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MANIFESTATIONS OF THE CHANGES OF UPPERMOST TERTIARY AND QUATERNARY SOURCE AREAS IN THE JÁSZSÁG BASIN

B. MOLNÁR and Á. FEKETE

INTRODUCTION

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With a view to its great significance and to its other detailed geological process-g, it would be desirable to re-examine the core material in order to meet the

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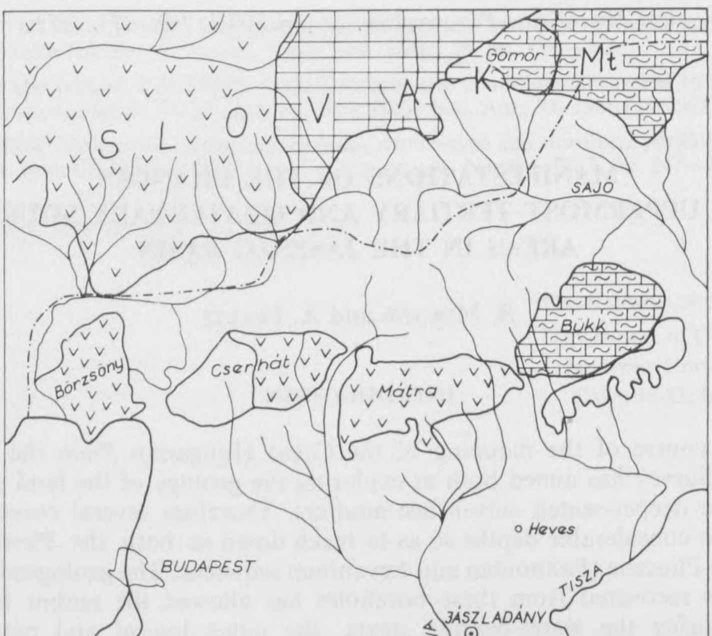

Fig. 1. Lithology of the Jászság Basin and of the areas to the north of it *1.* Crystalline schist *2.* Carbonate rocks, *3.* Volcanic rocks, *4.* Detrital rocks

afore-mentioned requirements. Namely, the results that may thus be obtained can be used as a basis for comparison with further drilling data and they may help assess more correctly the latest Pliocene and Pleistocene history of the area as well.

EXAMINATION OF THE MINERALOGICAL COMPOSITION OF SAND SAMPLES FROM THE JÁSZLADÁNY BORE PROFILE

Selecting of the samples and their preparation for analysis

As far as it was possible, sands of subidentical to identical predominant granulometric composition were selected for analysis (Table 1). Thus the author also attempted to avoid possible errors due to grain size differences. *Nota bene*, as shown by earlier comparative studies, it is favourable to select small-grained sands (0,1—0,2 mm) for analyzing the heavy mineral composition of the Great Hungarian Plain's Pliocene and Pleistocene sands [B. MOLNÁR, 1970].

It is in the case of this granulometric composition that the results can be correlated with one another. The investigations have also shown that the 0,1 to 0,2 mm fraction of small sands is advantageous to analyze. In the Great Plain's Pliocene and Pleistocene sediments in this fraction the striking concentration of garnet and magnetite towards the finer grain sizes cannot yet be observed, but mica and chlorite also fail to increase in concentration towards the coarser fractions. Instead, the sample yields the most favourable heavy mineral composition.

Therefore the author has selected for further research the small sand fraction or — where only fine sand was available in the studied interval — the 0,1 to 0,2 mm fraction of fine sands in the Jászladány profile as well. This fraction was separated conventionally (with bromoform) into a portion of light and a portion of heavy specific weight.

Using mineralogical microscope, the author determined 250 to 300 grains from the heavy mineral fraction of each sample and he calculated then therefrom the percentage quantities of the individual minerals within the sample. Namely, according to A. L. Dryden [1931], the possible error will markedly decrease at about 300 grains determined. The Great Hungarian Plain's Pliocene and Pleistocene sediments contain, as a rule, 15 to 25 different heavy minerals. If in these sediments the minerals are present in the afore-mentioned number and if one wishes to determine only the predominant minerals sufficient for locating the catchment area of the transporting river, it is enough to determine 200 or eventually 150 grains. If, however, the determination of the quantity of minerals present in low amount is also attempted, at least 300 grains or more have to be determined [B. Molnár, 1970]. Accordingly, the figure of 250 to 300 grains determined can be said to be the optimum for the present purpose.

The obtained results have been grouped — as far as it was possible — according to the origin of the minerals (Table 1).

After separation on bromoform the residual light fraction was used for the determination of the quantity of quartz, plagioclase and potash feldspar as wel as for the examination of the forms of occurrence of the light minerals. In quantitative analyses the colouring process developed by Bailey and Stevens [1960] was applied.

The Jászladány sand samples are loose, unconsolidated, therefore the sand grains before analysis were first mounted in Canada balsam on the object plate and they were then pressed down softly to the object plate. Afterwards the slide was polished with the finest abrasive powder so as to possibly half the 0,1 to 0,2 mm grains. This way a smooth surface corresponding in size to most of the grains was obtained.

After painting 1000 grains per sample were determined under binocular stereomicroscope for the determination of the most appropriate proportion of minerals within the fraction. According to E. D. Jackson and D. D. Ross [1956] namely, this number of grains is already sufficient for the determination of the proper mineral ratio.

Evaluation of the heavy mineral analyses

Evaluating the data summarized in Table 1, let us conclude that in the Jászladány drilling profile, between the surface and the deepest sand sample recovered from 915 m depth, five major changes in source area can be recognized. Let us quote them:

1. The heavy mineral composition of the *Upper Pannonian* is characterized by the relatively small number of minerals. The column diagram of the calculated weighted averages of the most essential minerals of the seven samples encompassing the Upper Pannonian interval indicates that the sequence under consideration contains but a few minerals, of which chlorite is present in a striking quantity. (Minerals having values below 1% have not been represented for technical reasons, see *Fig. 2.*)

In the sequence, characteristic minerals beside chlorite are garnet, other representatives of pyroxene (predominantly bronzite), magnetite-ilmenite, limonite and weathered minerals. The minerals diagnostic for the Upper Pannonian interval and distinguishing it from the overlying sequence have been distinguished by framing the respective items in Table 1. That the formation has a simple mineralogical composition is proved by the diagram of *Fig. 3*, too, in which predominantly chlorite, a few weathered minerals and one apatite grain can be observed.

