GEOLOGICAL, MINERALOGICAL AND PETROGRAPHICAL INVESTIGATION ON NAGYKŐMÁZSA HILL AT MISKOLCTAPOLCA

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INTRODUCTION

In order to explore the raw material reserves of the Hejőcsaba Cement and Lime Works the Central Research and Design Institute for Silicate Industry carried out detailed geological prospecting on the Nagykőmázsa Hill at Miskolctapolca, in the years 1966—1968.

On the area of study, which joins the actual Nagykőmázsa quarry of the HCM *(Fig. 1)*, detailed mine geological surveying, 24 core drillings of about 1795,5 metres, hydrogeological observations, and complex geophysical measurements have been made (radioactive logging in every borehole). Multilateral and numerous tests have been made on the core samples in order to establish their mineralogical and petrographical composition and their qualification for use in cement and lime industry.

The present paper deals with the principal results of the aforesaid examinations.

GEOLOGICAL CONDITIONS

Geological setting. The Nagykőmázsa Hill at Miskolctapolca consists of Ladinian limestone (total thickness about 700 metres), of predominantly light grey colour, with local patches of rose-colored calcite. *(Fig. 1).* The limestone is exposed on the greatest part of the explored area; at some places; however, it is covered by 0,3—2,5 metres of brown and reddish-brown, silty-clayey loam of Pleistocene age. The latter is thicker at the base of the slopes, growing thinner upwards.

The uniformity of the strongly karsted limestone series is disturbed by clayey contaminations filling up caverns and open rock fissures, with subordinate occurrences of bigger calcite veins and hydrothermal effects. The brown and reddish-brown filling of the karstic cavities, caverns and wider cleavages is identical with the Pleistocene cover in both mineralogical and petrographical respects, so it can be considered as its derivate. The less common flesh-red, sometimes grey clays, on the contrary, are older (Tertiary) residual sediments due to tropical-subtropical weathering.

