EXAMINATION OF CEMENT—INDUSTRY RAW MATERIALS FROM THE SW BÜKK MOUNTAINS

by

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Our Institute carried out, in the years 1964—1965, a limestone and clay exploration, for the planned cement plant in the neighbourhood of Eger—Felnémet. For limestone prospecting, the limestone and marl strata composing the Bükkbérc-range, for the purpose of clay the Middle-Oligocene stratas between Eger and Noszvaj seemed the best suited (*Fig.* 1). The manysided investigation of materials of 11 borings (1514 meters) from the Bükkbérc and that of 34 borings (1210 meters) in the neighbourhood of Noszvaj were carried out.

GEOLOGICAL CONDITIONS OF THE AREA

The geological structure of the exploration area is demonstrated on *Fig.* 1. In accordance with this, first Eocene terrestrial, later marine formations are deposited upon the Triassic.

We tried to penetrate, with the 300 meter deep Bikkbérc № III—0 drilling, the Eocene terrestrial strata too, drilled earlier with 257 meter thickness in the bore-hole Noszvaj (Sikkut) № 1. The well bored in 179,5 meter thickness, from 120,5 meter to the bottom, consists of mostly many-coloured sandy clay layers. Thin sandstone, sand, gravel and clayey breccia interbeddings are in the many-coloured clay. Ladine age shale, gravel of sandstone origin and again many-coloured clay followed in between 287—290 meters. The „gravel" supposedly means that the bot tom of terrestrial stratas is near. For the time being, the age of terrestrial stratas is not cleared reassuredly since pollens or other fossils are missing.

All the wells of Bikkbérc reached the average 1—2 meter thick lowest part of the Upper-Eocene marine strata, composed from base conglomerate, with clayey-marly binding material, and breccia. First clayey marl, marl, calcareous marl, afterwards clayey limestone and limestone is bedded upon the base conglomerate.

We found thinner limestone stratas too, in the marl-calcareous marl deposits, which compose a quarter part of the marine layers, penetrated with 72 to 177 m thickness in the wells. But the bulk of the clayey limestone and limestone was found in the upper 3/4 of the sequence of layers. The bedding of stratas is shown in *Fig.* 2.