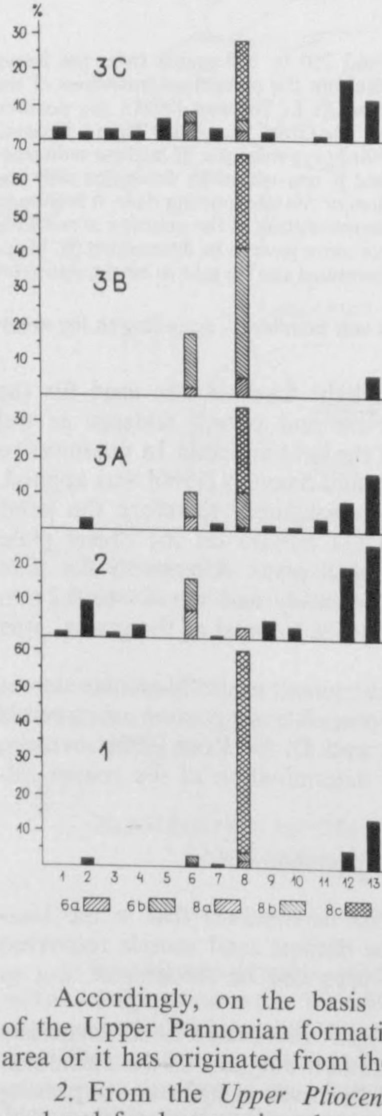

Fig. 2. Averages of minerals predominant in horizons of different heavy mineral composition of the Jászladány drilling profile

1. Upper Pannonian, *2.* Upper Pliocene (Levantine) — Pleistocene *3A, B, C* horizons *1.* Hypersthene, *2.* Other rhombic pyroxenes, *3.* Augite, *4.* Diopside, *5.* Basaltic hornblende, *6.* Magnetite-ilmenite *(6a)* and limonite *(6b)*, *7.* Apatite, *8.* Biotite *(8a)*, chloritized biotite *(8b)* and chlorite *(8c)*, *9.* Tourmaline, *10.* Rutile, *11.* Hornblende, *12.* Garnet, *13.* Weathered minerals

Accordingly, on the basis of the heavy mineral composition, the material of the Upper Pannonian formation derives from a slightly metamorphosed source area or it has originated from the redeposition of chlorite-rich sediments.

2. From the *Upper Pliocene (Levantine)* formation, 13 samples have been analyzed for heavy mineral composition. A substantial change with regard to the Upper Pannonian formation can be observed. In the Levantine formation there appear a greater number of minerals as compared to those observed in the Pannonian. This is warranted by the diagram of *Fig. 2* showing essentially more mineral variants.

TABLE I.

Mineral comoposititon of the Upper Pannonian, Upper Pliocene (Levantine) and Pleistocene sands of the Jászladány borehole

