DATA ON THE GEOLOGICAL AND MINERALOGICAL KNOWLEDGE OF LOWER LADINIAN SCHISTS IN THE BÜKK MOUNTAIN

by

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In the course of the industrial prospecting for raw materials, carried out on the west margin of the Bükk Mountain [TAKÁTS, 1964], the schist area situated on the north side of the limestone range of the Bélkő has been investigated in detail *(Fig. 1)*. By the investigations good basic and comparative data to the mineralogical knowledge of the Lower Ladinian schist formation in the Bükk Mountain has been obtained.

GEOLOGICAL CONDITIONS

Geological structure. We explored the schist formation in detail on the Vanna field of Bélapátfalva. This area is situated on the west border of the mesozoic basement of the Bükk Mountain. Among the published geological works of other authors on the area and its close surroundings, the studies of Z. SCHRÉTER [1943, 1954a, 1954b, 1960], S. JASKÓ [1953] and K. BALOGH [1964] are the most important ones.

During the years 1963, on the prospecting area of the Vanna field, Bélapátfalva, thirty-seven 1—3 m deep exploring shafts, one 12 m deep, two 30 m deep and eight 50 m deep core drillings of 76 mm ∅ were made.

The selecting of the places for exploratory drillings was strongly influenced by the transporting difficulties inherent to the ground, but in spite of that we sought to place them in such manner that they should 1. form, as far as possible, a regular network, 2. clear up the connections between the geological and morphological conditions [TAKÁTS—VITÁLIS, 1965].

The prospecting area of the Vanna field is built up dominantly by the schist formation of the Lower Ladinian. The schist formation is not of homogeneous origin, it contains interposed beds of limestone and sandstone, subordinately calcareous schist and flint-shale of varying thickness.