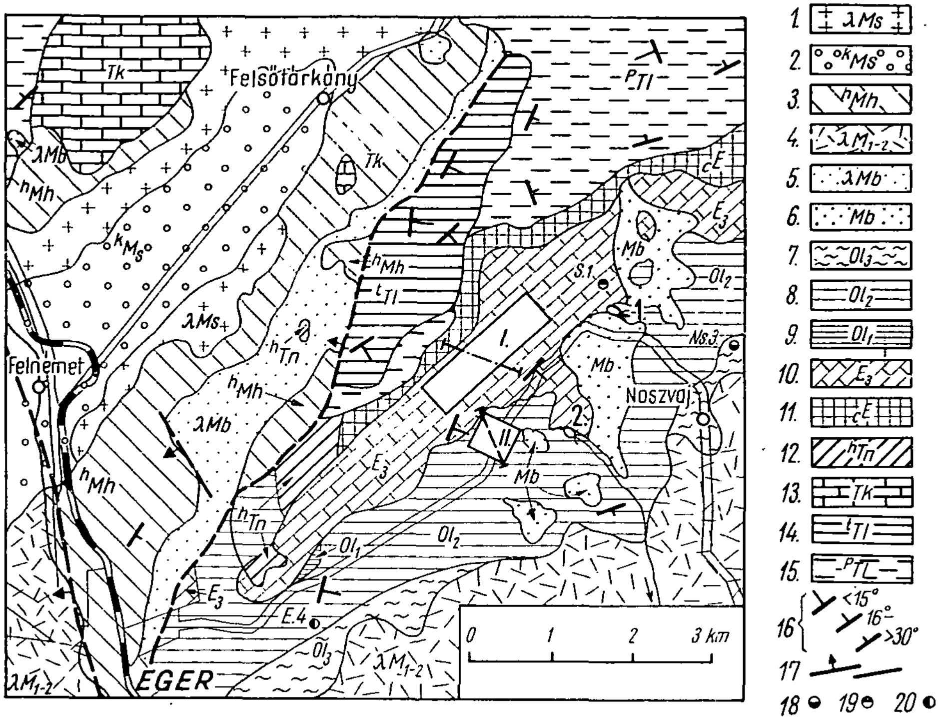

Fig. 1. Geological sketching map of the surroundings of Eger—Felsőtárkány—Noszvaj. (after K. Balogh) *1. Sarmatian* upper rhyolite tuff; *2.* gravel, sand, terrestrial clay, partly with tuff; *3. Helvetian* clay, sand, sandstone, gravel, brown coal; *4.* rhyolite tuff; *5.* lower rhyolite tuff, gravel and lower rhyolite tuff; *6. Burdigalian* gravel, sand, sandstone, conglomerate, coloured clay and gravel; *7. Kattian* sandy clayey marl: *8. Rupelian* grey clay and clayey marl with sandstone and andesite tuff layers; *9. Lattorfian* grey clay and calcareous marl; *10. Bartonian* lithothamnium and nummulitic limestone and calcareous marl; *11. Lower Eocene* terrestrial many-coloured clay, sand, gravel; *12. Norian* grey limestone; *13. Karn* „berva limestone" *14.* grey chert limestone partly with dolomite; *15. Ladine* dark grey shales, sandstone with chert limestone or siliceous shale interbeddings; *16.* Dip; *17.* Fault; *18.* oil exploration well; *19.* brown coal exploration well; *20.* manganese exploration well; I. Limestone exploration area; II. Clay exploreation area. 1. Sikfőkút; 2. Forrókut.

In the marine formations the *Nummulites fabianii* Prever is frequent, as well in limestone as in marls. This and the *Neocarpenteria cubana* [Cushman and Bermundez], *Stomatorbina torrei* [Cushman and Bermundez], *Queraltina epistominoides* Marie, *Chapmanina gassinensis* [Silvestri], *Spirolypeus granulosus* [Boussac], *S. carpaticus* [Uhlig], *Grzybowskia multifida* Bieda, *G. reticulata* [Rütimeyer] found in the same complex, gives the age of Upper Eocene.

In the Middle Oligocene stratas of the Noszvaj clay exploration area, tested generally with 40 meter deep wells, the brown, yellow and grey coloured, mainly silty clay, clayey silt, rock floured silt, silty rock flour, less sandy rock flour, rock floured sand and sand, rarely sandstone stratas are alternating with one another. Some layers of these are more hard and compact.

The foraminifera species determined by Mrs. Maria Jámbor from the samples of well № I—3 and I—9 for justifying the age of the formations represent the foraminifera horizon № 3 (agglutinated) according to Majzon.