Number	Depth m	Hypersthene	Other rhombic pyroxenes	Augite	Diopside	Basaltic-Hornblende	Magnetite—Ilmenite	Apatite	Zircon	Biotite	Chloritized Biotite	Chlorite	Tourmaline	Epidote	Zoizite	Rutile	Hornblende	Actinolite—Tremolite	Garnet	Staurolite	Kyanite	Glaukophane	Calcite-dolomite	Clastic carbonate	Limonite	Pyrite	Other micas	Weathered minerale	Total quantity minerals in the examined fraction	Quartz	Plagioklase	K-felspar	Quartz—felspar ratio	Plagioklase — K-felspar ratio	Dominant grain diameter mm	Age
		HEAVY MINERALS																												Light minerals						
		Dominantly magmatic minerals										Dominantly metamorphic minerals											Other minerals													
1	32,50— 32,68	5,2	0,7	4,1	0,4	4,5	3,4	3,4	—	1,9	7,9	23,2	2,2	1,5	—	0,7	6,4	1,1	4,9	—	—	—	3,4	—	3,4	3,4	2,2	16,1	1,6	61	28	11	1,56	2,54	0,06—0,1	3 Pleistocene C
2	33,22— 33,51	7,5	2,6	4,5	2,6	2,2	3,7	2,6	0,7	1,1	6,3	15,7	0,7	2,2	0,4	0,7	3,0	1,5	23,5	0,7	0,7	—	1,1	—	2,2	2,6	1,5	9,7	3,2	42	38	20	0,72	1,90	0,06—0,1	
3	44,87— 45,26	1,6	—	1,6	1,0	5,2	2,0	1,0	—	7,8	1,0	47,8	2,0	1,0	—	1,6	0,5	—	10,1	—	0,5	—	1,6	—	1,0	—	0,5	10,4	1,8	65	25	10	1,85	2,50	0,06—0,1	
4	57,71— 58,50	0,9	2,8	3,8	1,4	12,7	2,8	3,8	0,5	3,3	0,5	21,3	3,8	1,4	0,5	0,5	1,9	0,9	15,1	—	1,4	—	2,8	—	5,2	2,8	0,9	9,0	0,6	75	17	8	3,00	2,12	0,06—0,1	
5	60,25— 60,63	0,4	1,6	3,7	2,6	7,0	5,3	2,9	—	2,5	1,6	20,6	2,5	0,8	0,4	0,8	1,6	—	20,2	—	1,2	—	1,2	—	3,3	2,9	2,5	14,4	0,8	63	26	11	1,70	2,36	0,06—0,1	
6	81,65— 82,10	2,9	2,9	0,4	5,3	2,0	7,8	3,7	—	0,8	1,2	11,5	2,0	1,2	—	0,8	2,9	—	30,2	0,4	0,4	0,4	0,8	5,3	2,0	2,0	0,4	12,7	1,2	69	21	10	2,22	2,10	0,06—0,1	
7	97,17— 97,51	1,9	2,2	1,1	0,8	6,3	6,7	3,4	—	1,1	5,6	28,0	2,6	2,6	1,5	1,5	1,9	—	11,2	—	—	—	1,9	2,6	4,1	2,6	1,1	9,3	0,5	63	23	14	1,70	1,64	0,1 —0,2	
8	122,62—122,70	3,3	3,3	2,6	3,7	5,9	10,3	7,0	—	2,6	—	10,0	3,3	1,8	1,8	0,7	1,1	0,7	19,4	—	1,1	—	2,6	0,7	1,5	5,6	0,7	10,3	0,5	69	18	13	2,22	1,38	0,06—0,1	
9	130,87—131,40	0,6	—	—	0,6	—	—	0,6	—	8,1	32,6	30,3	—	1,1	—	0,6	—	—	0,6	—	—	—	0,6	—	18,3	—	1,1	4,9	1,6	47	33	20	0,88	1,65	0,06—0,1	B
10	165,50—166,50	—	0,5	—	—	1,5	8,1	2,5	—	1,0	14,1	28,9	1,0	0,5	0,5	0,5	2,5	—	2,0	—	—	—	—	—	19,7	0,5	3,6	12,6	1,0	63	24	13	2,62	1,84	0,1 —0,2	
11	167,26—168,06	0,9	—	0,5	—	—	1,7	—	—	1,7	10,7	27,9	—	—	—	—	0,5	—	0,9	—	—	—	0,5	—	39,8	—	0,5	14,4	0,4	56	28	16	1,27	1,75	0,06—0,1	
12	178,73—178,83	—	—	—	—	—	—	1,3	—	8,6	63,6	25,8	—	—	—	—	0,7	—	—	—	—	—	0,7	—	—	—	7,3	2,0	2,1	45	32	23	0,81	1,39	0,06—0,1	
13	179,16—179,25	—	—	—	—	—	—	—	—	5,2	71,6	16,5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4,5	2,2	2,4	49	31	20	0,96	1,55	0,06—0,1	
14	191,20—191,57	0,7	1,5	1,6	1,1	1,1	3,3	4,1	—	2,2	15,9	19,1	1,1	—	1,1	0,7	1,6	—	6,7	—	0,7	0,7	—	—	8,9	0,7	4,8	21,6	0,1	56	18	26	1,27	0,69	0,06—0,1	A
15	202,18—303,40	0,7	3,3	1,5	1,8	0,4	11,0	1,8	—	0,7	5,1	13,6	2,9	0,7	0,7	0,7	1,1	—	11,0	—	—	0,7	—	—	16,5	0,4	2,2	23,5	0,4	63	19	18	1,70	1,05	0,06—0,1	
16	245,00—245,50	—	—	—	0,8	—	—	—	—	—	60,3	19,8	—	0,8	—	—	1,6	—	2,4	—	0,8	—	—	0,8	—	—	2,4	10,3	0,5	57	25	18	1,32	1,38	0,06—0,1	
17	272,50—273,06	1,0	2,0	1,0	0,7	2,4	9,9	1,5	—	—	25,6	15,3	2,0	0,7	0,4	0,7	2,7	1,0	8,2	—	—	0,4	—	—	6,1	—	4,8	13,6	0,9	59	20	21	1,43	0,95	0,1 —0,2	
18	287,82—287,98	1,6	3,3	0,3	0,7	1,3	5,2	6,5	—	1,0	1,3	17,6	3,3	2,6	—	2,9	9,4	0t7	15,5	—	0,3	0,7	0,3	—	5,9	—	1,3	18,3	0,3	54	36	10	1,17	3,60	0,1	
19	290,82—291,16	1,0	2,9	0,7	2,6	1,3	8,5	2,0	—	0,3	6,2	15,0	4,2	1,0	0,3	1,0	4,2	0,3	17,6	—	0,3	1,0	—	—	5,2	0,3	5,6	18,5	0,2	70	19	11	2,33	1,72	0,1	
20	299,58—299,69	0,4	0,9	1,3	0,9	—	5,8	2,7	0,4	1,8	30,1	11,5	0,4	0,4	0,9	0,9	0,4	—	6,6	—	—	—	0,4	—	11,0	—	3,1	18,1	0,3	59	19	22	1,43	0,86	0,1	
21	317,00—317,31	0,7	0,7	0,7	—	—	8,8	1,6	—	0,3	11,4	17,7	1,6	—	0,3	0,3	0,3	0,3	10,7	—	—	—	—	—	20,8	—	3,6	20,2	0,6	67	8	25	2,03	0,53	0,1	
22	324,50—325,10	0,7	1,8	0,4	0,7	0,7	5,6	2,1	1,1	1,4	7,7	31,3	5,6	0,4	—	4,6	2,1	0,4	11,2	—	—	1,1	0,4	—	7,0	—	4,2	9,5	0,2	55	37	8	1,22	4,62	0,1	
23	332,32—333,16	—	4,4	0,4	3,0	—	—	2,2	—	6,3	5,2	36,5	0,7	0,7	1,1	0,4	7,0	4,4	4,1	—	1,5	—	1,8	—	1,1	—	6,3	12,9	1,3	45	34	21	0,81	1,61	0,1	
24	353,47—353,80	1,6	6,3	1,6	2,3	0,4	2,7	3,1	—	—	—	5,1	2,0	0,4	0,4	3,9	3,1	0,4	21,7	—	—	1,2	—	—	16,4	—	2,0	25,4	0,4	73	17	10	2,70	1,70	0,1	
25	365,14—365,31	—	—	—	—	0,5	—	—	—	2,3	8,8	48,4	—	0,5	—	1,8	2,8	1,8	—	—	—	—	—	—	1,8	9,2	3,2	18,9	1,3	47	46	7	0,88	6,57	0,06	
26	389,02—389,37	0,6	—	—	—	7,2	—	0,6	—	—	—	5,0	1,7	—	0,6	1,1	1.1	0,6	3,9	—	—	—	—	55,0	7,0	—	—	15,6	0,9	74	15	11	2,96	1,36	0,1 —0,2	
27	395,14—395,96	0,7	5,5	1,1	2,9	—	—	1,5	0,4	0,4	1,1	29,0	0,4	0,4	0,4	—	9,6	1,8	6,6	—	2,6	—	4,0	3,7	2,2	9,6	4,0	12,1	0,8	53	17	30	1,12	0,56	0,1	
28	410,50—414,17	0,7	17,0	2,1	9,0	—	—	1,7	0,7	—	—	12,5	1,0	3,1	1,0	0,3	2,4	0,7	12,8	0,7	2,1	—	0,7	—	6,9	2,1	4,2	18,0	0,7	39	32	29	0,64	1,10	0,1	
29	417,74—418,48	0,8	1,7	—	1,3	0,8	0,8	0,8	—	0,4	0,8	41,8	—	0,4	0,4	—	1,3	—	1,3	0,4	0,8	—	18,5	5,5	0,8	7,4	5,0	8,0	3,1	52	24	24	1,08	1,00	0,1	
30	428,00—428,86	—	2,4	—	2,6	0,9	0,9	2,0	—	—	0,9	40,1	1,6	1,6	1,2	1,2	1,6	0,9	2,4	—	0,9	—	5,3	0,9	1,2	8,9	13,0	10,1	0,3	47	36	17	1,30	2,11	0,06—0,1	
31	438,50—438,60	2,0	5,6	1,2	1,2	—	5,2	—	—	—	1,2	4,4	5,2	0,4	0,4	1,6	0,4	—	9,6	0,8	0,4	0,8	1,2	2,8	44,4	2,4	1,6	7,2	0,2	62	26	12	1,63	2,16	0,1	2 Upper Pliocene (Levantine)
32	443,81—444,21	0,7	5,2	2,6	1,9	0,4	2,6	0,7	—	0,4	—	4,1	7,4	0,4	0,4	5,9	—	—	15,2	0,4	—	1,5	0,7	—	14,5	2,6	1.1	31,3	0,3	75	14	11	3,00	1,27	0,06—0,1	
33	449,42—450,42	0,7	5,9	0,7	3,1	—	8,0	1,4	—	—	—	2,4	8,3	—	—	5,9	0,4	—	17,3	0,4	0,4	0,7	—	—	11,0	—	1,4	32,0	0,5	74	15	11	2,96	1,36	0,1 —0,2	
34	491,65—492,45	1,0	4,6	1,3	2,6	—	3,3	1,0	0,3	—	0,7	1,0	7,6	0,7	1,3	5,6	—	—	19,5	—	0,7	—	—	—	10,3	—	2,6	35,9	0,1	75	16	9	3,00	1,77	0,1	
35	567,50—567,70	1,7	7,0	—	2,2	0,4	0,4	—	—	—	—	1,7	6,5	0,9	—	8,7	—	—	14,3	—	—	—	—	—	6,5	—	1,3	48,8	0,2	57	33	10	1,32	3,30	0,1	
36	613,35—614,70	1,7	10,1	5,0	3,4	—	14,0	2,1	—	—	—	—	3,4	1,7	0,4	2,1	—	—	31,2	—	0,8	—	—	—	4,2	—	—	19,9	1,4	56	26	18	1,27	1,44	0,1	
37	616,00—617,50	0,8	10,0	5,0	2,5	—	10,2	2,5	0,4	0,4	—	3,3	5,0	2,1	0,8	1,7	—	—	25,5	1,3	2,5	—	0,4	—	4,6	—	—	21,0	2,2	68	23	9	2,12	2,55	0,2 —0,5	
38	664,97—665,37	0,8	17,2	4,3	5,5	—	6,3	1,2	1,2	—	—	4,7	5,5	4,7	0,4	1,6	—	0,4	16,0	2,0	0,8	—	—	—	2,4	—	—	26,0	0,6	63	20	13	1,90	1,53	0,06—0,1	
39	670,70—671,63	1,6	15,1	1,2	3,7	—	12,0	3,7	0,5	—	—	5,3	2,9	2,5	—	2,0	—	—	25,0	0,5	2,5	—	—	—	—	—	0,5	21,0	2,0	69	24	7	2,22	3,42	0,1 —0,2	
40	678,66—679,01	1,9	16,3	3,1	9,0	—	15,1	4,7	0,4	—	—	3,1	1,9	—	0,4	1,6	—	—	17,4	—	1,2	—	—	—	—	—	1,2	22,7	0,9	69	26	9	1,97	2,88	0,06—0,1	
41	715,40—718,70	2,8	9,8	1,2	4,5	—	8,5	2,8	0,8	—	0,4	3,3	2,4	2,0	—	1,2	2,8	—	32,1	0,4	1,2	—	—	—	1,2	—	1,2	21,4	1,1	61	29	10	1,56	2,90	0,1 —0,2	
42	740,40—741,40	1,9	5,2	2,2	1,9	—	5,6	2,2	0,4	—	0,4	25,0	2,6	1,5	—	1,5	5,6	1,1	19,6	0,4	—	—	0,4	—	—	0,7	1,5	20,1	5,0	58	28	14	1,38	2,00	0,06—0,1	1 Upper Pannonian
43	750,60—750,88	—	0,7	—	0,7	—	—	0,7	—	—	—	66,9	0,7	—	—	—	—	—	0,7	—	—	—	2,9	—	14,0	—	—	12,7	0,9	57	31	12	1,32	2,58	0,06	
44	759,75—759,95	—	3,1	0,5	0,5	—	—	—	—	1,0	—	45,8	1,0	—	—	—	2,1	0,5	4,7	—	0,5	—	3,6	—	—	18,8	2,7	15,3	1,7	52	32	16	1,36	2,00	0,1 —0,2	
45	773,30—773,95	—	1,4	—	—	—	0,7	—	—	2,0	8,8	64,6	—	—	—	—	0,7	—	1,4	—	—	—	0,7	—	—	0,7	6,8	12,2	2,1	46	29	25	0,71	1,16	0,06—0,1	
46	777,00—778,00	—	1,9	—	0,9	—	—	—	—	2,8	—	83,3	0,9	—	—	—	2,8	—	0,9	—	0,9	—	—	—	—	0,9	0,9	2,8	2,4	70	8	22	2,33	0,36	0,1 —0,2	
47	889,56—889,75	0,8	1,8	—	1,8	—	2,7	4,9	—	1,3	4,0	35,4	1,3	0,4	0,4	0,4	—	—	5,3	—	—	—	11,1	—	—	4,0	1,8	22,6	0,3	40	41	19	0,66	2,15	0,06	
48	915,12—915,55	—	0,8	—	—	—	—	0,8	—	5,0	3,3	72,5	—	0,8	—	—	—	—	0,8	—	2,5	—	—	—	—	—	—	13,5	0,5	51	37	12	1,04	3,08	0,06	