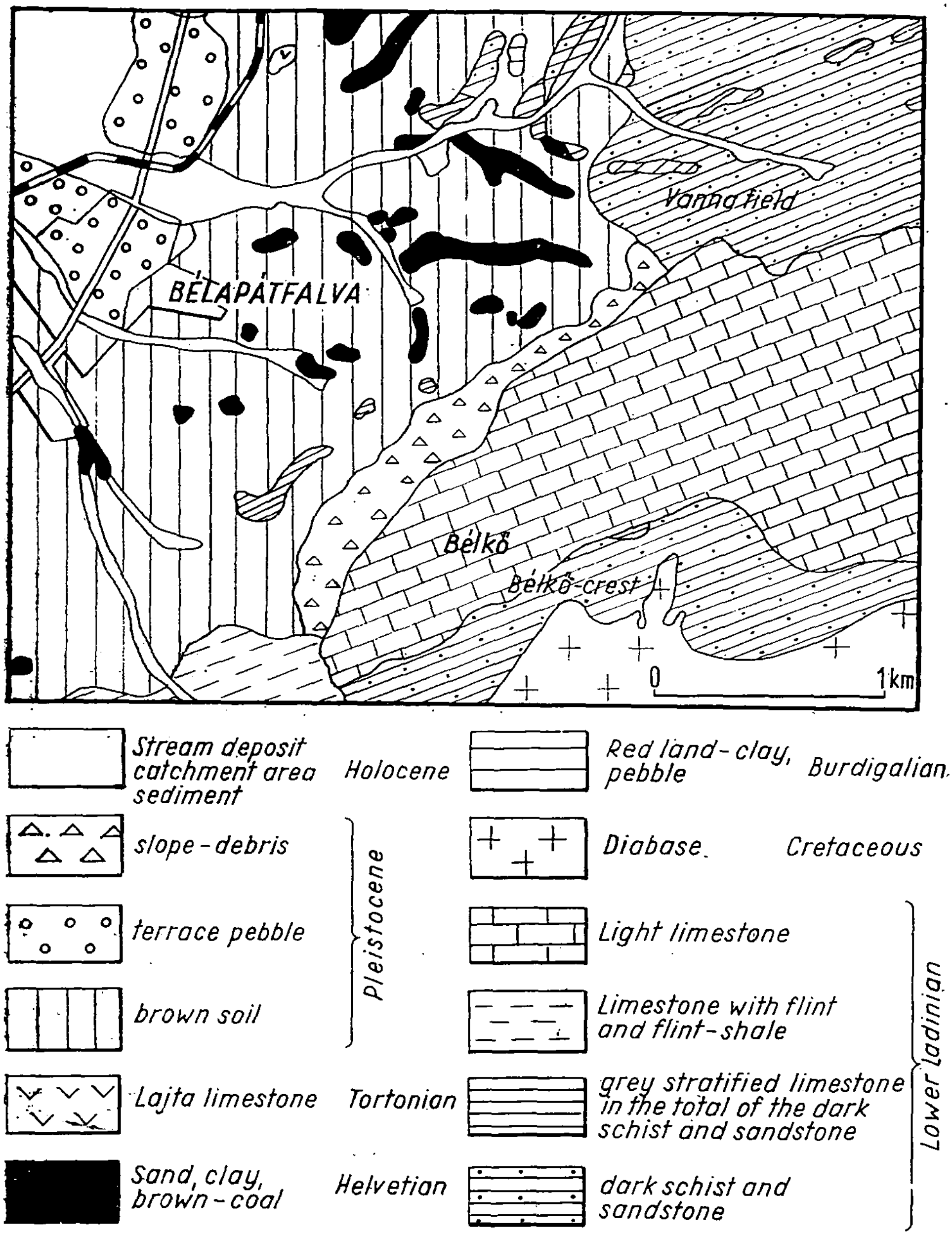
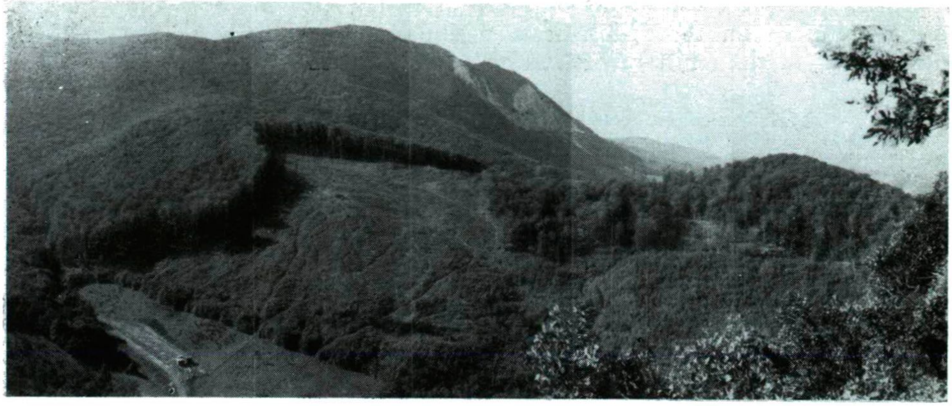


Fig. 1. Sketchy geological map of the surroundings of Bélapátfalva (after SCHRÉTER, Z.)

The schist formation less resistant against erosion, nestling to the sides of the steep NW–SW limestone range of the Bélkő is conspicuous even from the inclines sloping in a milder extent. *(Picture 1).* On the other hand, the peaks, ridges or crests morphologically slightly emerging out from the schist



Picture 1. The perspectivic picture of the prospecting area of the Vanna field Bélapátfalva. (Above the midline of the picture the limestone quarry of the Bélkő, on the right of the picture the peak of Őzlövő.)

formation attract the attention upon the limestone and sandstone formations settled into the schist complex (e. g. Őzlövő peak).

Upon the schist, sandstone, and limestone formations of Lower Ladinian, a Pleistocene cover of 0–5 m thick schist (subordinately limestone and sandstone) rubbled brown and red-brown clay is settled.

The extent and thickness conditions of the geological formations building up the area of prospecting are illustrated on the engineer-geological map [TAKÁTS and VITÁLIS, 1965; VITÁLIS, 1965] as well as on the sketchy geological profiles displayed in *Figure 2.*