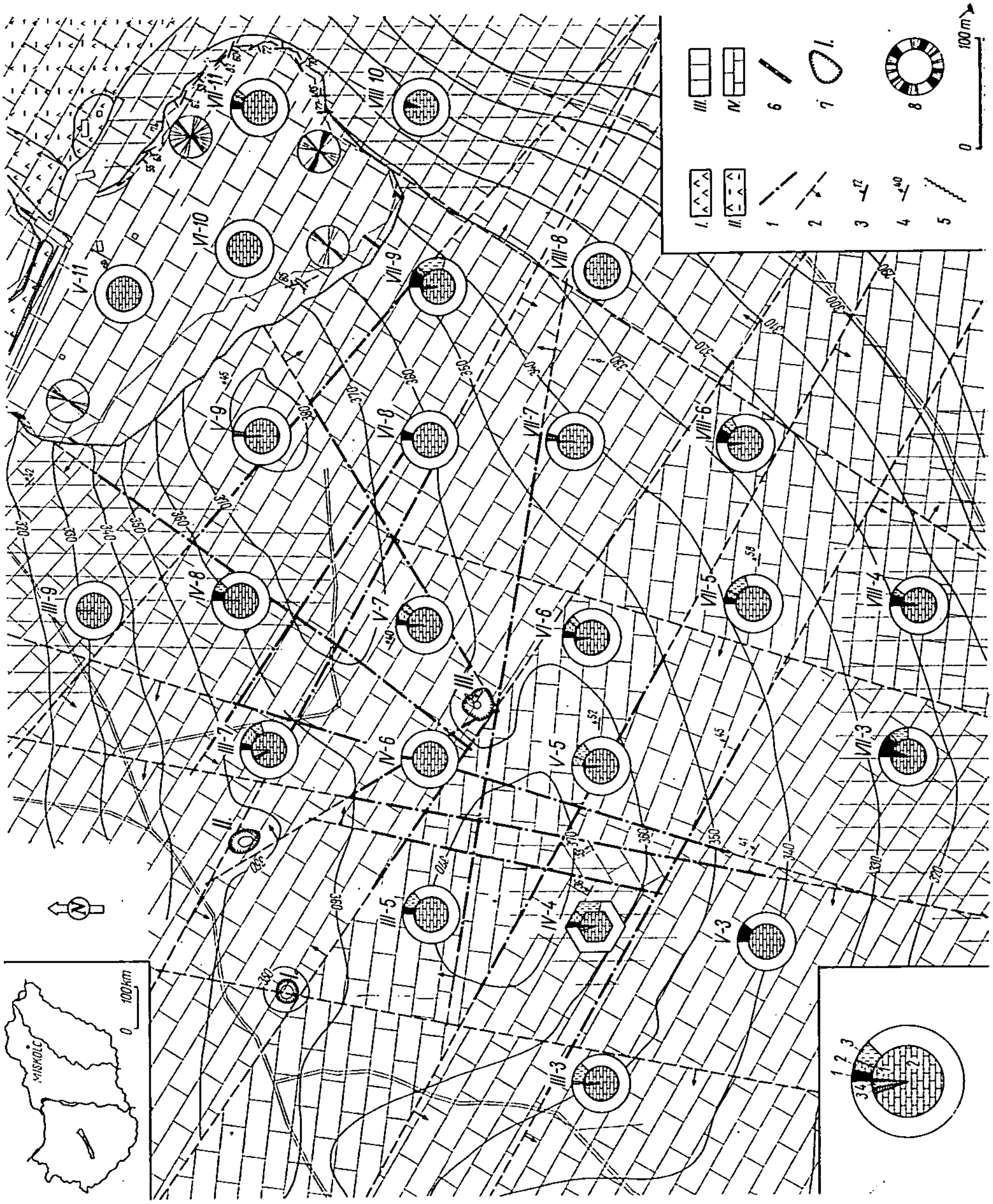


Fig. 1.

Calcite veins and other traces of hydrothermal activity are indicative of a possibly Pleistocene hot spring influence.

Geological structure. Nagykőmázsa Hill and its immediate surroundings belong to the NE wing of the Répáshuta—Hollóstető—Bodzáskút anticline range of the SE Bükk Mountains. The folded forms, brought about by older tectonic movements, have been strongly dismembered by NNE—SSW and perpendicular WNW—SES oriented younger faults; the actual structural pattern is mostly faulted.

The mostly unstratified and very stressed limestone series dips at 45° to the NNE. The lithoclases measured in the quarry strike preferentially WNW—SSE, NNE—SSW and NE—SW. The same is true for the measured smaller faults and for those detected by geophysical measurements. Fault planes dip at an average angle of 70°.

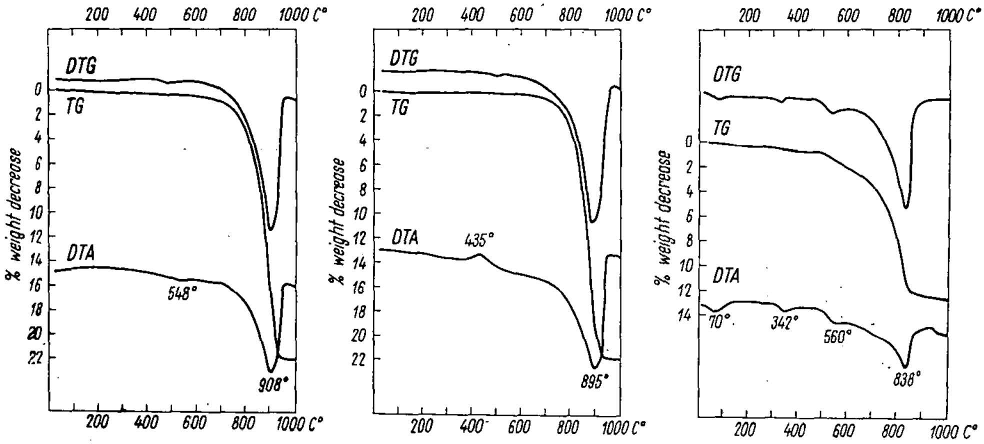


Fig. 2. Derivatogram of the limestone sample with hydrothermal traces from 50,0 depth of borehole V—3.

Fig. 3. Derivatogram of the limestone sample with hydrothermal traces from 239,0 m depth of borehole V—7.

Fig. 4. Derivatogram of the red clay from the fissure of the limestone.