Outnumbering the 6 minerals or mineral groups of the Pannonian, the mineral groups occurring in the Levantine are already 11 in number. One of the most remarkable changes of the Levantine formation with regard to the Upper Pannonian consists just in the fact that chlorite decreases greatly, being reduced to just a few per cent in contrast with the figure of about 60% in the former case.

Considerable role is played in the Levantine formation by the other rhombic pyroxenes (predominantly bronzite) and magnetite-ilmenite and limonite. The appearance of these minerals in the formation indicates that the source must have included a magmatic area. The presence of a volcanic mountain (Mátra) in the marginal zone was a guarantee for such a magmatic supply still in Levantine time *(Fig. 1)*.

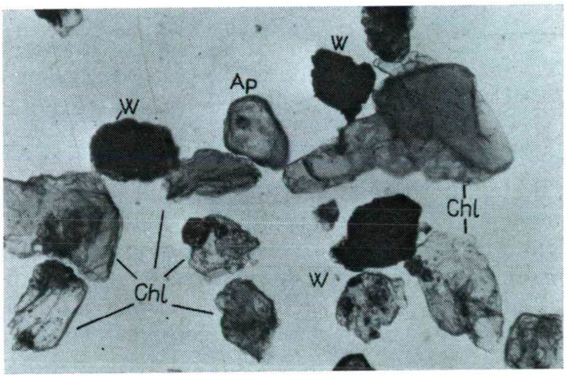

Fig. 3. Heavy minerals of Upper Pannonian sands from 889,5 to 889,7 m of the Jászladány drilling profile H: Hypersthene, OP: Other ortho-rhombic pyroxenes, BH: Basaltic hornblende, AP: Apatite, ChB: Chloritized biotite, Chl: Chlorite, T: Tourmaline, A—T: Actinolite-tremolite, Ho: Hornblende G: Garnet, Ky: Kyanite, Clc: Clastic carbonate, W: Weathered minerals. The photographs were made under mineralogical microscope in plane-polarized light with the minerals mounted in Canada balsam. Magnification: 80 to 100 x.