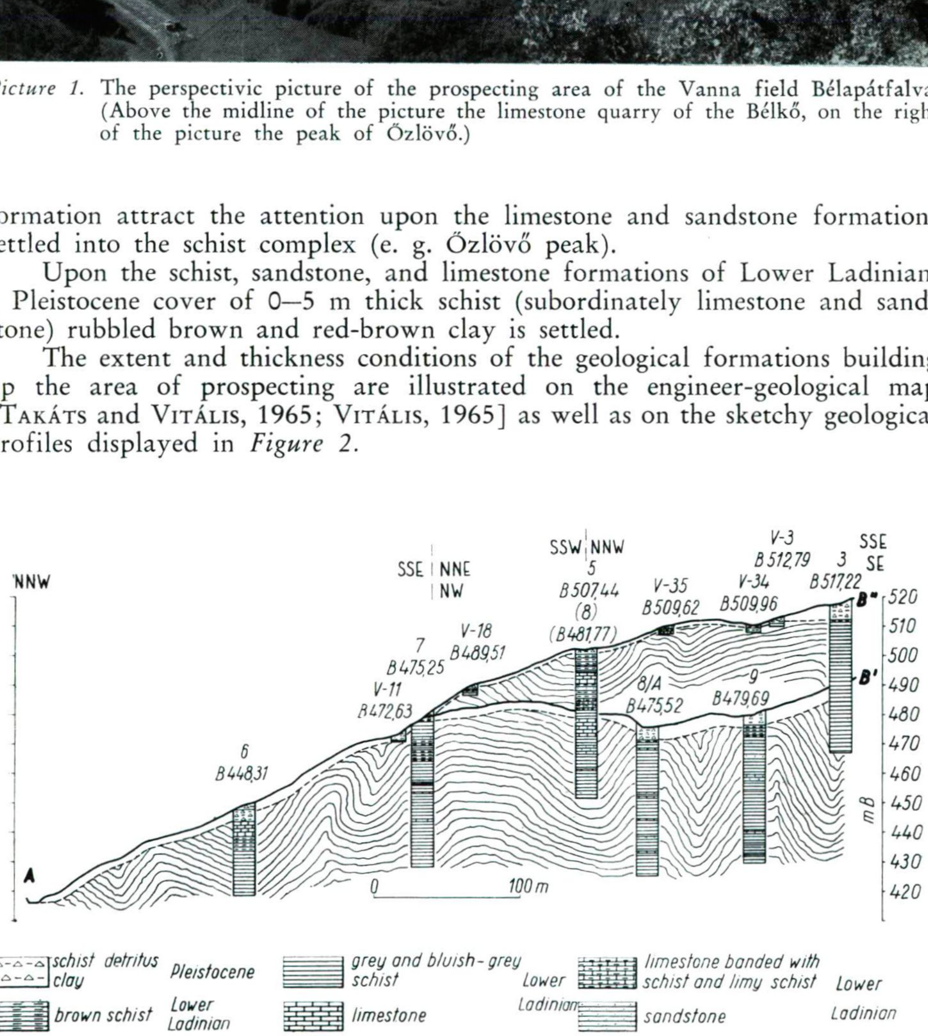


Fig. 2. Sketchy geological profile of the Vanna field.

The geological conditions of the prospecting area at the Vanna field are displayed even on the SM (silicate module) maps illustrating the industrial utilisability of the schist raw materials *(Figures 3—5)*.