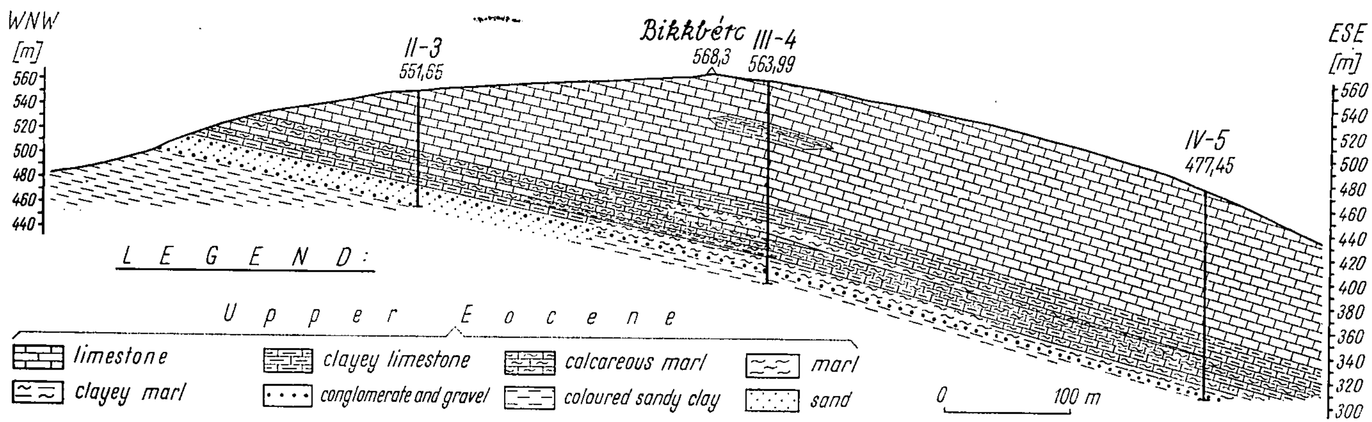

Fig. 2. Geological profile of the Bikkbérc limestone exploration area.

The Middle Oligocene formation discovered by drillings, contains generally 2, 3 or 4, averagely 2,39 meter thick little manganic and 1,81 meter thick manganic silty rock flour, rock floured silt, clayey silt and silty clay stratas. It is known on the base of manganese ore explorations made earlier in the neighbourhood, that the scattered found manganic clay layers are not commercial deposits for the manganese mining. The manganese ore exploring well Eger № 4, transversed the Middle Oligocene clay-clayey marl formations till the depth of 114,4 meters. This formation is several hundred meters thick, on the base of drilling datas from the greater region.

2—8 m thick reddish brown, brown silty clay, clayey silt and rockfloured silt, Pleistocene cap rock is bedded upon the Middle Oligocene stratas.

On the maps and sections, the silty clay, clayey silt and rock floured silt layers, important resources used for cement fabrication, are summed up as stratas of clayey development.

For the qualitative presentation of rock materials, SM (silicate module) maps and profiles were constructed. The drawing of the boundaries of quality were coordinated with the geologic sections from the same place, *(Fig. 3)* during completing of SM profiles. These illustrate first of all the industrial utilization of the raw material and in the same time the petrographical conditions of the area.

The faulted forms are characteristic of the structure of the Bikkbérc and Noszvaj exploration areas.

The Upper Eocene stratas of Bikkbérc, risen along NNE—SSW (generally 30°—210°) faults, dip in ESE direction (120°) averagely with 15° *(Figs. 2 and 3a)*.

Further, small faults are probable on base of morphological conditions in the limestone formations of Bikkbérc.

In the geological dip profile of the Middle Oligocene area bordered also by NNE—SSW faults *(Fig. 3a)*, the stratas have a 12—15° dip, with ESE direction.

The slightly manganic lenses prospected by drillings, were well usable the identification of stratas in contradiction to the case of experiences from the region of Eger.

Hydrogeology. The setting of the ground-water in the Noszvaj clay exploration area, is shown with the static ground-water level datas of the subsoil map and geological sections *(Fig. 3a)*. Where the water level data is not shown, there was no ground- nor layer-water observed till the bottom of the drilling.

The karstic features of the limestone — calcareous marl layers of the exploration area of Bikkbérc were shown by the escape of the drilling fluids as well as by the caverns detected by geophysical methods. Comparing the places of the water-escape — which amounts to 5—32 m^3 per shift — and the locations of the fissures and the caves to be supposed on the basis of sharp peaks of the gamma — gamma and neutron — gamma curves, in many cases a good agreement could be established.

The Middle Oligocene clay — clayey marl is generally impermeable for water and plays a damming role on the margin of the mountains. The Upper Eocene nummulitic limestone and calcareous marl is theoretically a good water reservoir. Its water-houshold is common with the Middle Triassic limestone. Water was yet not observed in the exploration wells of the Bikkbérc area, because they penetrated only the downward karst. The wells of Sikfőkut, flowing from Upper Eocene nummulitic limestones in 340 m and the Forrókut wells in 280 m highness above sea level as structural wells too, indicate the supposed karst water-level banked up by Middle Eocene clay formations *(Fig. 1)*.