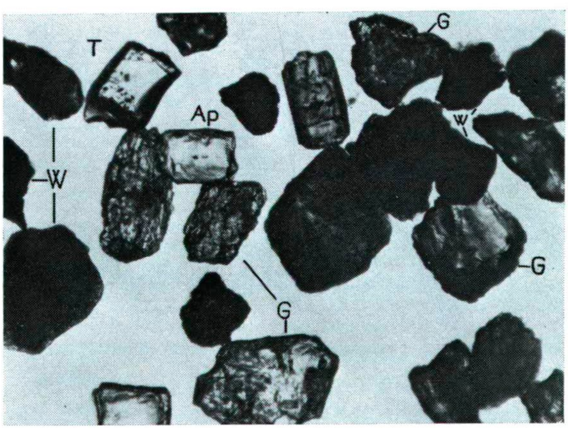

Fig. 4. Heavy minerals of the Upper Pliocene (Levantine) sands deriving from the 613,35 to 614,70 m interval of the Jászladány drilling (For explanation, see *Fig.3*)

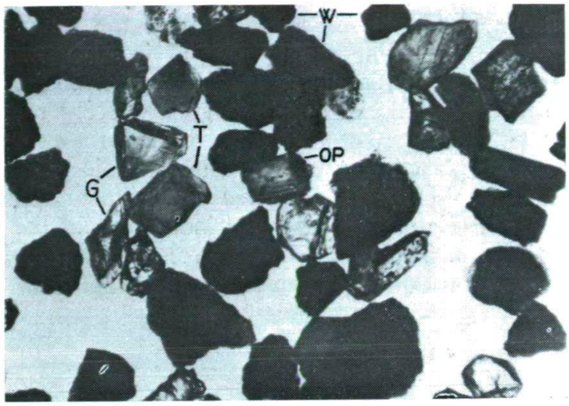

Fig. 5. Heavy minerals of the Upper Pliocene (Levantine) sands deriving from the 443,8 to 442,2 m interval of the Jászladány drilling (For explanation, see *Fig. 3*)

Interesting is the relatively high quantity of rutile which may indicate, unlike the previous magmatic minerals (suggestive of a magmatic source area), the influence of the Slovak Metalliferous Mountains constituted by metamorphic schists and containing some rutile; eventually, the pegmatitic supply of the Mátra Mts. of volcanic origin may also have contributed to the accumulation of rutile. It is here that the quantity of the weathered minerals is the highest in the entire drilling log.

Examples for the heavy mineral composition of the Levantine formation are shown by *Fig. 4.* and *Fig. 5.* It is striking in both, that, in contrast with the monotonous Upper Pannonian, predominantly chloritic, of *Fig. 3*, the representatives of chlorite almost completely lack here. In *Fig. 4*, tourmaline, apatite, garnet and weathered minerals appear. *Fig. 5* shows minerals similar to the former as well as other representatives of pyroxene.

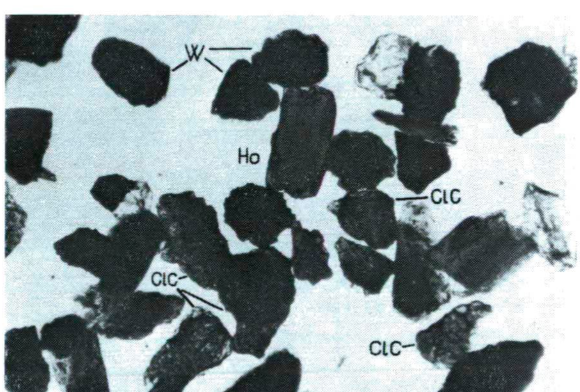

Fig. 6. Heavy minerals of the Pleistocene sands of Horizon *3A* from the 417,7 to 418,1 m interval of the Jászladány drilling (For explanation, see *Fig. 3*).

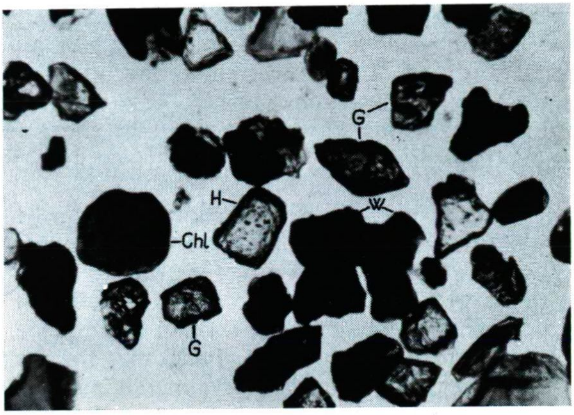

Fig. 7. Heavy minerals of the Pleistocene sands of Horizon *3A* from the 324,5 to 325,1 m interval of the Jászladány drilling (For explanation, see *Fig. 3*)

On the basis of the above let us conclude that the Levantine formation differs from the Upper Pannonian one and that its source area must have included both a metamorphic zone (with a possible redeposition of chlorite-rich sediments) and a magmatic one.

3. The greatest number of analyzed samples, about 30, have been recovered from the *Pleistocene* formation. The composition of the Pleistocene formation shows a substantial change as compared to the Levantine. The Upper Pannonian and the Levantine formations cannot be further subdivided on the basis of their heavy mineral composition. Within the Pleistocene formation, however, three horizons of different heavy mineral composition can be distinguished. In Table 1 and *Fig. 2*, these are indicated as *3 A*, *B*, *C*.

3 A. Within the Pleistocene formation the first heavy mineral horizon can be found in the 191 to 428 m interval. The heavy minerals of this horizon differ from those of the Levantine formation by the lower quantity of magmatic and weathered minerals and garnet in it *(Fig. 2)*. The percentages of common hornblende and chlorite, however, are somewhat higher.

Remarkably enough, the quantity of carbonates, particularly so of detrital carbonate, shows a considerable increase in the lower part of the horizon *(Fig. 6)*

Out of the 13 minerals represented in *Fig. 2*, nine occur in a quantity higher than 1%. Accordingly, the number of such minerals is only a little lower than in the previous horizon. Therefore this horizon too can be said to be rather diversified, as evidenced by the diagram of the sand sample recovered from this horizon, in which chlorite, garnet and weathered minerals are represented *(Fig. 7)*.

On the basis of the heavy mineral composition the material of the horizon derives from sources of mixed genesis.

