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MIDDLE TRIASSIC VOLCANISM IN THE BUDA MOUNTAINS

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Abstract

The volcanogenic materials, like pebbles of the Middle and Upper Eocene basal conglomerates in the Buda Mts. were considered as products of the neutral volcanism beginning in the Middle Eocene. But in the last years the andesite gravels are supposed to be Triassic lava products. The present paper shows the presence of other volcanites, like rhyolite, ignimbrite, trachyte and tuff. These may have originated from a volcanic cycle of Middle Triassic age. It is supported by a detailed petrographical-geochemical comparison with the Middle Triassic volcanogenic material of Inota. The studied volcanic activity is the same which has produced the so-called "pietra verde" tuffitic beds in the Transdanubian Central Range. According to the megatectonic relations, these results are compatible with the general magmatic data on the Middle Triassic of the Southern Alps.

Introduction

The Eocene basal conglomerate of the Buda Mts. lies unconformably on Middle or Upper Triassic rocks. It indicates Middle Eocene (at János hill) and Upper Eocene (Róka hill, Kálvária hill) transgressions (WEIN, 1977). The conglomerate itself and the overlying limestone and marl contains thin tuffitic layers. This is the common cause for the widespread opinion that the considerable amount of andesite pebbles in the conglomerate has originated from Middle Eocene and younger volcanism (HOFFMANN, 1871). SZÉKY-FUX and BARABÁS (1953) considered the pebbles as of the same age, on the grounds of the occurrence of Eocene volcanic rocks in the other parts of the Transdanubian Central Range. The Budaörs – 1 key borehole penetrated an andesite body within a Triassic sequence between 775,1 – 831,4 metres. This was considered as Eocene, too (NAGY et al., 1967). The andesite and rhyolite pebbles of the conglomerate are of Eocene origin, according to WEIN (1977). During the revision of the igneous rocks in Budaörs – 1 borehole, Upper Cretaceous alkali ultrabasite-dykes were found within the andesite, consequently the andesite volcanism is of Mesozoic, most probably of Triassic age (KUBOVICS, 1985).

The Triassic sequence of the Buda Mts. is known downwards until the upper part of Ladinian; this sequence does not contain any igneous rock, except an uncertain, Carnian tuffitic layer (WEIN, 1977). The "pietra verde" tuffitic beds are widespread in other parts of the Transdanubian

Central Range. These are of Late Anisian to Early Ladinian age, with potassiumtrachyte and rhyolite composition (SZABÓ and RAVASZ, 1970; RAVASZ, 1973). A sequence of the same age, containing also lava rocks, was found at Inota; these rocks form pebbles in an Upper Ladinian abrasion conglomerate (RAINCSÁK, 1980).

Geological investigations

This study is based on the examination of three exposures of the basal conglomerate in the Buda Mts. (Fig. 1). Grain-size frequency distribution analysis was measured at all localities. Taking lithology into consi-