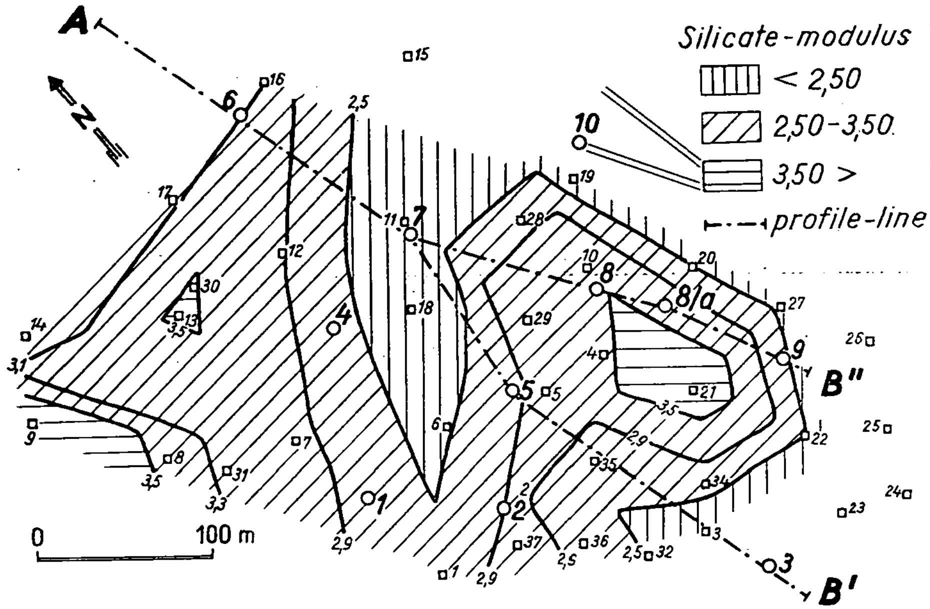


Fig. 3. The SM map of the Pleistocene clay covering of the prospecting area of the Vanna field.

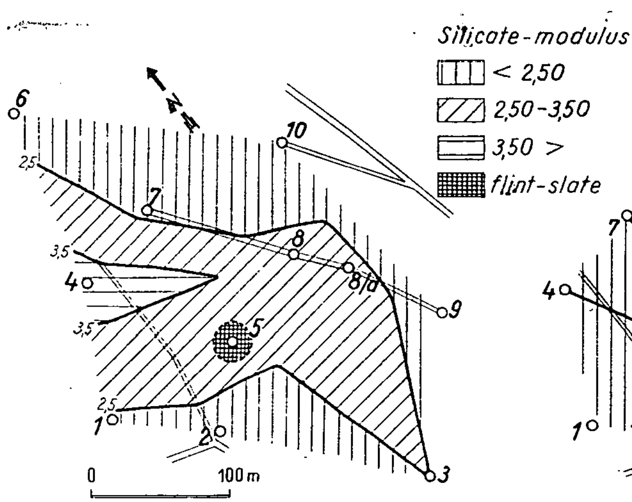


Fig. 4. The SM map of the Lower Ladinian schist layers of the prospecting area of the Vanna field at 20 m below the surface.

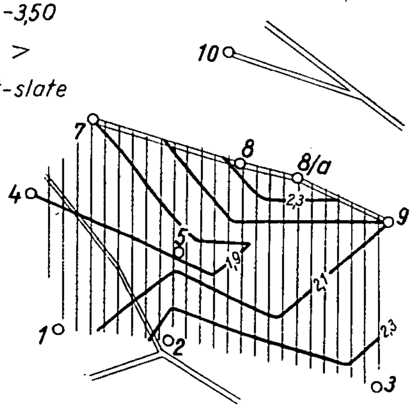


Fig. 5. The SM map of the Lower Ladinian schist layers of the prospecting area of the Vanna field at 40 and 50 m below the surface.

The SM maps were constructed with interpolation on the basis of the SM values concerning the corresponding depths. We chose the numerical values of the contour lines connecting the places of same quality, respectively separating the parts of different quality on the basis of the frequency of values gained from the results of examinations. We drew the line on the basis of frequency as well for the summarizing cartographical delineation respectively separation of the SM values at 2,50, between 2,50 and 3,50 and above 3,50.

For the multiple control of the stratification we had electric log examinations too, made in two borings. On the basis of the carottage profiles made in the 8/A and 9 borings, the boundaries of the layers can be marked out reliably, at the determination of the material, on the other hand, they depended mostly on those given by the boring. According to the resistance profiles the quality of the schist varies even within an appointed layer *(Figure 6)*. The