3 B. The second horizon within the Pleistocene formation, 130 to 179 m interval, shows a composition much simpler than the former. In *Fig. 2* only three mineral groups figure in this horizon. With this low number of minerals the horizon of poorest heavy mineral content of the entire drilling log can be identified. Of the three mineral groups, striking is the quantity, nearly 70%, of biotite, chloritized biotite and chlorite.

The high percentage of chloritized biotite is conspicuous. It is a matter of common knowledge, that in igneous rocks the biotite can be altered into chlorite as a result of autohydration or of hydrothermal action and also in the course of weathering. The chloritized biotites occurring here seem to derive from this kind of alteration. These mineral grains show partly still the characteristics of biotite, partly already those of chlorite. Accordingly, their alteration has not yet been completed.

The presence of a very simple mineral composition consisting of just a few minerals is shown by *Fig. 8*. The light-coloured minerals in the diagram are chlorites, the dark ones are predominantly chloritized biotites.

The source of this horizon seems to have been for the most part a magmatic area, though a redeposition is highly probable to have taken place. The composition shows many features akin to those of the Upper Pannonian formations. For instance, a common characteristic is the low number of minerals and the high quantity of chlorite. The difference between the two consists mainly in that the Upper Pannonian sediments are much less poorer in chloritized biotite.

3 C. Between 0,0 and 122 m the third Pleistocene heavy mineral horizon can be found. This horizon is more diversified in composition than all the preceding ones, differring very markedly from the underlying sequence *(Fig. 9, 10)*. This is indicated by the 12 minerals and groups of minerals shown in *Fig. 2.* as well.

The alluvium of the contemporary rivers of the Great Hungarian Plain are well known from earlier investigations. In the Great Hungarian Plain the composition of the sediments of the rivers is well differentiated from the composition of the foot-wall [B. MOLNÁR, 1964].

The difference in the heavy mineral composition between the alluvium of the present-day rivers and their foot-wall is indicated by a distinct boundary occurring at different depth, but available everywhere. This boundary appears everywhere, so at Jászladány as well, below, though close to, the *Viviparus böckhi* Horizon distinguished by M. KRETZOI and E. KROLOPP [1972]. A comparison of the composition of the uppermost mineral horizon of Pleistocene age at Jászladány with the alluvium of the present-day rivers allows one to conclude that the Jászladány horizon was deposited by the Zagyva river [B. MOLNÁR, 1964].

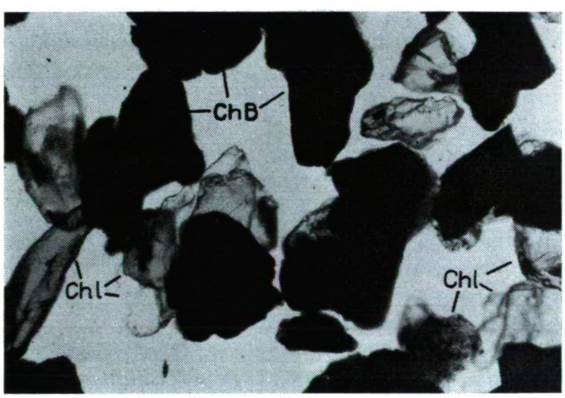

Fig. 8. Heavy minerals of the Pleistocene sands of Horizon *3B* from the 178, 7 to 178, 8 m interval of the Jászladány drilling (For explanation, see *Fig. 3*)

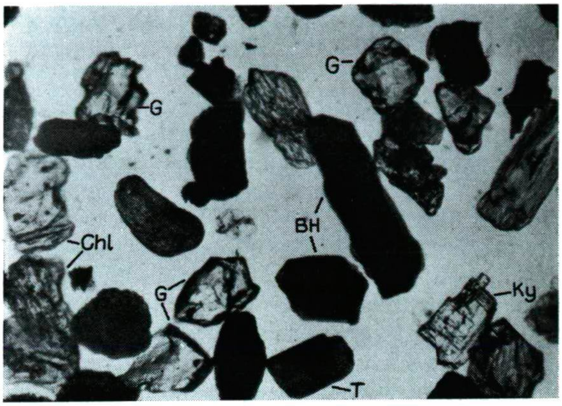

Fig. 9. Heavy minerals of the Pleistocene sands of Horizon *3C* from the 122,6 to 122,7 m interval of the Jászladány drilling (For explanations, see *Fig. 3*)

This composition is also characterized by the lower hypersthene, augite and basaltic amphibole content of the sediment as compared to the alluvium of most of the tributaries of the Tisza river. However, the percentage of garnet, magnetite and limonite is higher in it.

This third Pleistocene horizon of diversified heavy mineral composition resembles to the Levantine sequenc which differs from it primarily by the higher quantity of rhombic pyroxene (bronzite).

Analyses of the light fraction

The changes in source area observed as a result of heavy mineral analyses are also reflected by the quantitative and qualitative changes of the light minerals. Therefore analyses of the light fraction have been examined and grouped according to the depth intervals of the five different horizons.

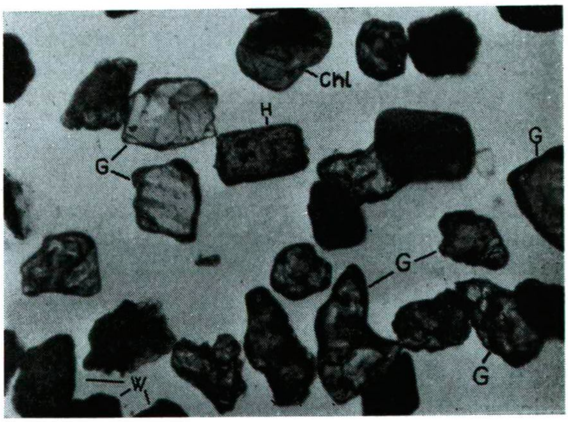

Fig. 10. Heavy minerals of the Pleistocene sands of Horizon *3C* from the 33,2 to 33,5 m interval of the Jászladány drilling (For explanation, see *Fig. 3*)

The samples were examined first macroscopically, with the aid of a stereo-binocular, then of a petrographic, microscope. The results can be summarized as follows:

The light fractions of the *Upper Pannonian* sands are light yellow in colour. In the samples the quartz grains are sharp-edged, splittery and limpid. Many quartz grains contain parallel arranged opaque inclusions: an indication of metamorphic sources. In a few samples they exhibit a very fine impregnation by pyrite. Potash feldspars are predominantly represented by orthoclases. Every sample contains a very high quantity of mica. Most of the micas are represented by muscovite, the smaller fraction by biotite. Chlorite grains are also frequent. Calcite-dolomite and light grey detrital carbonate grains are very great in number.

