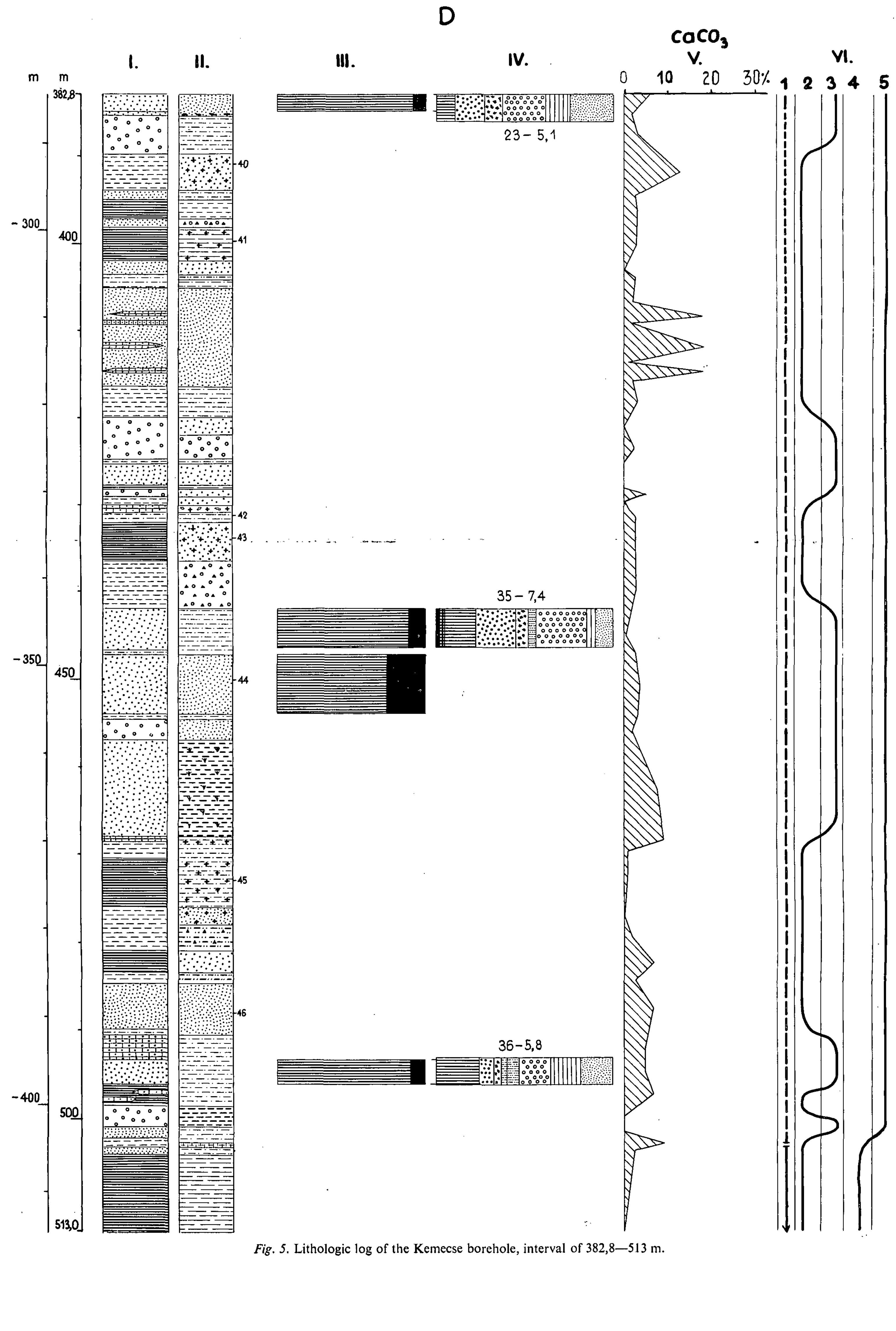

Fig. 5. Lithologic log of the Kemecse borehole, interval of 382,8—513 m.