The calcite veins and fissures filled up by clayey material observed in the quarry are oriented approximately NE—SW. Accordingly, open fissures, calcite veins, and clayey contaminations are likely to be oriented similarly, in contrast to the conditions established for the Hungarian Central Mountains.

Fig. 1. Mining geological map of the Nagykőmázsa limestone exploration area. Diagram and legend (bottom left). Inner circle: percentages of the geological formations intersected by drilling from the surface down to 285 metres a. s. l. 1) clay cover, 2) limestone, 3) limestone with clayey contamination. Outer circle: percentages, down to the same level, of 1) cavities, 2) clayey fillings, 3) cataclastic intervals, as detected by radioactive logging. (In borehole represented by a hexagon — to 324 m a. s. l. only.)

Legend (bottom right). I. waste stockpile (Holocene); II. slope debris (Holocene-Pleistocene); III. clay cover (0,3—2,5 m thick). Pleistocene; IV. Limestone (Ladinian), (> 250 metres). 1) fault detected by geoelectric measurement, 2) fault constructed by structural, geoelectrical measurements and geomorphological observations, with the assumed dip; 3) fault dip; 4) stratum dip; 5) calcite vein; 6) fissure filled up by clay; 7) dolina; 8) synthetizing lithoclase diagram.

TABLE I.

Chemical analyses

Symbol of the sample (m)	Name of rock	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	SO_3	$CaCO_3$
		Percent by weight										
Nagykőmázsa V—7/210,0	Limestone	43,60	0,15	0,01	0,03		55,30	0,10	0,27	0,07	0,32	98,76
VI—6/20,0	Limestone with hydrothermal traces	42,55	1,62	0,80	0,44		53,95	0,10	0,22	0,08	0,06	96,30
V—3/50,0	Limestone with hydrothermal traces	43,12	0,75	0,75	0,12		54,39	0,19	0,24	0,09	0,05	97,09
V—7/235,0	Limestone with hydrothermal traces	43,37	0,68	0,11	0,54		54,63	0,09	0,25	0,08	0,08	97,51
limestone quarry	red clay	12,11	44,98	16,73	6,16	1,47	11,15	2,17	0,18	4,80	0,01	19,90
limestone quarry	gray clay	5,79	53,33	20,77	6,96	1,90	2,23	3,00	0,19	6,32	0,08	3,98
overburden	pleistocene clay	9,19	58,04	18,91	7,85		2,23	1,01	0,45	1,53	0,10	3,98
max. and average value analyses from 56 limestone samples	minimum	42,96	0,05	0,01	0,01		54,36	nyom	0,02	0,01	nyom	97,06
	maximum	43,84	0,82	0,31	0,84		55,87	0,65	0,49	0,09	0,32	99,78
	average value	43,51	0,25	0,09	0,08		55,31	0,39	0,22	0,05	0,06	98,78

The faults and fissures of WNW—ESE strike observed in the quarry are closed; consequently, in such direction no hydrothermal alterations, calcite veins or clayey fillings are likely to occur.

MINERALOGICAL AND PETROGRAPHICAL STUDIES

Chemical and thermic examinations. The investigation results of some rock types showing hydrothermal alterations should be presented.

Figs. 2 and *3* show the derivatograms of two limestone samples from different boreholes and depths. The chemical composition of these samples is given in Table *I*, along with the chemical composition of the predominant "pure" limestone of the area. Some orientative spectrographic data are to be found in Table *II*. The extreme and average value of the complete chemical analysis of 56 limestone samples, representative of the entire area, are also represented in Table *I*.

It is obvious from the data of Table *I* that the $CaCO_3$ (calcite) content of the hydrothermally altered rock samples is lower than the average (98%) of the "pure" limestone. The difference is due mainly to the higher percentage of the Fe, Al and Si contaminations. The thermic (derivatographic) and X-ray tests reveal the presence of quartz, clay minerals and pyrite, brought about by the hydrothermal influence.

On the DTG and DTA curves of *Fig.* 2 beside the well developed calcite peak at 900 °C one can observe a quite well marked endothermic effect between 500 and 600 °C. The X-ray diagram of these samples indicates the presence of quartz and kaolinite. The thermic peak suggests that these are only slight traces.