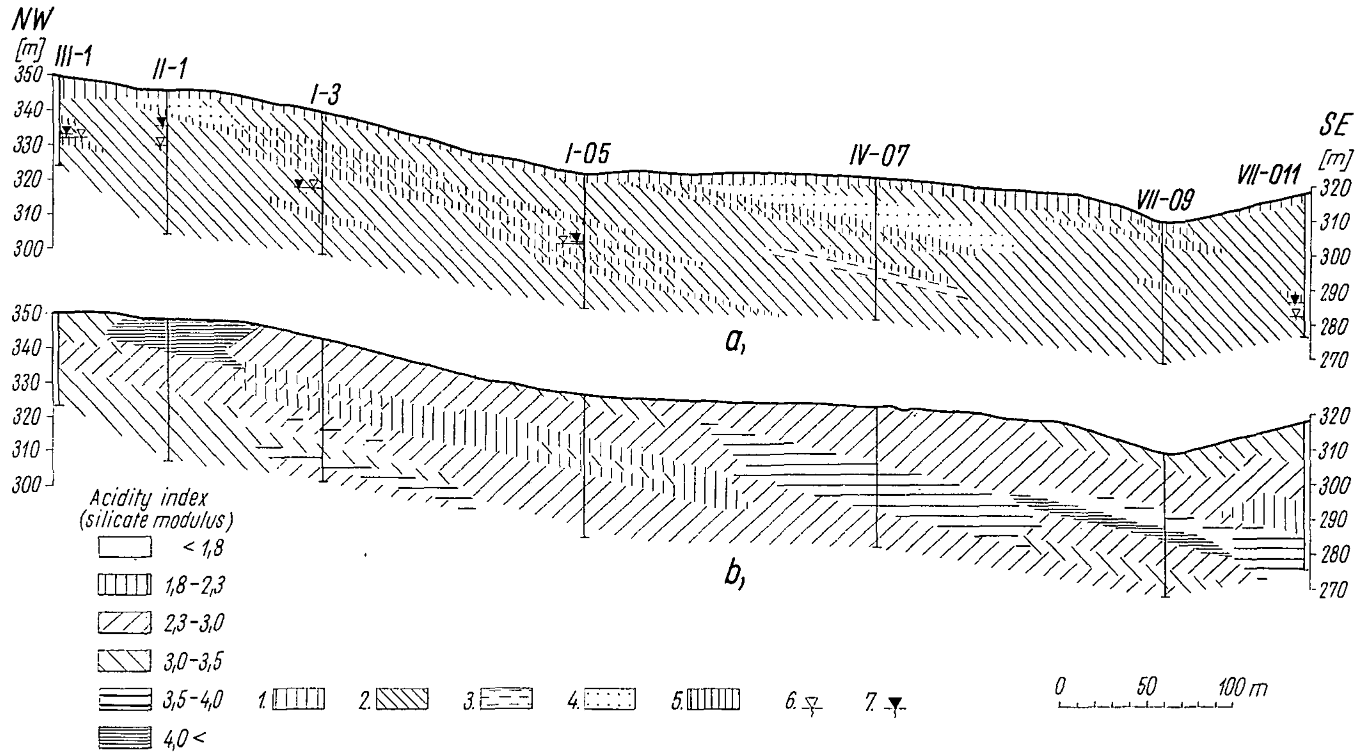

Fig. 3. Geological profile of the Eger—Noszvaj clay exploration area (s), and SM profile (b). *1. Pleistocene* rock floured silt, clayey silt, silty clay; *2. Middle Oligocene* rock floured silt, clayey silt, silty clay; *3.* silty rock flour; *4.* fine sandy rock flour, sandy rock flour, rock floured sand, sand; *5.* silty rock flour with manganese patches and manganese, rock floured silt, clayey silt, silty clay; *6. ground-*water level; *7.* static ground-water level.