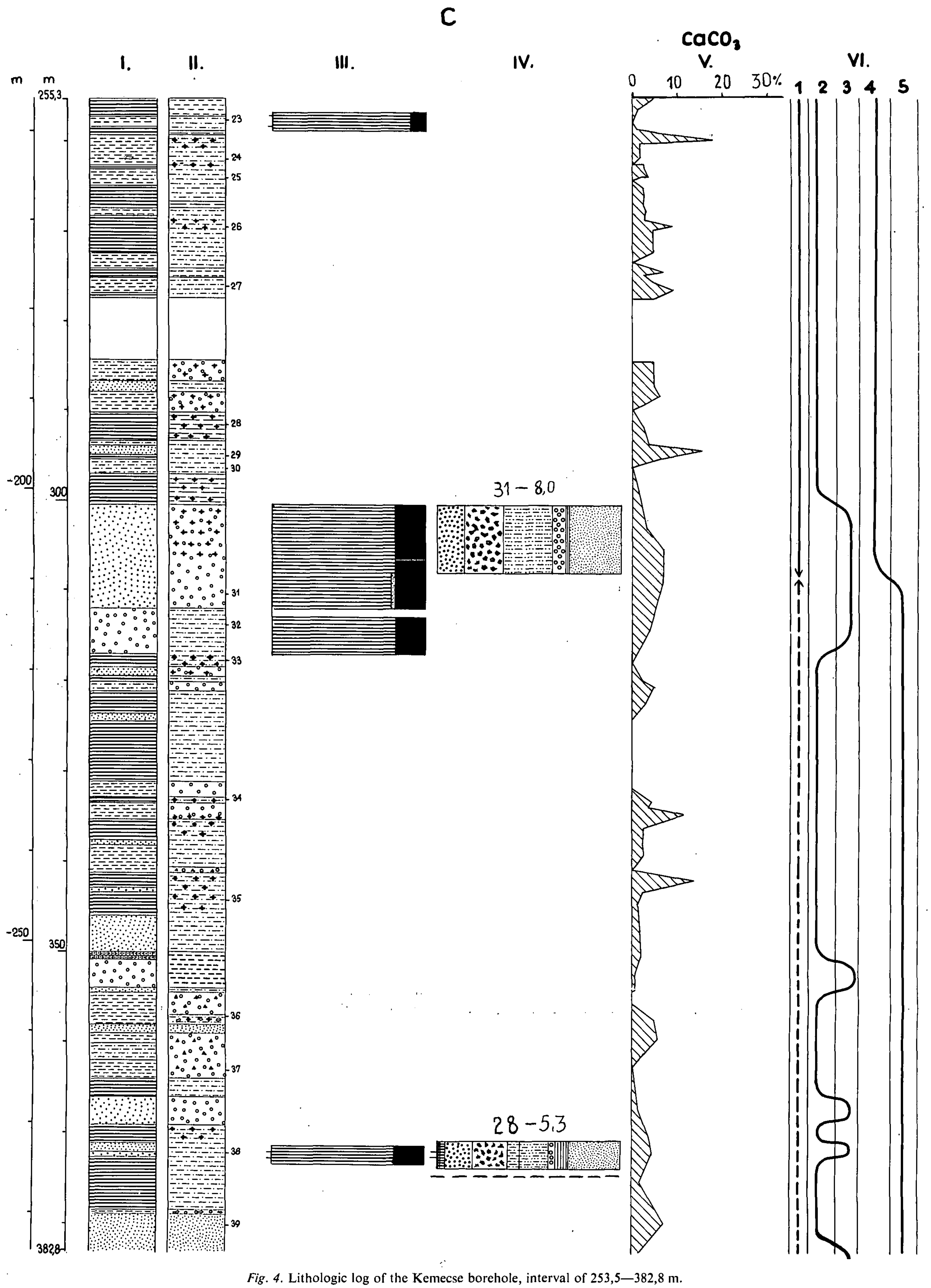

Fig. 4. Lithologic log of the Kemecse borehole, interval of 253,5—382,8 m.

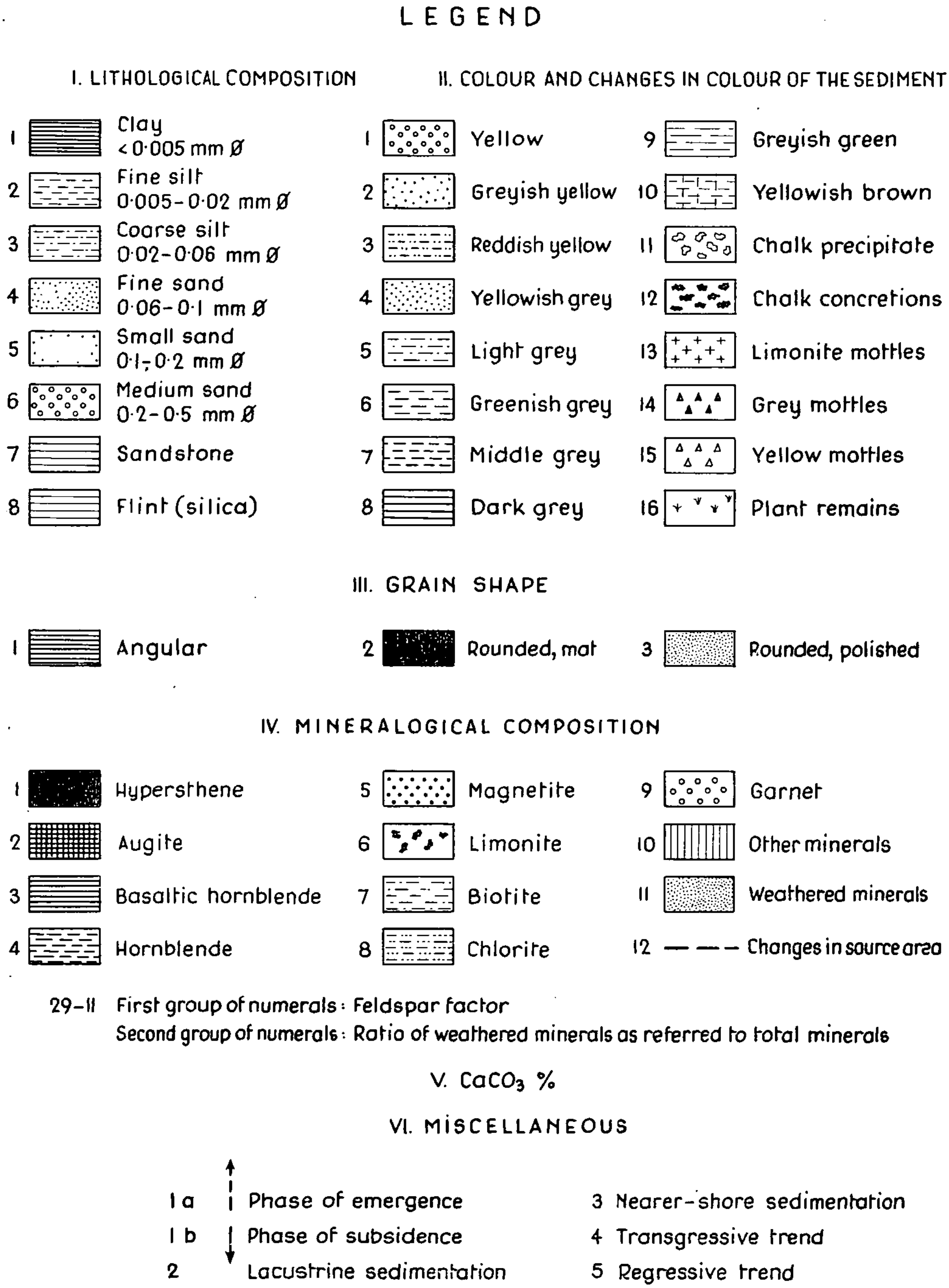

Fig. 6. Legend to *Figs. 2* to *5*

1960; L. Kőrössy, 1962], this formation would be absent in the norther Great Hungarian Plain, while others believe it to be represented by a thickness of 200 to 400 m [I. Dobos, 1965; M. Széles, 1965].