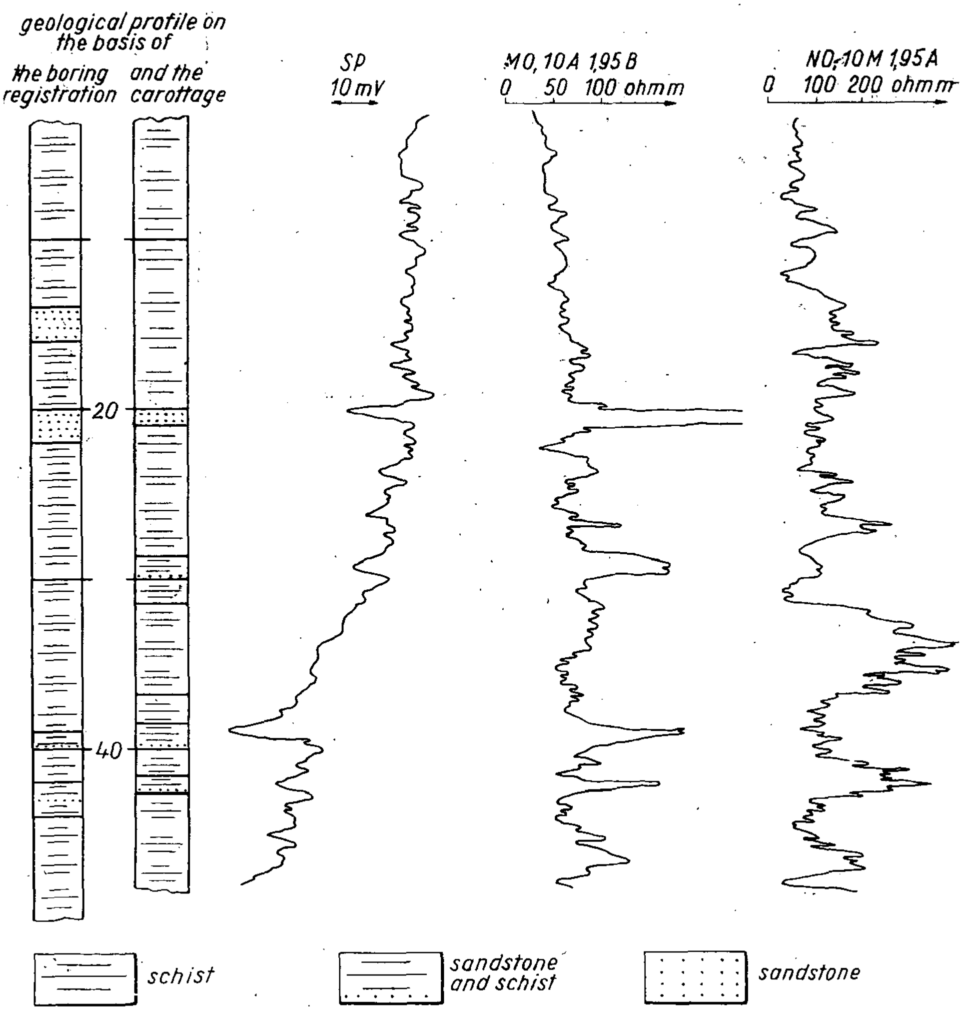


Fig. 6. Electric well log of the boring N° 9.

boundaries of layer marked out in the schist formation display the rough differences of quality.

Mountain structure. For the prospecting area of Vanna field the folded forms are characteristical. The strike of the several geological formations is in agreement with the roughly NE–SW strike of the Bélkő range. The folded forms of the schist complex could be well studied, peculiarly in the exploring shafts, in which we observed very strong dips of the strata with diverse, respectively caotic foldings. The dips measured had mostly SSE and NW courses, the minimal angle of dipping was 32°, the maximal 84°.

Based upon these it could be supposed, of course, that the schist complex penetrated with borings was also folded. Therefore, on the rudimental profile made of the area *(Figure 2)*, the strata of identical petrographic development penetrated by the several borings, could not be connected with absolute certainty, we demonstrated only the strong folding of the complex.

Hydrogeological conditions. No water appeared during the prospecting borings in the Lower Ladinian formation. The schist complex can be considered watertight. The smaller limestone lenses wedged into the schist are permeable to water, but they are practically dry as they can obtain only a very poor water supply through the schist.

The whole prospecting area of the Vanna field is situated above the karstwater surface known in the surroundings (approximately 365 m above sea level). The bottom B of the boring No 6 deepened to the least sea level height, reached 418,31 m, thus the opening of a mine in the area is, with respect to the karstwater, not dangerous.

TEST RESULTS

In the course of examination of the possibilities for utilizing the Lower Ladinian schist for industrial purposes, — for characterizing the raw material — the chemical and mineralogical composition, the burnability, the nodule strength as well as the grindability of the samples was determined.

The determination of the mineralogical composition — with consideration of the chemical composition — took place by the reconciliation and evaluation of the results of different instrumental examinations. The procedures applied were: dilatometry, X-ray diffraction, differential thermal analysis and derivatographic examinations.

Dilatometers of Bollenrath-type, made by Leitz, were used. The heating rate was 7 C°/min. in every case, the highest temperature attained was 1000°C. Samples were prepared by pressing, adding tylose if necessary.