On the DTA curve of *Fig. 3* appears an exothermic peak at 435 °C, due to pyrite oxidation. Accordingly, the iron oxide content of these samples is higher indeed. (According to our experience, such small amounts of pyrite can not be detected by X-ray diffractometry in carbonate rocks.)

In the fissures to be seen in the limestone quarry, there is red (subordinately grey) clay, considered as a product of Tertiary tropical-subtropical karstification. The near-surface cracks are filled up by the brown to reddish brown silty, clayey loam of the Pleistocene cover. For the sake of comparison, the results of the investigations on these are also shown (chemical composition in Table *I*, spectrographic data in Table *II*). According to the thermoanalytic and X-ray tests, the red clay contains illite, kaolinite, quartz, calcite, and gibbsite, the grey one — illite, kaolinite, quartz, calcite, while the Pleistocene clay consists of illite, kaolinite, quartz, feldspar and organic substances. Spectrographic data suggest that both the red and the grey clays have been affected by hydrothermal alteration.

Thin section studies. The genetical characteristics of the Ladinian limestone are well illustrated by the thin section photos (cross-polarized light), *(Photos 1—8)*, photographed and studied by I. Csordás, geologist, Mineralogical and Petrographical Department of the Technical University of Heavy Industries, Miskolc.

The pelitic microspar matrix, characteristic of the limestone studied, is well observable in all thin sections. The tectonically rather affected nature of the area is clearly demonstrated by small nodular or lenticular macrospar

TABLE II.

Informational spectral analyses

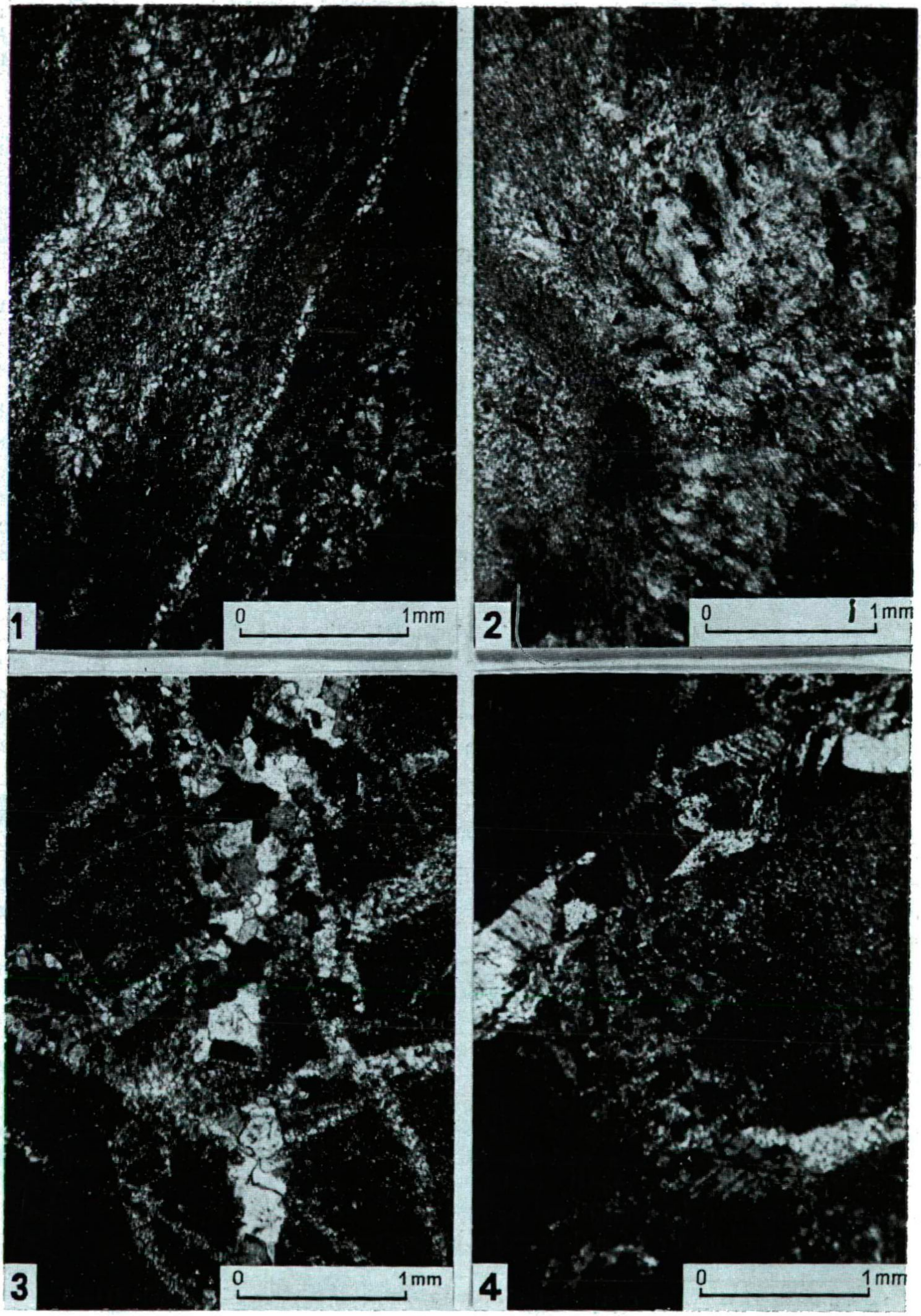
Name of rock	approx. % traceable element				
	10^1	10^0	10^{-1}	10^{-2}	10^{-3}
bore hole V—7. limestone from depth 210,0 m	Ca	Mg	Cu Si	Mn Pb	Sn Fe Al
bore hole VI—6. limestone with hydrothermal traces from depth 20,0 m	Ca	Mg	Fe Si Al Mn Cu		Ni
bore hole V—3. limestone with hydrothermal traces from depth 50,0 m	Ca	Mg	Al Mn Fe Si	Cu	Cu
bore hole V—7. limestone with hydrothermal traces from depth 239,0 m	Ca	Mg	Fe Si Mn Al	Mn Cu	Ni
red clay from fissures of Nagykőmázsa limestone quarry	Si Al	Ca Ti Mg	Fe V K Cr Ni	Na	Co B
gray clay from fissures of Nagykőmázsa limestone quarry	Si Al	Mg Ti Ca	Ni V Cu Cr Fe K Co	Na	Mn B
pleistocene clay Nagykőmázsa	Ca Si Fe	Mg Al Ti V	Mn Cu B	Na Ni	Cr Pb