In post-Pliocene time the northeastern Great Plain area was completely emerged and affected by considerable down-drops (sudden subsidences). The Pannonian ridges which remained emergent between the subsided parts are no longer reflected by present-day morphology, for the 50 to 100 and even 250 m level differences have been planated by the wind-blown and water-transported sediments of the Quaternary period. South of Nyíregyháza, the Pannonian surface shows particularly high and varied relief. The Hajdúság is formed by a Pannonian plateau of higher position with regard to its neighbourhood, where the Pannonian sequence can be reached as high as about 10 m below the surface [M. Erdélyi, 1962; B. Molnár, 1966].

The 50- to 250-m-thick Quaternary sequence, represented predominantly by fluviatile sediments, shows a reduction of grain size from the mountain frame towards the centre of the Nyírség area [J. Urbancsek, 1965]. In the Bodrog-köz area the fluviatile deposits are still rather gravelly, but as one proceeds southwards, the sand fraction will gain predominance, being intercalated by several silt layers.

According to J. Sümeghy [1944, 1955], the Nyírség Pleistocene would suggest a comparatively late subsidence. Consequently, the majority of the alluvial fan sequence would represent the second half of the Pleistocene.

The 20- to 25-m-thick Pleistocene sequence of the Nyírség is constituted by uppermost Pleistocene loesses and wind-blown sands and Holocene eolian sands [A. Rónai —L. Moldvai, 1966].

In 1958 and 1959 the Hungarian Geological Institute had a borehole drilled, by core-drilling for the most part, at Kemecse and Macs in the northeastern Great Hungarian Plain, a measure which aimed at a detailed investigation of the poorly known Upper Pannonian and Pleistocene basin facies and at the exploration of the possibilities for tapping artesian waters *(Fig. 1)*.

The hydrogeological evaluation of the Kemecse borehole was performed earlier, by M. Erdélyi [1960]. However, the careful lithological processing of the cores has been delayed to the time of the present study. The writer of the present paper should like to fill this gap, to enhance a better understanding of the facies of the Upper Pannonian basin sediments, to provide a contribution to the problem of the absence or presence of the Upper Pliocene in the northeastern Great Hungarian Plain, to promote the lithological locating of the Pliocene—Pleistocene boundary, and, finally, to determine the sources (origin) of the Upper Pannonian and Pliocene sediments.

Within the 513 m log of the Kemecse borehole, a substantial lithological change can be observed at 177 m. As shown by the interpolated data of L. Kőrössy [1962], the total thickness of the Upper Pannonian sequence may be 600 to 800 m. The lower 336 of the Kemecse borehole has uncovered about the half, and surely one-third, of this. The uncovered interval is exactly that which comprises the major part of the sedimentary sequence of the final regression of the Upper Pannonian inland sea which used to cover the entire Great Hungarian Plain area.

A considerable part of the lithological log and of the analyses have been illustrated in *Fig. 2* to *Fig. 5* (in four divisions: A, B, C, D). In each of these, the absolute altitude and the depth of drilling have been indicated on the left side of the lithologic log. The rest of the signs have been given in the legend *(Fig. 6)*. In the figures the finer and darker sediment has been indicated by a denser hachure, the coarser and lighter one by a wider-spaced hachure. The numerals beside the IInd column of the figures are identical with the serial numbers of Table 1.

Grain composition and its statistical evaluation

According to grain composition, the borehole can be divided into two substantially different parts: *a)* in the 177 to 513 m interval the sediment is represented predominantly by clays and silts with somewhat less fine sand, i.e. sediment of finer grain fraction, *b)* the 0 to 177 m interval is constituted by medium sands. The medium sands of the 157 to 177 m interval include some 10 to 15% of coarse sand, too: this is the coarsest part of the entire lithological log *(Fig. 2* to *Fig. 8)* (Samples *1* to *46*).

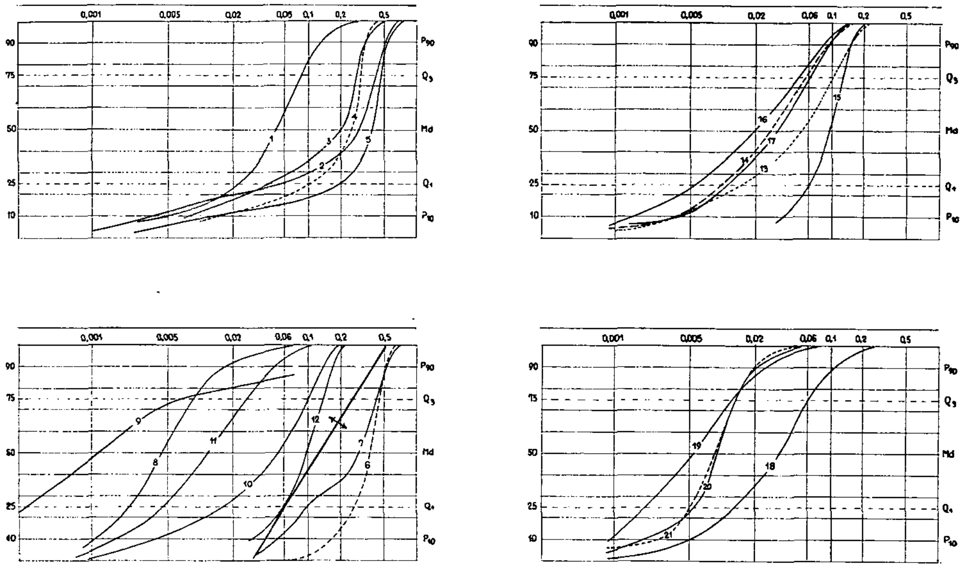

Fig. 7. Granulometric curves of the samples from the interval 0 to 252,3 m

The lithological statistical values of the examined strata have been presented in *Fig. 9* and Table 1. Although not all of the strata have been analysed in detail, the analyses have been extended to all lithological types. The analysed samples are rather evenly distributed within the profile, so that the variation of the results are suitable for the characterization of the sedimentation processes. The 0 to 150 m interval of the borehole was drilled with full hole, but bottom hole flushing was applied at 50 cm intervals. Consequently, the taken samples cannot be analysed granulometrically.