X-ray diffraction examination was done partly by Debye-Scherrer procedure (with Mikrometa apparatus), partly by diffractometer procedure (with Rigaku-Denki apparatus). In all cases Cu Kα radiation was applied with nickel filter.

The differential thermal analysis (DTA) records served the quick information. These were made with the „rapid" DTA apparatus of Kliburszky–Földvári. To the quantitative evaluation DTA, TG and DTG graphs were made with the derivatograph of Paulik–Paulik–Erdey. The highest temperature attained was in every case 1000°C, recording time was 90 minutes.

Table I. Total chemical analysis

Place and depth of sample taking (m)	Name of rock	Loss on ign.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	S M
		weight %								
6. boring										
10—14	brown schist	5,39	55,50	22,63	9,10	0,86	0,42	0,95	3,34	1,75
20—24	bluish grey schist	4,60	58,21	21,06	8,70	0,50	0,18	0,93	3,43	1,96
28—30	bluish grey schist	5,87	53,16	23,79	8,25	1,18	trace	0,91	3,16	1,66
7. boring										
19—21,5	bluish grey schist	4,55	60,64	18,95	7,60	0,50	0,11	1,02	2,50	2,28
40—44	grey schist	4,89	56,78	22,63	7,50	1,10	3,08	1,08	3,24	1,88
9. boring										
16—20	grey schist	5,72	57,57	18,47	9,82	1,28	0,18	1,35	2,30	2,03
39,7—42	grey schist	5,51	55,40	22,26	8,12	0,60	0,22	1,05	3,19	1,82
10. boring										
20—21	bluish grey schist	5,26	57,59	20,56	8,40	0,49	0,72	0,87	3,00	1,99
27—30	bluish grey schist	5,68	58,72	19.05	8.59	0,69	0,29	0,76	2,57	2,12

* In the value the Al_2O_3 component, the TiO_2 and the MnO take as well.

Chemical investigations. Not all samples were examined, only types characteristic for the occurrence. Total analyses were made of nine samples *(Table 1).* From one hundred and ten samples the most important characteristics were determined only; the percentage of silica, aluminum and iron oxide as well as, in some cases calcium oxide.

As the matter in question is a raw material of the cement industry, in the judging of the material the ration of silicic acid to the R_2O_3 is playing a significant part. Therefore, for the simplified characterizing, the value of the silicate modulus (SM) was computed. On the basis of the complete and partial chemical analyses the SM value of the clay and schist is ranging in the bulk between 1,66 and 3,44. As it is demonstrated in the SM maps *(Figures 3—5)* as well, the SM value is reduced in the deeper levels.

The CaO value is raised in some cases by calcareous interbeddings. Potassium is always present in greater amount than sodium.

DTG and DTA examinations. Diagrams published in *Figures 7—12* show that the DTG curves of all samples examined are of illitic character, as they show a strong endothermic peak between 500 and 600°C. The presence of quartz increases the height of this endothermic peak, but an extra quartz peak appears only if the quartz is present in a dominant quantity *(Figure 11).*

Some curves *(Figure 8)* indicate strongly the calcite content. On most curves a decided bulging can be observed about 450 °C, before the endothermic peak of 550 °C, indicating the crystal-water loss of illite. This hints to the presence of some pyrite content.

Thermogravimetrical (TG) curves show that all samples — with the exception of calcareous samples — lose their bound water between 500 and 600°C. This means illite and kaolinite respectively. The carbonate-containing

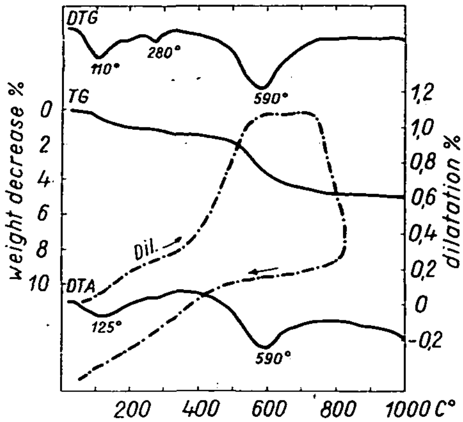


Fig. 7. The thermic curves of the Lower Ladinian schist from the shaft No V—25, at 2,2 m depth.