On the basis of the above, a considerable part of the material can be considered to have derived either from a slightly metamorphosed area or from a source rich in chlorite though previously metamorphic for the most part. The smaller fraction must have been introduced from a magmatic and carbonate rock source into the Jászság Basin.

The light fractions of the *Levantine* sands are light yellow in colour. The grains of the Levantine samples are somewhat less abundant in inclusions as compared to the Upper Pannonian sands. Inclusions, if any, are constituted by bulbs of liquids or gases. Needle-shaped crystals, however, may also occur as inclusions. All these features combined are indicative of a magmatic origin. Plagioclase grains showing polysynthetic twinning bands occur frequently. Potash feldspars are represented by plagioclases. Micas are poor in every sample.

Accordingly, the light fractions in the Levantine sequence differ in character from those of the Upper Pannonian and they indicate magmatic source to have been involved in the origin of the sediment.

The light fractions of the samples belonging to the Sequence *3 A of the Pleistocene* are light grey down to 317 m at the bottom. Above this level an alternation of light yellow and light grey sand layers can be observed. The grains in the light yellow sands are partly coated by finely distributed iron hydroxide. This coating is responsible for their yellow colour. The sand grains are sharp-edged, splittery and dull on their surface.

The quartz grains contain parallel arranged opaque inclusions, crystal inclusions being also frequent. Accordingly, the quartz grains partly suggest a metamorphic, partly a magmatic origin. Feldspars are represented predominantly by orthoclases. Among the plagioclases there are polysynthetic twins. The mica content is in all samples higher than was in the Levantine samples. The micas are represented predominantly by muscovite and biotite. Detrital carbonates and calcite-dolomite attain again considerable quantity. Most of the detrital carbonates are here, unlike the previously mentioned light grey ones, light yellow. In the yellow sands above the 317 m level the quantity of detrital carbonate and calcite-dolomite is somewhat lower than at the depths belonging to the Sequence *3 A* underneath.

Similarly to the heavy minerals, the character of the light minerals also indicates a source area of mixed genesis.

The light fractions of the samples belonging to the Sequence *3 B of the Pleistocene* are light yellow. The grains of the samples are partly coated. The quartz grains are sharp-edged, splittery and dull-surfaced. Many quartz grains contain opaque inclusions arranged in parallel. Like the former ones, the potash feldspars are represented by orthoclases. The mica content of the samples is mean. Detrital carbonate and calcite-dolomite are seldom present in them.

Accordingly, the source area of the sediment seems to have been of mixed genesis in this case, too.

Out of the samples belonging to *Pleistocene 3 C*, the sample deriving from 97 m is light yellow, the rest being light grey. The quartz grains are for the most part sharp-edged, splittery, but, unlike in the previous cases, rounded to well-rounded wind-blown sand grains occur frequently here. The quartz grains contain liquid, gas and crystal inclusions. The potash feldspars are predominantly orthoclses.

Muscovite, biotite and chlorite are poor in the samples, the same may be said of detrital carbonate and calcite-dolomite as well.

The sequence belonging to *3 C* had the same source as the present-day Zagyva river.

Next to do was to determine under stereomicroscope the *percentage distribution of quartz*, plagioclase and potash feldspar as found within the 0,1 to 0,2 mm fraction of the sand samples painted in slides by the Bailey—Stevens techniques (Table 1). Beside absolute percentage values the quartz-to-feldspar ratio and the plagioclase-to-potash feldspar ratio have also been calculated (*Fig. 11*, Table 2).

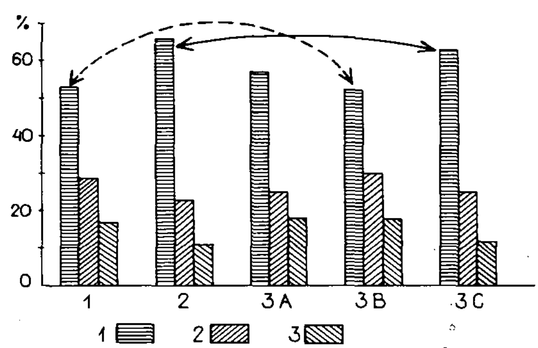

Fig. 11. Percentages of quartz and feldspar from the horizons of different heavy mineral composition of the Jászladány drilling profile

For explanations of *1*, *2*, *3A*, *3B*, and *3C*, see *Fig. 2*.

1. Quartz, *2*. Plagioclase, *3*. Potash feldspar. The arrows indicate the horizons of similar composition.

As evident from *Fig. 11*, quartz attains the highest value in the Levantine (66%) and the Pleistocene *3 C* sequence (63%). The lowest amount is found on its turn in the Upper Pannonian (53%), showing an affinity in terms of heavy mineral composition as well, and in the Pleistocene *3 B* horizon, second as counted from the base and very poor in heavy minerals (52%). In *Fig. 11*, the sequences showing affinity in terms of heavy mineral composition are connected by arrows.

According to *Fig. 11*, the affinity between the individual sequences is confirmed by both the subidentical percentage figures of quartz and the similar quantities of plagioclase and potash feldspar.

Alone the composition of the lowermost Pleistocene sequence (*3 A*) is different from all the others. It seems that the time of deposition of this very sequence was the period when the source area was the most diversified within the entire Pliocene and Pleistocene of Jászladány. It is in this area that the transported sediments, wich both earlier and later derived only from one or the other of the areas, got mixed up. This is also suggested by the fact that the highest fluctuations in mineralogical composition of the entire sequence occur exactly here.

TABLE 2

Quartz-to-feldspar and plagioclase-to-potash feldspar ratios of sequences of different age in a borehole at Jászladány

Age and symbol of borehole		Quartz/feldspar ratio	Plagioclase/potash feldspar ratio
3 C	Pleistocene	1,70	2,08
3 B		1,08	1,67
3 A		1,33	1,39
2 Levantine		1,94	2,09
1 Upper Pannonian		1,14	1,77

The *average of the quartz-to-feldspar ratio,* grouped according to the five mineralogical horizons so far distinguished, are shown in Table 2. These values have been calculated from the data of Table 1. For instance, in the Upper Pannonian sequence the average of quartz as found in the seven samples examined is 53%.In the same sapmles the figure obtained for the two feldspar groups combined is 47%. The average of quartz has been divided by the average of the feldspars and so the value 1,14 characteristic of the Upper Pannonian was obtained. The ratios were calculated in the same way for the other sequences as well.