The value of sorting *(So)* varies within a very wide range (1.15 to 5.25). However, stretches with well-sorted and with more poorly sorted sediments can be selected. For instance, a good sorting has been found in the 372—513 m (Samples *38—46*) and the 0—255.3 m (Samples *1—22*) intervals, while the sediments of the 253.3—372 m (Samples *23—37*) interval have proved to be less and rather variably sorted. The last-mentioned phenomenon reflects the unsteadiness of sedimentation. In this interval the other sedimentological characteristics also change.

The value of curtosis *(K)*, indication the ratio of 50% to 90% of the curve, varies between 0,18 and 0,38. In the sequence below 245 m it has a lower value, above this level, a higher value. This means that in the lower part of the sequence the fluctuation

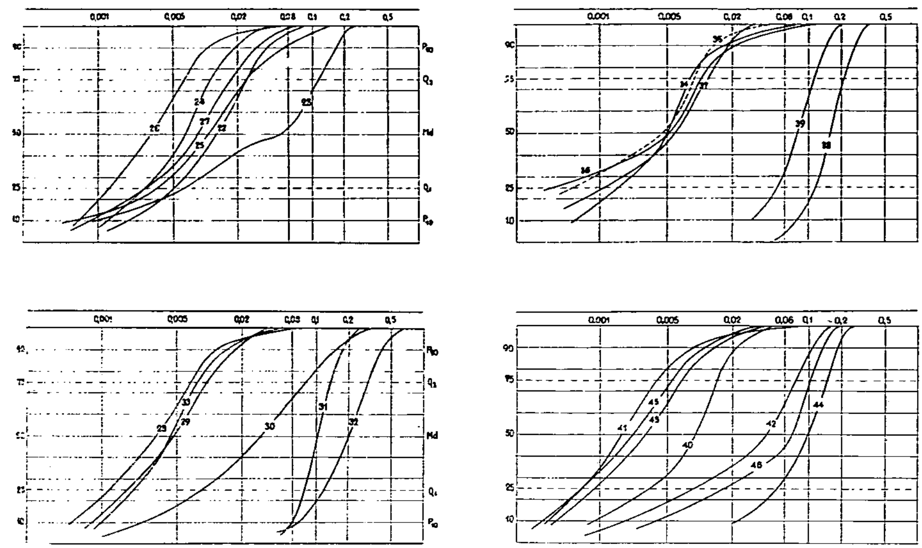

Fig. 8. Granulometric curves of the samples from the interval 254—490 m

of deposition energy was smaller, in the upper part (the complete regression sequence of the Pannonian inland sea and the Pleistocene fluviatile sequence) it was greater.

The skewness *(Sk)*, indicating the asymmetry of grain size with regard to the average value and showing the deviations of the changes of deposition energy from the average energy, varies parallel to the *K* value. Accordingly, below the 245 m level

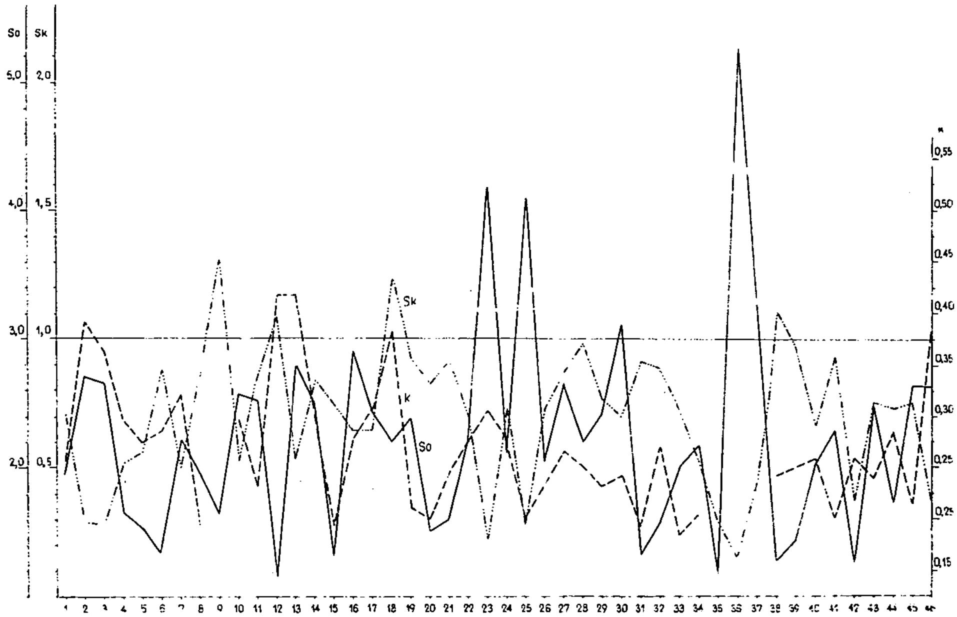

Fig. 9. Lithological statistics of the analysed samples (the numerals equal the serial numbers on the side Column II., *Figs. 2—5* as well as those of Table 1).

it is usually smaller, while above it greater values can be observed (within the 0.23 to 1,33 range, just like the amplitude of *K* variation (*Fig. 9*, Table 1).

Consequently, on the basis of grain composition and its statistical characteristics, three intervals of different sedimentation conditions can be distinguished in the Kemecse borehole log: *a)* the interval below 245 m characterized by a relatively steady, balanced sedimentation, *b)* the 177 to 245 m interval characterized by more unsteady, more rapidly changing conditions, and *c)* the 0 to 177 m interval suggesting sedimentation conditions substantially different from the former two. Intervals *a* and *b* are the result of continuous sedimentation, while interval *c* overlies unconformably the *a* and *b* sequences.

Grain shape

The shape of sand grains was examined by the method of A. CAILLEUX [1952, 1961]. Thus three grain types could be distinguished: *a)* gritty-splittery, unrounded grains, *b)* rounded, bright-faced grains transported by water for more than 400 km distance, *c)* rounded, dull grains characteristic of wind-blown sands. The method applied is a statistical one. Accordingly, the problem of origin is determined by the predominant grain type within the sediment.

In the Upper Pannonian sequence of the Kemecse borehole, gritty-splittery grains of *a* type were found to predominate; in addition to them, a few slightly rounded, dull grains have also been found. Although confined to 308 m depth, 1 to 2% rounded, bright grains have also been encountered.