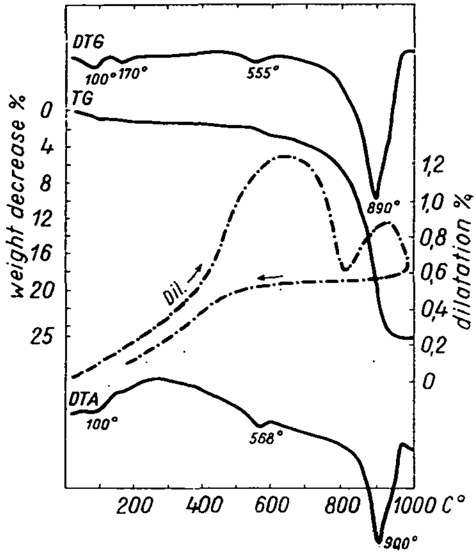


Fig. 8. The curves of limy Lower Ladinian schist from the shaft No V—37, at 2,0 m depth.

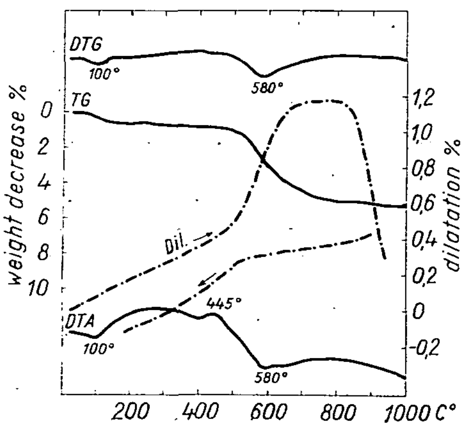


Fig. 9. The thermic curves of the bluish grey Lower Ladinian schist derived from the boring No 6, at 20—21 m depth.

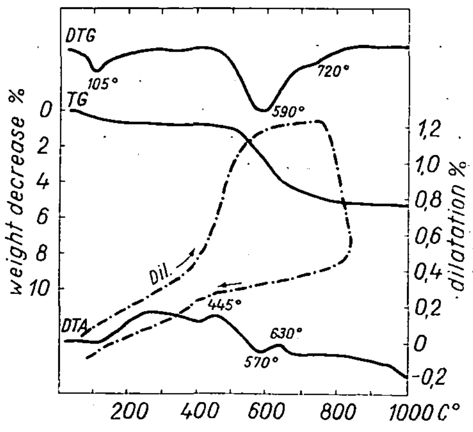


Fig. 10. The thermic curves of the bluish grey Lower Ladinian schist from the boring No 6, at 29,30 m depth.

samples showed above 800°C a strong weight loss, as indicated by the intense decline of the TG curves. The peak of the derived TG curves (DTG curves) are much the same as those of the DTA curves and indicate the initial and terminating temperature of the reactions. On the DTG curves of a few samples the minima indicating the loss of weight can be recognized even about 300°C

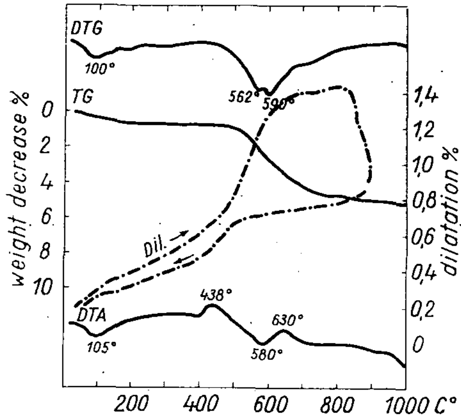


Fig. 11. The thermic curves of the bluish grey Lower Ladinian schist from boring No 7, at 19—20 m depth.

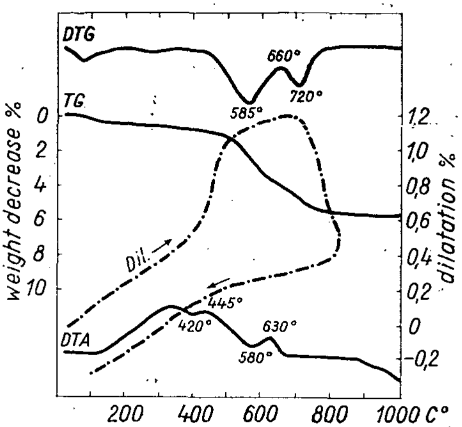


Fig. 12. The thermic curves of the grey Lower Ladinian schist derived from the boring No 9, at 19—20 m depth.