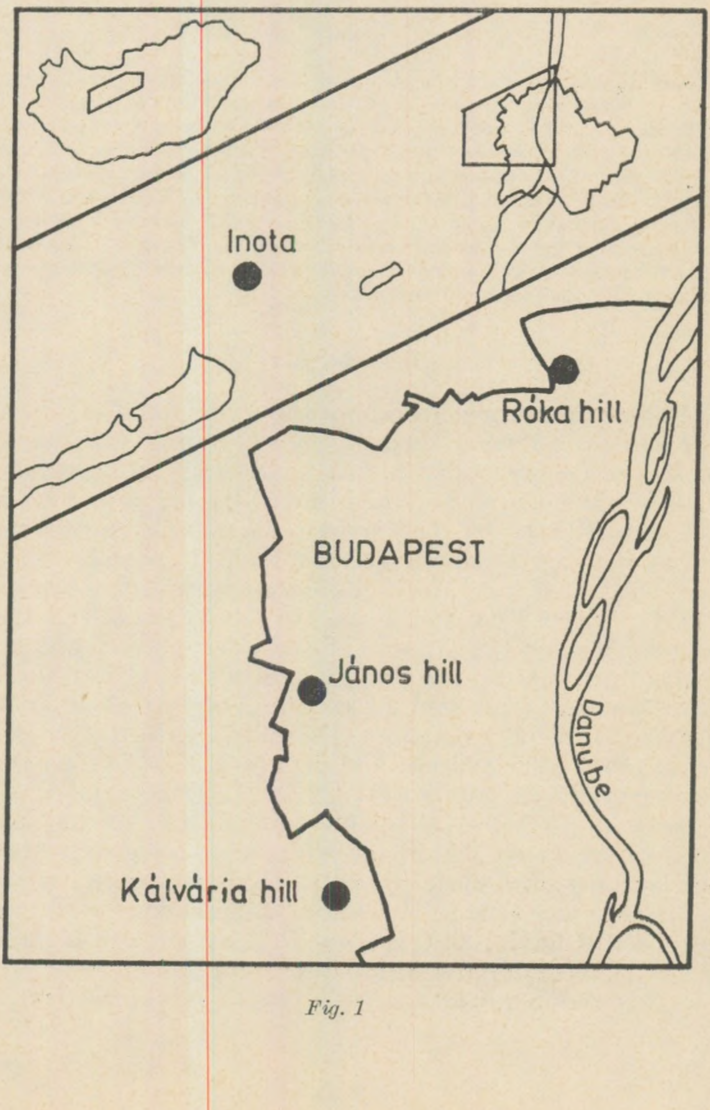

Fig. 1

deration, figure 2 summarizes these results. The dominant component of the clasts are carbonate rocks (Middle and Upper Triassic limestones and dolomites). The amount of volcanite pebbles at Kálvária hill is about 30, at János hill 15 and at Róka hill 5 percents. This relative decrease