bodies of subparallel orientation *(Photo 1)*, by folded forms at the boundary between the macro- and the microspar *(Photo 2)*, by the cataclastic texture *(Photo 3)*, and by nodular, medium-grained macrospar with pressure twin lamellae, formed within the predominant pelitic microspar, and affected by dissecting tectonic movements and by formation of a new generation of hydrothermal macrospar with pressure twin lamellae. *Photo 4)*.

Younger tectonic and hydrothermal effects are demonstrated by *Photos 5* to *8*. Such are: several generations of a tectonically controlled vein network *(Photo 5)*, coarse macrospar formed along tectonic lines, of first and second generation, with twin lamellae *(Photo 6)*, second-generation calcite vein crossing the vein network of the first generation, with a third-generation rim *(Photo 7)*, and a microfault *(Photo 8)*.

These thin section photos reflect very well the tectonic pattern observed in this area. The angle of the big fault system *(Fig. 2)* corresponds well to the angles closed by the calcite veins to be observed in thin sections, although the thin sections are not oriented.

Phot. 1. Thin section of the Ladinian limestone from 105,0 m of borehole V—7
Phot. 2. Thin section of the Ladinian limestone from 57,3 m of borehole III—5
Phot. 3. Thin section of the Ladinian limestone from 30,0 m of borehole V—6
Phot. 4. Thin section of the Ladinian limestone from 58,0 m of borehole VII—5



Phot. 1—4.

In conclusion, the hydrothermal activity of probably Pleistocene age, which has affected the Ladinian limestone series of Nagykőmázsa Hill, has produced no considerable alterations. Only traces of the characteristic hydrothermal parageneses have been found.

The clayey contaminations brought about by the hydrothermal activity can be discerned on the basis of the examinations performed from those due to karstification or to other types of weathering.

HYDROGEOLOGY

Hydrogeological sketch. The karsted limestone block of Nagykőmázsa Hill is morphologically well delimited from its surroundings. From the hydrogeological (respectively hydrological) point of view, however, it does not represent an independent unit; it is a part of the Bükk Mountains karst.