In all of the Pleistocene samples the water-transported grains are predominant, though in the 15 to 52 m interval the ratio of the rounded, dull, wind-blown grains is comparatively higher. Incidentally, some water-transported, bright, rounded grains can also be encountered. These must have derived from the redeposition of older sediments, for the length of the rivers of the northeastern Great Hungarian Plain does not attain 400 km. Hence, these grains may derive from the coasts of the Pannonian inland sea (*Fig. 2* to *Fig. 5*, IInd column, and *Fig. 6*, IIIrd column).

Mineralogical composition

1. Heavy minerals. In the Upper Pannonian sequence of 336 m vertical range the heavy mineral composition changes thrice, in the 177 m of Pleistocene sediment, once. Hence, from bottom to top, the following types can be distinguished:

a) The sand samples of the interval, ranging from 372 m down to the bottom of the borehole, are dominated by basaltic hornblende and garnet, while magnetite and limonite show an upward increase. Two samples from this interval have a considerable tourmaline content (*Fig. 5*, Table 2, Samples *12* to *14*).

b) The samples of the 225—372 m interval can be distinguished from the underlying sediment by their higher chlorite and limonite contents, while basaltic hornblende and tourmaline vanish or are reduced to insignificant amounts in them. The frequency of garnet also diminishes. Magnetite keeps on being an important component (*Fig. 3* and *Fig. 4*, Table 2, Samples *9—11*).

c) The Upper Pannonian sample from 204 m is conspicuous for its striking chlorite (50%) and biotite (13,4%) contents. However, magnetite disappears and it is alone limonite that attains a 20% ratio even here (*Fig. 2*, Table 2, Sample *8*).

d) The Pleistocene sample from the 171—174 m interval shows a mineralogical composition which is intermediary between the underlying Upper Pannonian and the overlying younger Pleistocene sediments. Limonite is abundant, hypersthene augite and garnet appear (*Fig. 2*, Table 2, Sample 7.).

e) Finally, the sediments of the 0 to 163 m interval are characterized by a composition corresponding to that of the recent sediments of the Tisza river: hypersthene, augite, basaltic hornblende, magnetite, garnet, and limonite [B. MOLNÁR, 1964].

2. Light minerals. First of all, the quantitative changes of feldspar grains have been studied on the basis of the method developed by A. CAILLEUX [1965]. Accordingly, different causes may provoke the enrichment of feldspar (cold climate, proximity of eruptive rocks). However, the decrease of the amount of feldspar is always due to the intensification of chemical weathering (and *not* to physical disintegration). According to CAILLEUX, a sediment characterized by a feldspar index of 10 to 80 is considered feldspar-rich, while one having an index of 4—5 is considered feldspar-poor.

Although the material of the Kemecse borehole can be declared feldspar-rich on the whole, yet various intervals of different feldspar content can be distinguished within the stratigraphic column of the borehole. In those two samples taken from the basalt stretch of the borehole in which the ratio of basaltic hornblende attained 19 to 23%, the feldspar index too is 35 to 36 *(Fig. 5)*. The feldspar index decreases with the upward decrease of the ratio of magmatic minerals, being as low as 25 to 30 in the rest of the Upper Pannonian sequence. In the lower sample of the Pleistocene it is 31, but it increases upwards with increasing feldspar ratio. Its value of 29 to 46 seems to vary parallel with Pleistocene climatic changes (*Fig. 2—Fig. 5*, IVth column).

The ratio of the weathered and coated grains to the total of the mineral grains (2,5 to 11%) has also been examined, but this does not show any striking regularity.

Carbonate content

As compared to the rest of the Great Hungarian plain, the carbonate content is low throughout the log, being 4 to 7% on the average. The highest value does not attain 25% either.

THE HISTORY OF ACCUMULATION AS EVIDENCED BY THE KEMECSE BORE LOG

1. *Upper Pannonian sequence:* in the 253.5 to 372 m interval most of the lithological characteristics are other than below and above this interval. Consequently, a substantial lithological change has taken place within this interval. That this must have been due to tectonic movement is evidenced by the change of source area. Thus the 338-m-thick Upper Pannonian section can be subdivided into two sedimentation phases at 372 m.

a) Within the 253.5—372 m interval it is difficult to draw any exact limit of overall change in sedimentation, for this change was gradual.

Still, the lower 202 m stretch (between 300 and 502 m) can be regarded as a minor regression phase on the basis of its position within the entire geological section (*Fig. 3* and *4*; VIth column). At 502 m the borehole has ended in clay. From this level up to 300 m the fine sands also play an important role. Between 372 and 382 m, as shown above, the source area has also changed. Underneath, the presence of basaltic hornblende indicates the redeposition and reworking of the late volcanic materials of the marginal zone. The presence of garnet may suggest the redeposition of garnet-bearing older sediments. In the stretch above 372 m the disappearance of basaltic hornblende and the considerable amount of chlorite prove the intensification of the erosion of sediments. This is also confirmed by the feldspar index which has the highest

TABLE 2

Heavy mineral composition of the Upper Pannonian and Pleistocene sands of the Kemecse borehole