Average and extreme values of chemical analyses* **Table 1.**

	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	MnO	SO_3
	Weight percent										
Limestone (U-E)**											
Average	42,40	1,70	0,60	0,36	0,04	34,12	0,22	0,42	0,41	–	0,30
Minimum	39,05	0,25	0,10	0,14	0,02	50,37	0,03	0,07	0,11	–	0,03
Maximum	44,08	3,50	2,47	0,79	0,05	55,69	0,83	0,96	1,67	–	1,37
Clayey limestone (U–E)											
Average	40,20	6,84	2,34	0,81	0,10	49,28	0,32	0,36	0,44	–	0,84
Minimum	38,28	1,55	1,34	0,12	0,10	46,37	0,04	0,08	0,12	–	0,01
Maximum	42,42	9,07	3,81	1,55	0,15	51,09	0,80	0,85	0,87	–	2,02
Calcareous marl (U–E)											
Average	31,29	20,11	6,24	2,04	0,35	36,19	1,38	0,20	0,65	0,55	2,27
Minimum	30,71	17,34	4,84	1,62	0,29	35,74	0,19	0,08	0,45	0,55	0,75
Maximum	32,03	24,15	7,82	2,35	0,40	36,73	3,83	0,39	0,94	0,55	3,12
Marl (U–E)											
Average	24,83	31,05	8,48	3,13	0,44	27,20	1,01	0,26	0,48	–	3,40
Minimum	21,31	25,41	4,07	2,47	0,22	20,55	0,34	0,08	0,09	–	1,50
Maximum	27,97	34,22	13,70	3,89	0,57	31,14	1,98	0,73	0,90	–	6,30
Many-coloured sandy clay (U–E)											
Average	5,27	59,47	16,72	5,30	0,23	0,59	0,39	0,34	1,31	–	0,10
Minimum	4,08	55,52	13,61	1,56	0,16	0,18	0,04	0,07	0,23	–	0,02
Maximum	8,34	74,29	19,67	9,95	0,31	1,31	0,89	0,81	2,07	–	0,45
Rock floured silt — silty clay (Ol)											
Average	11,30	51,30	11,91	5,54	0,62	8,42	2,91	0,84	2,03	3,65	1,74
Minimum	6,17	22,84	0,45	3,37	0,15	1,40	0,21	0,23	0,71	0,12	0,14
Maximum	22,18	66,39	16,49	9,36	0,88	18,45	9,79	1,87	3,27	22,67	5,40
Rock floured silty clay — silty clay (Pl)											
Average	9,82	55,90	14,29	7,23	0,84	4,15	1,24	0,44	1,54	1,75	0,81
Minimum	8,09	52,29	12,62	6,03	0,74	1,84	0,15	0,22	1,29	1,60	0,81
Maximum	12,40	64,25	16,49	7,99	0,90	8,38	1,97	0,74	1,98	1,91	0,81

* Remarks: Maximum and minimum values in the Table, are not everywhere datas of the same rock samples.

** (U–E)= Upper Eocene, (Ol)= Middle Oligocene, (Pl)= Pleistocene

The rock material explored by borings, was first of all tested to decide the appropriateness for cement industry and for the mineralogical- petrographical knowledge of the area.

Chemical investigations. From the Bikkbérc limestone explorating area, altogether 298 (56 total and 242 partial) analyses were carried out. During the partial chemical analyses the $CaCO_3$, CaO and MgO contents of rocks were determined. We used BÁRDOSSY's nomenclature for defining sorts of limestones. The average and extreme values of the total analyses are shown in Table 1.

We made a total of 191 (44 total and 147 partial) chemical analyses from the Noszvaj clay exploration area (Table 1). From the 44 analysed samples, the MnO content of 7 samples varies between 6,84—22,58 per cent. We found in 30 other samples smaller quantities of (average 0,76 per cent) MnO. The above results are in accordance with the data of the published literature from the area.

For technological evaluation and estimating of reserves the SM values of the raw material were calculated. The average and the weighted SM value of the useful material is equally 2,85.

Thermal examinations. To ascertain the mineral composition of samples, thermal (derivatographic and dilatometric) examinations were carried out. The thermograms of 5 characteristic samples of 100 thermograms of the two exploration areas, are shown in *Figs.* 4—8.