(this is indicated by a quite slight inclination of the TG curves too), which means that the samples contain hydrargillite as well.

Dilatometric examinations. The results are illustrated in *Figures 7—12* as well. The dilatation curves are very similar. The most typical is the curve of *Figure 9.* The initially moderate dilatation is followed, after 500°C, by a more intensive dilatation up to 600°C. At this temperature the steepness of the curve decreases, and after a horizontal phase lasting up to 800°C, the curve indicates a rapid shrinkage. This is the typical illite curve. The ascending phase of the curve is changing from sample to sample; this change can be brought about by kaolinite and quartz content. Cooling curves were prepared as well, to get some information about the quartz content of the material. As it can be seen in the figures, the cooling curves indicate in every case a quartz content, in some samples even in a considerable quantity. In *Figure 8* the characteristic calcite curve can be seen. The sample shows above 700°C an intense shrinkage, but above 800°C it is swelling again to begin the final shrinkage after 900°C.

The samples, the dilatograms of which show on the ascending branch above 200°C a smaller or greater break, as the sample illustrated in *Figures 7—10* and *12,* contain besides quartz a great quantity of kaolinite. The characteristic dilatogram of the kaolinite can not develop on account of the great quartz and illite content.

X-ray examinations. In accordance with dilatometric examinations quartz appears in all samples in dominating quantity. The kaolinite and illite can be recognized with definite reflections. In most samples feldspar can be observed too by its most intensive reflection. In some samples montmorillonite can be demonstrated too, though its quantity is on the basis of the intensity dates only slight. In the calcareous schist samples calcite lines appear as well.

It is interesting that there are a few samples in which illite reflections could not be observed. These contained much quartz and kaolinite. The intensity values of the kaolinite are rather low, which means that the degree of crystallization is low.

Mineral composition. On the basis of analytical data and instrumental examination it can be stated that the mineral composition of the samples is diversified. In all samples great quantities of quartz can be found, not only in the sandstone but in the schist samples as well. This statement can be derived chiefly from dilatometric and X-ray examinations. The clay minerals are represented by illite and kaolinite. Their absolute quantity and their quantity in relation to each other differs from sample to sample. In some of the samples no illite reflections were observed, in other samples kaolin was absent. The dilatometric and derivatographic curves indicate a greater illite than kaolinite content. The considerably greater potassium than sodium content is a hint to illite content as well. On the DTA curves the exothermal peak of the kaolinite is absent, but this may happen and suggests the conclusion that the degree of crystallization in the kaolinite is rather poor.

In some samples montmorillonite was found by X-ray, but the intensity of the reflections is small, thus its quantity is not considerable. This explains that the clay is not plastic and its nodule strength value is also slight.

Feldspar was also detected in many samples, though mostly by a single reflection only, thus its quantity might be minimal. DTA curves indicate pyrite in most of the samples. As by X-ray it was not demonstrable, its quantity might be max. 1—2%. By the evidence of derivatograms some samples contain hydrargillite in a smaller quantity.

The carbonated samples contain a considerable amount of calcite.

Examinations of burnability, nodule strength and grindability. Burnability examinations were carried out with raw meals of 0,9 saturation. To the raw flours we used so called „limestone of Berva" from Felnémet. The burning took place at 1400°C for 30 minutes. As it is known, the free CaO content indicates the burnability. The burnability was very variable, which is — considering the analytical data — considerable, for both the SM value and the AM value influence the burnability to a considerable extent. Accordingly the schist of average composition — in accordance with the literature data [Dolezsal, 1961] — has low burnability.

The nodule strength examinations were carried out on raw meals of 0,9 saturation, made of limestone of Felnémet, their grinding fineness being $R_{0,09}=10\%$. From each sample four tests were moulded with different humidity and heat-treated with Guy's method, and the setting stability measured. According to the data of the examination the granulability is rather poor, which can be explained by the scarcity or total absence of montmorillonite.

The data of *the grindability examinations* answered the expectations. This examination was carried out of course only with the sandstone and limestone samples.

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