Borehole V—7, situated at the very centre of the exploration area, started at a height of 364,83 m a. s. l., taking into account the 122,0 m a. s. l. source level of the cold springs at Miskolctapolca, has been deepened to 250,0 m (114,83 m a. s. l.). It has reached, in fact, tha karst water table, and it has been built out into a water table observation well (design VITUKI). The VITUKI carried out water level measurements every week from February 1968 till December 1968, observing a fluctuation ranging from 124,0 to 130,0 m a. s. l.

The other drillings traversed the descending karst only. Even the deepest point of the exploration area is above the karst water table. So there are no springs at all in this area.

It turned out — according to the results of the connection testing by salt addition — that the karst water of the region is in direct communication with that of the Miskolctapolca springs.

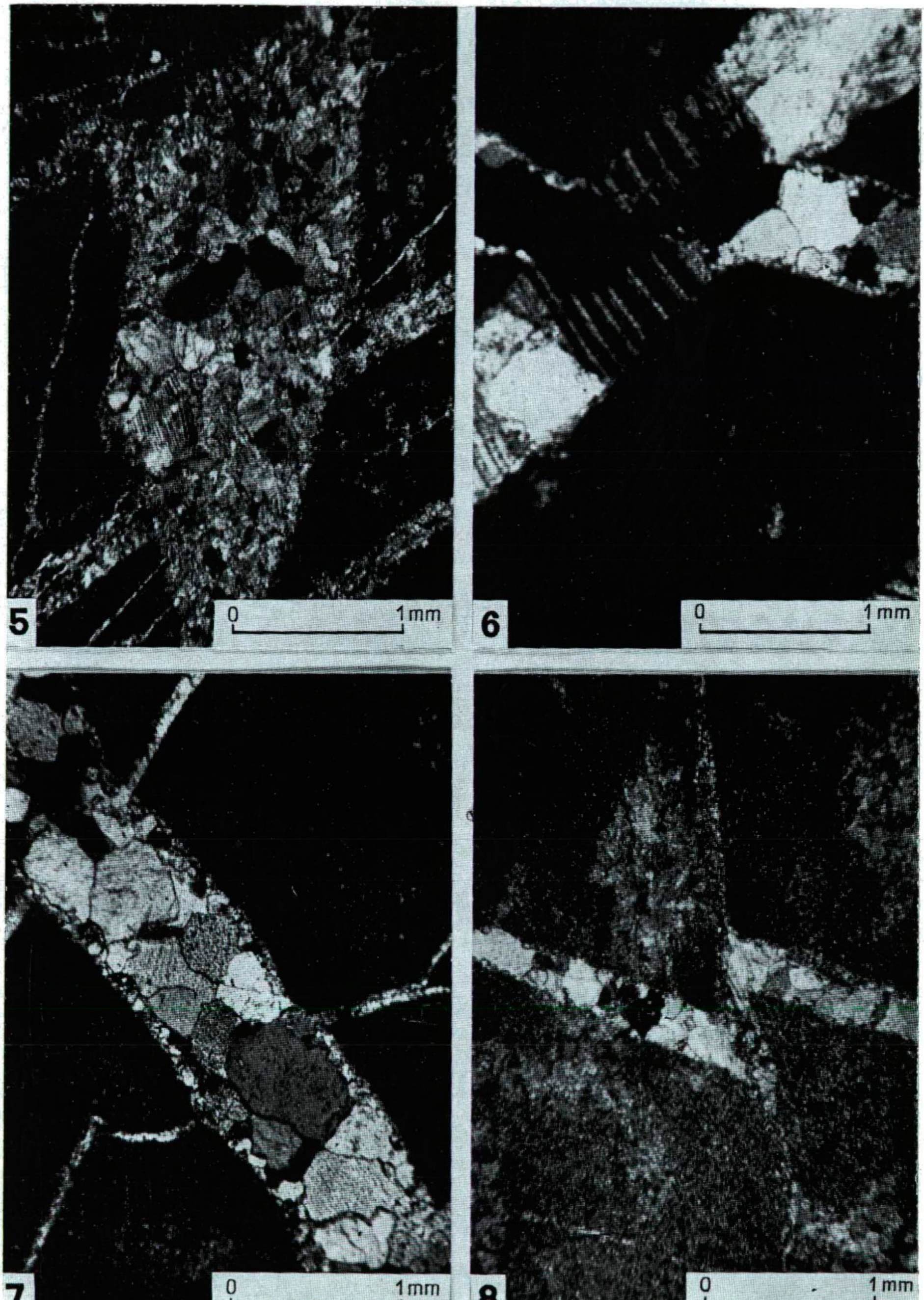
Karst phenomena. As for surface karst phenomena, strike-oriented lapies and smaller karrenfelden as well as two bigger and one smaller dolinas *(Fig. 1)* are characteristic.