On the thermogram of the Upper Eocene limestone only the endothermic peak characteristic of calcite can be observed, other peaks pointing to the presence of other crystalline phases do not appear (*Fig.*4). The DTA curve of *Fig.* 5 (Upper Eocene marl) shows an exothermic peak between 200—400°C characteristic of

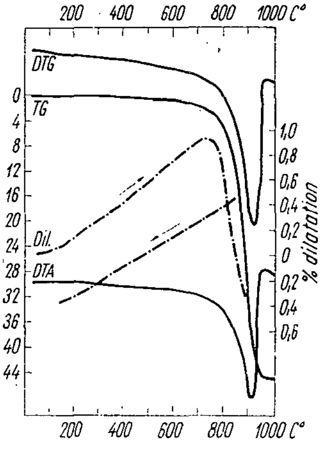

Fig. 4

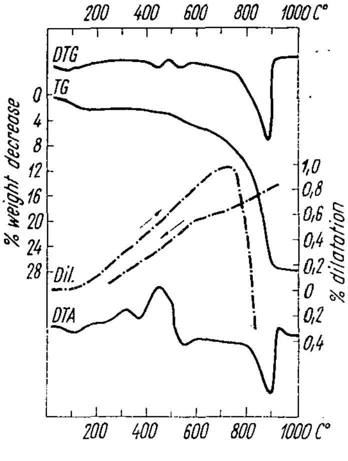

Fig. 5

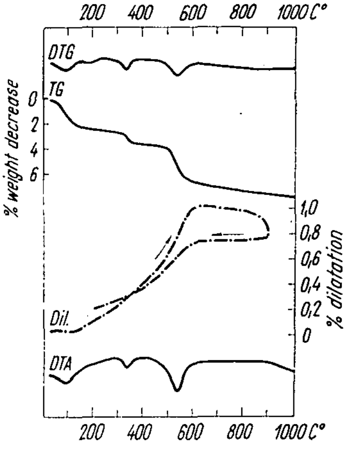

Fig. 6

Fig. 4. Thermal curves of the Upper-Eocene white limestone, from 15,0 m depth, No IV-5 boring Bikkbérc.

Fig. 5. Thermal curves of the Upper-Eocene grey marl, from 71,8—72,3 m depth. No IV. 3. boring Bikkbérc.

Fig. 6. Thermal curves of the Upper-Eocene many-coloured sandy clay, from 240,8 m depth, No III-0 boring Bikkbérc.

organic materials. The dilatation curves indicate quartz impurities of the limestones. The cooling curves show *(Fig.* 5 for example*)* a small quantity of quartz.

According to the thermograms of many-coloured sandy clays from the borehole Bikkbérc N III—0, the terrestrial stratas on the base of Upper Eocene, are mineralogically fairly uniform. The dilatation curves are characteristic of illite and quartz. We observe hereby that the average SM values of the mainly many-coloured sandy clay formations is 3,42, the extreme values are 2,35—5,10 *(Fig. 6).*

The thermogram typical for the Noszvaj Middle Oligocene clay area is shown on *Fig.* 7. The sample contains illite and montmorillonite according to the DTG, DTA and dilatation curves. The montmorillonite character is dominant especially

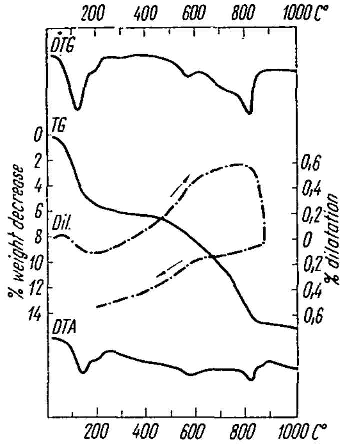

Fig. 7

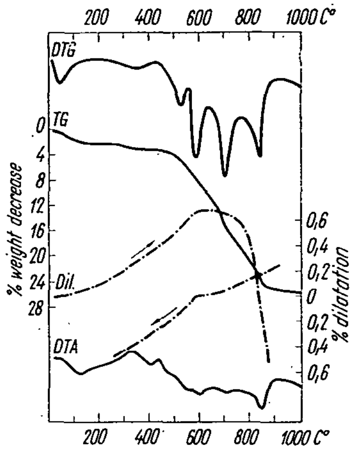

Fig. 8

Fig. 7. Thermal curves of the Middle Oligocene greyish silty clay, from 14,0 m depth, No I-9 boring, Eger—Noszvaj.