As evident from the results, the quartz-to-feldspar ratio markedly increases from the Upper Pannonian towards the Levantine, from 1,14 to 1,94; then, from there on, it shows again a marked decrease up to the Pleistocene *3 B* sequence (1,08). Finally, it attains the figure of 1,70 in Horizon *3 C.* It can be concluded from the results that in the Jászladány profile the least mature horizons are the Upper Pannonian and Pleistocene *3 B,* the most mature ones being the Levantine and Pleistocene *3 C.*

These data, however, are of relative value and are instructive only if related one to another. Namely, the high feldspar percentage of the sequence evidences that the absolute maturity of the sequence is still very low which is partly due to its relatively young geological age.

The similarity of the sequences showing up an affinity on the basis of the variation of the heavy mineral composition and of the quantity of quartz is confirmed by the similarity of the quartz-to-feldspar ratios.

The ratio of plagioclase to potash feldspar has also been calculated (Table 2). These values increase from the Upper Pannonian (1.77) towards the Levantine (2.09), to decrease then again up to Pleistocene *3 A* and attain, with 1,39, the lowest figure just there. This means that the difference between plagioclase and potash feldspar contents is the lowest in Horizon *3 A.*

Since potash feldspar too attains its maximum, beside *3 B*, here in *3 A*, this material or at least a considerable part of it derives from a somewhat more acid source. The same holds true of *3 B*.

The value of the plagioclase-to-potash feldspar ratio increases again from Pleistocene *3 A* to *3 C* (to 2,08).

EVALUATION OF CHANGES IN SOURCE AREA IN THE JÁSZSÁG BASIN

North of the Jászság Basin the Mátra Mountains still existing today and consisting predominantly of andesites were already present in Pliocene and Quaternary times. To the north of the mountains lay the Slovak Metalliferous Mountains including crystalline schists in their composition *(Fig. 1)*. To the east of the Slovak Metalliferous Mountains are the Gömörides containing considerable masses of carbonate rocks.

In the Pliocene and Quaternary this geological environment controlled the mineralogical and petrographic composition of the sediment that was being introduced into the Jászság Basin. In the Late Pannonian there was still a shallow-water lake in the territory of the Jászság Basin, but from the Late Pliocene (Levantine) on it was already characterized by terrestrial accumulation. As far as the conditions and characteristics of the accumulation taken place under such geological conditions are concerned, the following can be said.

The entire sequence examined is characterized, as compared to the composition of the other geological profiles of similar age of the Great Hungarian Plain, by the fact that the fluctuations in the percentages of the minerals occurring within single intervals of sediment of similar composition are here higher than elsewhere. This may be due to both the proximity of the basin margin and to rapid local changes of minor rivers.

The Jászladány profile is characterized by the fact that the biostratigraphic boundaries in it are at the same time boundaries of changes in mineralogical composition. So there is a marked change in source area at the Upper Pannonian-Levantine and the Levantine-Pleistocene boundaries. The Upper Pannonian and Levantine sequences cannot be further subdivided on the basis of the mineralogical composition. The Pleistocene sedimentary sequence includes further three horizons readily distinguishable from one another in terms of mineralogical composition.

The Upper Pannonian sequence shows a very monotonous composition. Its material derives either from a slightly metamorphosed source or from the redeposition of a chlorite-rich sediment. The influence of the near-by volcanic mountain is not reflected in it at all. This may be due to several causes. On the one hand, such of the volcanic area was then still covered by water so that little material could be transported from there into the Jászság Basin; on the other hand, the magmatic minerals could be lost from the sediment during weathering and diagenesis.

In Levantine time a paleogeographic change took place as compared to the earlier conditions. In the sequence there appear magmatic minerals along with metamorphic ones. Accordingly, the erosional area must have changed in the meantime. The removal of the sediment may also have been accelerated which prevented the minerals from any rapid weathering.

In the Levantine period the crystalline area of the Slovak Metalliferous Mountains contributed at an increasing rate to playing the role of sources, as evidenced by the relatively higher quantity of rutile *(Fig. 1)*.

From the Upper Pannonian Substage towards the Pleistocene the Pannonian shallow-water lake-sea was filled up, as shown for the Jászság Basin area, and in the Pleistocene it could witness only fluviatile sedimentation. It is the consequence of this paleogeographic change that the Pleistocene sedimentary sequence is not uniform in mineralogical composition, being split up into three parts. Accordingly, the source area must have thrice witnessed considerable paleogeographic changes. These were manifested on the basin margins by the appearance of rivers supplied by new source areas, in the Jászság Basin by the deposition of sediments of different mineralogical composition reflecting the corresponding change in the environment.

At the beginning of the Pleistocene (Horizon *3 A*) the rivers had partly still the ancient, partly by new, sources. Skirting the Mátra Mountains in the west and east, the rivers could have reached the Gömörides and the Bükk Mountains in the northwest and bring from those areas the considerable carbonate material of Horizon *3 A*. The afore-mentioned paleogeographic changes may have been responsible for the fact that Horizon *3 A* does not show a relationship with any other horizons.

The source area of Horizon *3 B* was partly simplified as compared to the former, as indicated most eloquently by the few heavy minerals present.

The present-day fluviatile drainage system, with the Zagyva river in its axis, was formed during the deposition of Horizon *C*.

The question that still remains to be answered in the following discussion concerns the difference of the present results from those of I. MIHÁLYI—LÁNYI and the new contribution that may be offered by the present study.

The most striking difference between the two authors' result consists in the percentages of the single minerals as related to one another. This is due, as indicated in introduction, to I. MIHÁLYI—LÁNYI's ignorance of the variation of grain composition in her investigations. In addition, she calculated the percentages of the abundance of the minerals by relying on one hundred determined grains only. Unlike her, the present author analyzed only the composition of small to fine sands and he determined three hundred heavy minerals grains from each sample. It was from these data that he has calculated the percentage of abundance of the single minerals (mineral variants).

The afore-mentioned circumstances are responsible for the further considerable changes as well. For instance, I. MIHÁLYI—LÁNYI supposes within just the Pleistocene interval nine changes to have taken place in the source area in accordance with the major fluctuations she found in mineralogical composition, whereas the present writer has presumed only three.

I. MIHÁLYI—LÁNYI believed much of the sediment below 199 m to have derived from the west, the Danube's drainage area. The mineralogical composition of the Danube's alluvium, however, is readily known from earlier investigations [B. MOLNÁR, 1964]. If these are compared with the present results, no evidence in favour of a western source effect can be found.

The results of the analyses of light minerals did well complement and confirm the analyses of heavy minerals. Similarly to the heavy mineral analyses, or parallel to them, the light mineral analyses also showed the analogies, or the dissimilarities, existing between the individual sedimentary sequences. The ratio of plagioclase to potash feldspar allowed the author to draw certain conclusions as to the petrochemical composition of the source area. Finally, information on the maturity of a sedimentary sequence has been supplied primarily by the light mineral analyses. These all were missing in I. MIHÁLYI—LÁNYI's results.

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