Number	Depth m	DOMINANTLY MAGMATIC MINERALS									DOMINANTLY METAMORPHIC MINERALS										OTHER MINERALS				Total quantity of minerals in the examined fraction	Dominant grain diameter mm	Age
		Hypersthene	Other rhombic pyroxenes	Augite	Diopside	Basaltic-hornblende	Magnetite	Biotite	Apatite	Zirkon	Chlorite	Tourmaline	Epidote	Zoizite	Rutile	Hornblende	Actinolite-tremolite	Garnet	Staurolite	Cyanite	Calcite-dolomite	Limonite	Other micas	Weathered minerals			
1.	0—5	12,3	—	4,5	0,7	1,3	1,3	0,7	—	—	9,7	1,3	—	—	—	—	—	6,5	—	—	—	18,2	9,8	33,7	0,9	0,06—0,1	Pleistocene
2.	35—37	17,4	1,5	16,9	0,5	6,6	13,4	0,5	3,1	—	8,7	1,5	—	—	—	6,7	—	4,6	—	—	—	3,6	2,6	12,4	0,9	0,2—0,5	
3.	68—70	22,2	2,8	10,4	0,7	7,0	4,2	—	—	—	2,1	0,7	1,4	—	—	3,5	0,7	8,3	0,7	—	—	4,8	—	29,5	3,6	0,2—0,5	
4.	100—101	22,4	0,7	6,3	1,4	4,3	6,8	—	2,1	—	4,9	—	—	—	0,7	2,1	0,7	9,1	0,7	—	—	9,8	0,7	27,3	2,1	0,2—0,5	
5.	134—135	10,2	1,1	5,4	3,2	8,7	14,6	—	3,2	—	7,2	1,1	—	—	1,6	3,2	1,1	19,4	—	0,6	—	5,9	1,1	12,4	3,5	0,2—0,5	
6.	160—163	28,5	1,3	9,5	0,6	5,1	6,3	—	0,6	—	2,5	0,6	—	—	—	1,9	3,3	11,4	—	—	—	3,7	0,6	24,1	1,5	0,2—0,5	
7.	171—174	4,4	1,3	3,8	0,6	1,3	1,3	—	—	0,6	4,4	0,6	1,3	—	—	1,3	—	20,7	—	—	—	50,2	—	6,9	1,5	0,2—0,5	
8.	204,8—205,5	—	—	—	—	—	—	13,4	—	—	50,1	—	1,3	—	—	—	—	4,9	—	1,3	—	20,4	—	8,6	0,5	0,1—0,2	Upper Pannonian
9.	225,5—226,0	0,7	—	1,4	—	—	19,4	7,6	4,9	—	13,2	1,4	0,7	—	0,7	—	—	8,3	—	—	—	31,3	—	10,4	1,0	0,1—0,2	
10.	300,5—307	—	—	—	1,1	—	14,7	—	—	—	26,2	—	—	—	—	—	—	7,9	—	1,1	—	21,5	—	27,5	0,2	0,06—0,1	
11.	371—372	0,6	—	1,2	—	1,2	17,9	5,4	1,2	—	16,0	1,8	—	—	1,8	—	—	3,6	—	—	—	19,6	2,9	26,8	0,6	0,1—0,2	
12.	382,8—384,8	—	—	—	0,9	9,7	17,5	—	—	—	—	6,1	2,6	0,9	—	—	—	25,4	—	—	—	9,7	3,5	23,7	1,6	0,06—0,1	
13.	442—446,7	1,8	—	1,8	—	19,0	22,6	—	1,8	—	4,7	1,8	—	—	—	—	0,9	29,6	—	—	—	6,6	—	9,4	0,4	0,1—0,2	
14.	493,4—498,6	—	—	—	—	23,2	9,7	3,5	—	—	7,0	5,3	2,6	—	—	—	—	17,8	—	—	7,0	4,4	—	17,9	1,1	0,1—0,2	

TABLE 1

Lithologic statistics of the studied Upper Pannonian and Pleistocene material of the Kemecse borehole