Subsurface karstification is evidenced by cavities detected by means of radioactive logging in boreholes, along with clayey fillings and kataclastic intervals.

Traces of hot springs. In the quarry, during the course of exploitation, spheric niches of hot spring cavities (along faults), 1—2 cm to 1 m thick calcite veins are found. Materials testing adds other evidences (hydrothermally decomposed limestone, calcite, quartz, kaoline).

Nagykőmázsa Hill lies 2 km to the West from the hot spring area of Miskolctapolca and the nearby marked traces of hot spring activity in the abandoned limestone quarries of Várhegy Hill. Taking into account that both in the Várhegy exposures and on Nagykőmázsa Hill the above mentioned traces (cavities, calcite veins), which occur up to the summit, are oriented NE—SW, they can be considered as earlier source sites of the actual Miskolctapolca hot spring, or of a larger spring system.

Phot. 5. Thin section of the Ladinian limestone from 60,0 m of borehole III—5
Phot. 6. Thin section of the Ladinian limestone from 57,7 m of borehole VII—5
Phot. 7. Thin section of the limestone sample from 57,7 m of borehole VII—5
Phot. 8. Thin section of the limestone sample from 35,0 m of borehole VII—9



Phot. 5—8.

The hydrothermal activity ended with the Pleistocene uplift of the SW Bükk Mountains: sooner on the more elevated Nagykőmázsa Hill (384 m a. s. l.) and somewhat later on the lower Várhegy Hill (222 m a. s. l.).

The actual hot spring of Miskolctapolca, together with some cold springs, is ascending along faults delimiting the east side of Várhegy Hill *(Fig. 5)*. Also the inactive spheric niches of the hot spring cavities to be seen in the Cave Bains testify to rather recent uplift, suggesting the possibility of discovering hot water at more considerable depths, in the area characterized by the presence of this of hot spring caves.

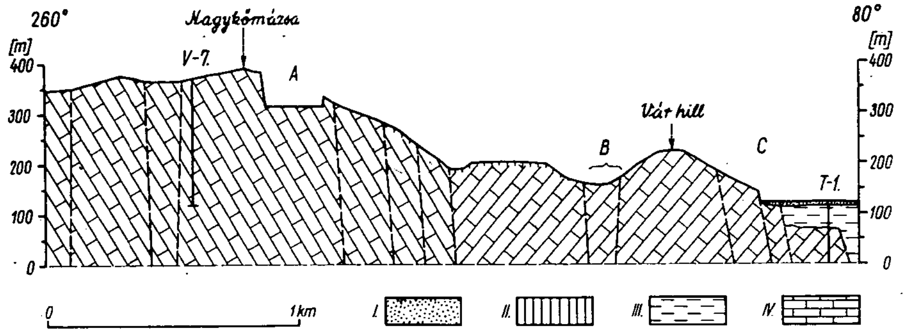


Fig. 5. General geological section across the Nagykőmázsa limestone exploration and Miskolctapolca spring areas. I. alluvium (Holocene), II. clay (Pleistocene), III. sand, clay, sandstone, gravel, brown coal (Helvetian-Tortonian), IV. limestone (Ladinian). *A* Nagykőmázsa limestone quarry; *B* Várhegy quarries; *C* Tapolca springs.

As a matter of fact, these caves are indicative of springs with higher temperature than that of the actual hot spring of Miskolctapolca (26—30 °C). Decrease in temperature is due to the uplift of the sediments of the SW Bükk Mountains, the displacement of resurgence sites and the cooling effect of cold water karst springs ascending along the same fault system, respectively.

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