Fig. 8. Thermal curves of the Middle Oligocene grey (manganic) rock floured clayey silt, from 29,0 m depth, No I-3 boring, Eger—Noszvaj.

on the dilatation curves of the quartz-poor materials. The manganese carbonate, characteristic of materials with higher Mn content, is rodochrosite on the DTG curves *(Fig.* 8*)*. In the DTA curves of samples with higher iron content, a peak characteristic of pyrite is to be seen. Besides this, peaks for calcite or dolomitic calcite are important.

X-ray examinations. After the evidence of 73 X-ray diffractograms, part of the limestone and marl samples of Bikkbérc are contaminated with quartz. Kaolinite could also be determined in the clayey limestone. This was not possible on the thermograms because of its poorly crystallization.

In the many-coloured clay formations, bored in well № III—0, hematite is present too, below 250 m depth. Clay minerals of this formation tested with X-ray examinations, are illite and kaolinite.

The results of the X-ray investigations from the Noszvaj exploration area, are in good agreement with that of the thermal investigations. A small quantity of kaolinite could be determined in many samples. This is not present with pointed peaks on the derivatograms. Feldspars are to be found subordinately in a great part of the samples.

We made grain size distribution examinations, to define better the characteristic materials of the Noszvaj exploration. We measured the grain-size distribution of samples, which belong to the normal or peptized (without coagulation)

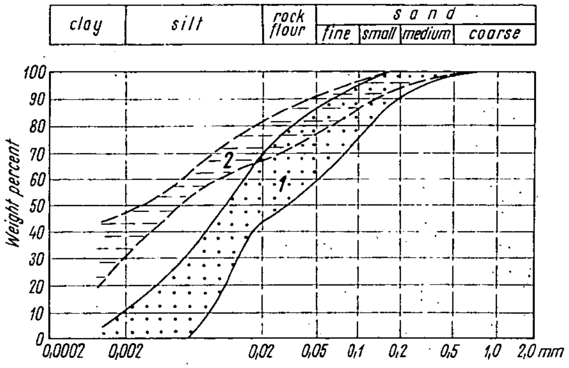

Fig. 9. Grain size composition cover curves of the investigated Middle Oligocene stratas from the clay exploration area of Eger—Noszvaj. *1.* Normal state; *2.* Peptized state.

state. The peptization was made with sodium ion exchange. The cover curves of grain size composition, on *Fig.* 9, show the extreme values in normal and peptized state. In accordance with this, the weight per cent of the clay fractions ($<$0,002 mm) changes between 0—10,5 in normal state and between 32,5—48,0 in peptized state. The flat curves reaching several ranges, illustrate the bad sorting of the sediments.

SUMMARY

The detailed geological knowledge of the two exploration areas, further the qualifying tests of materials, succeeded in the preliminary exploration of the planned cement plant's limestone and clay material. The limestone is directly accessible on the surface. According to the investigations, within the Upper Eocene formation every transition from the marl to the limestone can be found. Great part of the tested samples contains organic materials indicated also by thermal methods. In the limestone-marl stratas partly thin clay of marine origin partly clayey interbeddings formed afterwards during the weathering were found. The limestone has an average $CaCO_3$ content of 94,6 per cent, the clayley limestone 85,5 per cent, the calcareous marl 70,5 per cent and the marl 49,0 per cent. Below these layers mostly Upper Eocene terrestrial many-coloured clay stratas are deposited containing illite, kaolinite and quartz and in the deeper layers hematite too.

The clay of Middle Eocene age is to be found also on the surface. But its utilization is difficult owing to the interbedded manganic and sandy layers. The raw material contains dominantly illite, montmorillonite and less kaolinite.

The clay minerals are of divalent cation base, strongly coagulated. About 92 per cent of the samples investigated is of limy character, the carbonates are mostly present (6—20 per cent) as calcite and dolomitic calcite, respectively, according to the thermal and X-ray examinations.

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