Number	Depth m	P_{10}	Q_1	Md	M	Q_3	P_{90}	So $\left(S_o = \sqrt{\frac{Q_3}{Q_1}}\right)$	K $\left(K = \frac{Q_3 - Q_1}{2(P_{90} - P_{10})}\right)$	Sk $\left(S_k = \frac{Q_1 \cdot Q_3}{Md^2}\right)$	$CaCO_3$ %	Type of Sediment	Age
1.	154—157	0,0052	0,023	0,051	0,06	0,087	0,13	1,95	0,26	0,72	2,2	F. S.	Pleistocene
2.	157—160	0,004	0,06	0,30	0,37	0,44	0,52	2,71	0,38	0,29	3,2	M. S.	
3.	160—163	0,008	0,04	0,20	0,22	0,28	0,34	2,65	0,36	0,28	2,2	M. S.	
4.	163—166	0,014	0,11	0,25	0,28	0,30	0,34	1,65	0,29	0,52	3,5	M. S.	
5.	166—169	0,014	0,19	0,40	0,43	0,48	0,55	1,58	0,27	0,57	—	M. S.	
6.	169—171	0,17	0,27	0,38	0,40	0,48	0,55	1,33	0,28	0,89	4,4	M. S.	
7.	174—177	0,025	0,10	0,30	0,38	0,45	0,55	2,22	0,33	0,50	8,8	M. S.	
8.	177—180	0,001	0,0022	0,0047	0,0052	0,0085	0,018	1,96	0,18	0,85	5,3	CL.	Upper Pannonian
9.	185,5—188	—	0,00023	0,0011	0,0016	0,007	—	1,74	—	1,33	—	CL.	
10.	199,5—200,5	0,0032	0,015	0,053	0,052	0,10	0,14	2,58	0,31	0,53	3,5	C. Si.	
11.	202,2—202,8	0,0016	0,0044	0,012	0,013	0,028	0,05	2,52	0,24	0,85	4,4	F. Si.	
12.	204,8—205	0,041	0,09	0,10	0,10	0,12	0,17	1,15	0,37	1,08	3,5	S. S.	
13.	210,5—212,9	0,0046	0,0014	0,055	0,06	0,11	0,15	2,80	0,37	0,51	2,2	C. Si.	
14.	218,5—220,9	0,0035	0,010	0,027	0,034	0,06	0,095	2,45	0,27	0,82	—	C. Si.	
15.	225,5—226,9	0,035	0,065	0,096	0,011	0,11	0,15	1,30	0,19	0,76	8,8	S. S.	
16.	229,5—230,1	0,0015	0,0058	0,021	0,026	0,05	0,085	2,93	0,26	0,66	—	C. Si.	
17.	238,0—240,5	0,0042	0,011	0,033	0,036	0,065	0,094	2,43	0,30	0,66	4,4	C. Si.	
18.	240,5—242,9	0,0045	0,013	0,034	0,034	0,060	0,011	2,15	0,36	1,24	2,2	C. Si.	
19.	245,5—246,4	0,00081	0,0021	0,0052	0,0057	0,012	0,024	2,40	0,21	0,93	2,2	CL.	
20.	250,8—251,4	0,0017	0,0052	0,0090	0,0095	0,013	0,021	1,58	0,20	0,83	4,4	F. Si.	
21.	251,4—252,3	0,002	0,0051	0,0085	0,0095	0,013	0,019	1,60	0,23	0,92	4,4	F. Si.	
22.	254,0—255,3	0,0019	0,005	0,013	0,014	0,024	0,038	2,20	0,26	0,71	6,6	F. Si.	
23.	257,3—258,4	0,0007	0,0061	0,052	0,095	0,11	0,17	4,20	0,31	0,23	—	S. S.	
24.	262,4—263,2	0,0013	0,0026	0,0065	0,007	0,012	0,019	2,15	0,26	0,74	—	F. Si.	
25.	263,2—265,0	0,00055	0,0014	0,011	0,011	0,24	0,56	4,16	0,20	0,28	2,2	F. Si.	
26.	269,4—270	0,00095	0,0016	0,0031	0,004	0,0065	0,011	2,02	0,24	0,76	8,8	CL.	
27.	275,8—277	0,0008	0,0026	0,009	0,01	0,018	0,03	2,64	0,26	0,85	8,8	F. Si.	
28.	290,3—293,5	0,00052	0,0014	0,0031	0,0038	0,0067	0,011	2,19	0,25	0,97	2,2	CL.	
29.	295,0—295,4	0,0008	0,0017	0,0046	0,005	0,0097	0,018	2,39	0,23	0,78	5,7	CL.	
30.	295,4—297,4	0,0022	0,008	0,03	0,028	0,08	0,15	3,16	0,24	0,70	—	C. Si.	
31.	308,0—312	0,058	0,076	0,1	0,11	0,12	0,18	1,25	0,18	0,91	6,6	S. S.	
32.	312—317	0,065	0,12	0,2	0,21	0,3	0,4	1,58	0,27	0,90	3,5	M. S.	
33.	318,1—318,4	0,00095	0,0019	0,0044	0,0044	0,0076	0,018	2,00	0,17	0,75	—	CL.	
34.	332,9—333,5	0,00067	0,0017	0,005	0,0057	0,008	0,016	2,17	0,21	0,54	4,4	CL.	
35.	343,2—346,0	—	0,00065	0,0045	0,0055	0,009	0,013	1,17	—	0,29	0,9	CL.	
36.	357—358	—	0,0004	0,0052	0,0065	0,011	0,021	5,25	—	0,16	4,4	F. Si.	
37.	362—366	—	0,0013	0,006	0,0065	0,012	0,018	3,05	—	0,43	—	Ti. Si.	
38.	372—372,6	0,076	0,12	0,16	0,026	0,21	0,26	1,33	0,24	0,98	4,4	S. S.	
39.	378,5—382,2	0,03	0,051	0,08	0,084	0,11	0,15	1,47	0,25	0,88	6,6	F. S.	
40.	389,7—393,8	0,001	0,0034	0,009	0,009	0,014	0,021	2,03	0,26	0,59	12,6	F. Si.	
41.	398,2—402,0	0,00038	0,00075	0,0019	0,0023	0,004	0,0085	2,30	0,20	0,83	2,7	CL.	
42.	430,8—432,3	0,002	0,008	0,04	0,05	0,075	0,13	1,27	0,26	0,38	2,2	C. Si.	
43.	432,3—436,5	0,00046	0,0011	0,0031	0,0037	0,0067	0,012	2,47	0,24	0,77	2,2	CL.	
44.	447,2—454	0,021	0,05	0,1	0,11	0,15	0,19	1,74	0,29	0,75	3,5	S. S.	
45.	470,5—476	0,00038	0,0008	0,0024	0,003	0,0055	0,011	2,62	0,22	0,76	4,2	CL.	
46.	486,3—490	0,0038	0,016	0,07	0,08	0,11	0,13	2,62	0,37	0,36	6,6	F. S.	

CL. = CLAY < 0,005 mm ⌀, F. Si. = FINE SILT = 0,005 – 0,02 mm ⌀,
S. S. = SMALL SAND = 0,1 – 0,2 mm ⌀, M. S. = MEDIUM SAND = 0,2 – 0,5 mm ⌀
C. Si. = COARSE SILT = 0,02 – 0,06 mm ⌀, F. S. = FINE SAND = 0,06 – 0,1 mm ⌀,

values in the samples containing the greatest amount of basaltic hornblende (*Fig. 5*, IVth column).

Comparatively harder rocks cannot be encountered elsewhere, being limited to this depth. The cement is calcareous silica. The precipitation of this was promoted by the fact that with the decrease of the inland sea surface area, the waters of the influent rivers often changed the pH value of sea water. The large-scale growth of the seashore vegetation may have led to the same consequences.

Determined on the basis of changes in grain composition, the near-shore and farther off-shore phases have been indicated in stretches 2—3 of the IVth column of *Fig. 2* to *Fig. 5*. In this sector, in compliance with the regression-bound trend, the distance to the shoreline often changed in dependence on the changes of the marginal zone and of the equilibrium of accumulation and erosion.

b) In the 123-m-thick sequence between 177 and 300 m it is clay and silt that predominate. Accordingly, its lithological characteristics are also more balanced, so that the sequence is indicative of a slightly subsiding sedimentation basin. Occurring rather frequently, limonite nodules suggest a well-aerated lake-water environment of shallow depth (*Fig. 2* and *Fig. 3*). The heavy mineral composition and the feldspar ratio indicate the continuation of the conditions which characterized the upper part of the previous phase. Like in a number of other Great Plain Upper Pannonian profiles, the change of source area took place earlier than the inversion of regression into transgression [B. MOLNÁR, 1968*b*, 1968*c*]. Hence, the heavy mineral assemblage found at 204 m may represent the fore-runner of a final regression phase which is absent in the profile or which may even not have developed because of possible rapid emergence.

The Upper Pannonian sequence contains no consolidated rock within these uppermost 123 metres.

The entire Upper Pannonian sequence is devoid of fauna [M. ERDÉLYI, 1960]. However, M. FARAGÓ [1960] collected from the Upper Pannonian disclosed here, a pollen assemblage completely identical with that of the Upper Pannonian lignites occurring in the southern foreland of the Mátra Mountains. The Kemecse pollen assemblage also consists of shallow-water to paludal forms. This fact as well as the grading of the deeper, macrofossiliferous Upper Pannonian horizon into the pollen-bearing interval does not justify the assignment of the latter to the Upper Pliocene ("Levantine"). Neither does so the variegated, flamboyant nature of the colour of the sediments [M. SZÉLES, 1965], as F. BARTHA [in M. ERDÉLYI, 1960] described an Upper Pannonian fauna from a sedimentary sequence in the near-by Macs borehole, showing completely the same variegation *(Fig. 1)*.

2. *Pleistocene:* the 177-m-thick sequence can be split up into two parts:

a) The medium sands and fine silts of the 167—170 m interval are unconformable on the Upper Pannonian. The discrimination of this latter from the other Pleistocene developments is justified by that its source area is but partly identical with that of the others. East of the city of Nyíregyháza the morphology of the surface is particularly marked. The effect of the Upper Pannonian sediments removed from the higher portions of topography is reflected by the accumulation of the first Pleistocene strata of the deeper-seated Kemecse area.

b) The remaining 167 m of the Pleistocene shows a heavy mineral composition completely identical with, that produced by the present-day rivers of the north-eastern Great Hungarian Plain [B. MOLNÁR, 1964]. This sequence may have been deposited after the relatively late Pleistocene subsidence of the Nyírség area, recorded by J. SÜMEGHY [1944, 1955]. All these deformations are the result of a single, late crustal rhythm (subsidence), whereas in other areas, where the presence of older sediments can also be warranted, several sedimentation rhythmus can be shown to have occurred during the Pleistocene [B. MOLNÁR, 1967, 1968; A. RÓNAI, 1968].

Comparison of the Kemecse log with other near-by bore columns

The only 48-m-thick Pleistocene member of the Macs borehole drilled in the Hajdúság *(Fig. 1)* is substantially thinner than that of the Kemecse borehole. However, in its 453-m-thick Upper Pannonian section sedimentation rhythms, similar to those observed at Kemecse, could be revealed. In Pannonian time the Hajdúság was of higher hypsometric position than the Kemecse area was. Hence the frequency of lignite beds there. In the Upper Pannonian of Macs, four minor cycles have been revealed [B. MOLNÁR, 1965, 1966, 1968*b*]. However, the regression and transgression phases discovered at Kemecse are thicker than their two equivalents of Macs Accordingly, at Kemecse, where a sublittoral facies is present, the minor rhytms of crustal movements are not reflected perceptibly by sedimentation. At Macs the rhythms, which preceded the latest Pannonian final regression, were the shorter the closer to the completion of regression. The disappearance of the Pannonian inland sea was due to the gradual increase or the duration of uplift or static conditions opposed to the decrease of the duration of subsidence.

After the Upper Pliocene ("Levantine") break in sedimentation it is the Pleistocene that follows at Macs, too. However, it largely differs in lithology from the Pleistocene deposits of Kemecse. In Pleistocene time much of what is now the Hajdúság, inclusive of the Macs area, was a high-perched platform of Pannonian sediments, upon which there is no Pleistocene fluviatile accumulation. Despite its lower thickness, the Pleistocene sequence embraces a larger time span. Therefore, ten loess deposition phases, at least six soil genetic phases, and five wind-blown sand interlayers could be detected within the Macs profile.

CONCLUSION

In the northeastern Great Hungarian Plain the Upper Pannonian is represented by the following two types:

1. On the high-perched Pannonian platform of the Hajdúság there is a shallow-water, lacustrine, variegated sedimentary sequence with lignite seams which is in many respect similar to the contemporaneous developments of the Mátra— Bükkalja areas but which is constituted by sediments of increasingly smaller grain size farther off-shore. The source area seems to have been the marginal volcanic belt.

2. In the northern part of the Nyírség, in the vicinity of Kemecse, the lack of lignite is an evidence of a somewhat deeper, farther off-shore environment in which, however, variegated sediments like those of Macs were deposited, testifying to a shallow-water lake environment. Upwards in the column, the volcanic material is gradually outscored by the older sedimentary material of the marginal zone.

The lithology of the deposits of both the areas proves the rhythmicity of differential crustal movements. In the Hajdúság the single rhythms lasted for a shorter time, in the norther Nyírség for a longer time, so that the two areas also differ by the rate of accumulation of sediments within the span of time of the individual rhythms. Nota bene, in the Hajdúság the sediments accumulated within one cycle are thinner, in the northern Nyírség, thicker.

In the Hajdúság and the Nyírség the discrimination of the Upper Pliocene ("Levantine") is not justified by sedimentation. The author believes it to be absent there. The Hajdúság was the scenery of erosion in Latest Pliocene and Earliest Pleistocene time, whereas the Nyírség witnessed erosion even for a considerable part of the rest of the Pleistocene epoch.

The post-Pannonian red clay beds of the northern marginal zone are absent in many places of the basin's northeastern part. This seems to be due to break in sedimentation or to later erosion. The "red clay beds" of the Hajdúság cannot be identified with the red clays of the marginal zone. In fact, the former are loess-based soil layers of much coarser grain composition [B. MOLNÁR, 1966]. Where the red clays are absent, the Upper Pannonian — Pleistocene boundary can be traced on the basis of differences in lithology.

In the northeastern Great Hungarian Plain even the Hajdúság and Nyírség areas differ from each other in Pleistocene history.

The Hajdúság was abandoned by fluviatile accumulation in Pleistocene time and witnessed eolian accumulation processes for a considerable part of the Pleistocene.

In the Nyírség, in the early part of the Pleistocene, the higher-seated Pannonian ridges were eroded and the sediment worn away was deposited in the deeper-seated areas, giving rise to a thinner sequence (e.g. at Kemecse, too). That time the Nyírség rivers skirted the Hajdúság area and carried their load farther away, to deposit them in the depression of the Kőrös Riverine [J. URBANCSEK, 1965].

With the Late Pleistocene subsidence of the Nyírség [J. SÜMEGHY, 1955], the rate of fluviatile accumulation increased in the area. However, both loess and wind-blown sand are represented among the fluviatile sediments and above their sequence [Z. BORSY, 1961; A. RÓNAI—L. MOLDVAY, 1966]. As shown by recent data [GY. CSICSELY, 1968], in the western Nyírség the wind-blown sands play a considerable role even at greater depths than was demonstrated before.

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