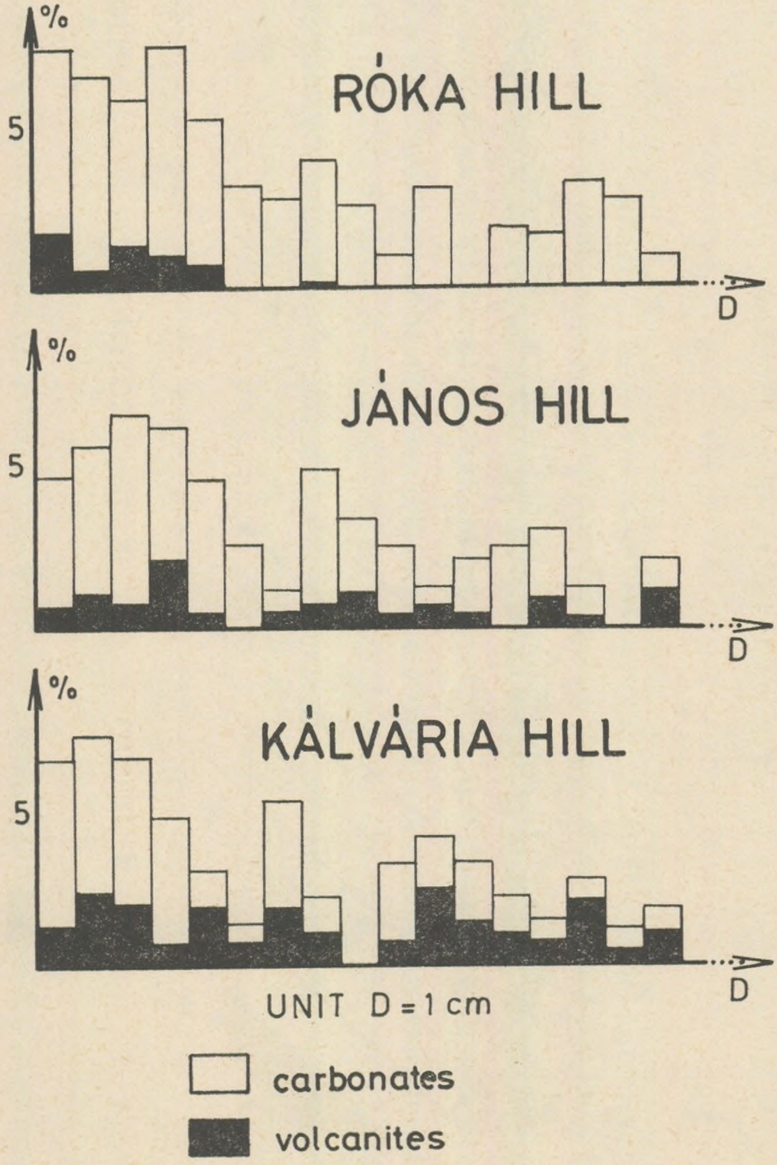

Fig. 2

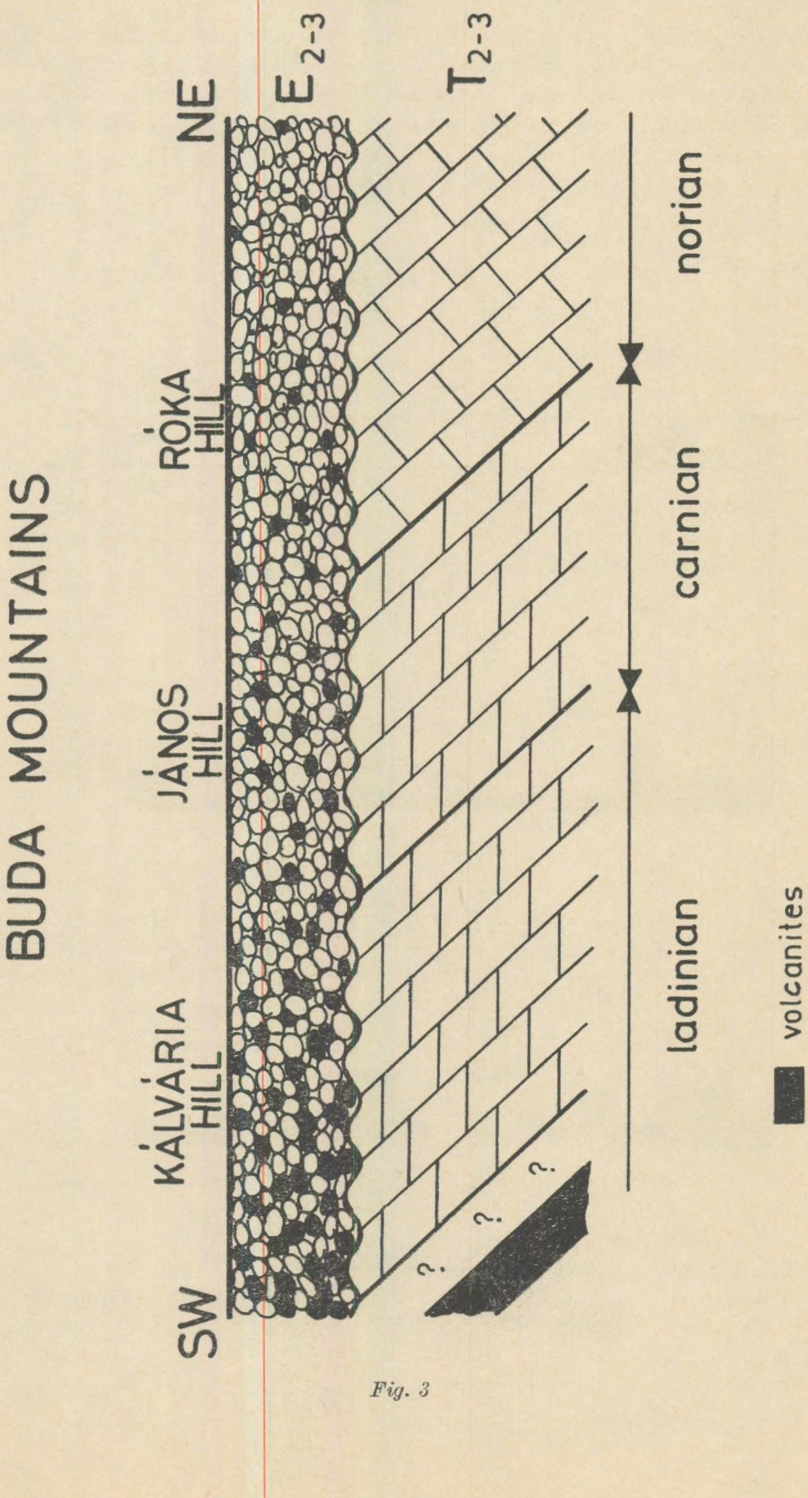
BUDA MOUNTAINS
SW
NE
KÁLVÁRIA HILL
JÁNOS HILL
RÓKA HILL
E_{2-3}
T_{2-3}
ladinian
carnian
norian
volcanites

Fig. 3

of volcanic material can be explained by supposing its origin from an Upper Anisian to Lower Ladinian volcanogenic level. It is well known that due to the Austrian tectonic event, the Triassic sequence of Buda Mts. is dipping to NE direction, therefore on the surface from SW to NE the formations are generally younger and younger. Thus the relative decrease in the amount of volcanite clasts is caused by the increase of stratigraphical distance, as it is shown in a very simple way on the figure 3. This is also supported by grain-size data because in the Southern outcrop (Kálvária hill) some of the boulders are over 40 cm in diameter, but in the Northern exposure (Róka hill) the maximal size is under 10 cm. Because of the presence of big boulders at the Kálvária hill, the source of this material might have been only some kilometers to south.

Since we have supposed a volcanic activity in the Buda Mts. of Middle Triassic age basing our hypothesis on the investigated volcanite pebbles, therefore it is necessary to make a comparison with a stratigraphically proven volcanogenic sequence of the same time. This occurence is at Inota. Here we have found a very similar volcanoclastic material as in the Buda Mts., so this was the basis for the detailed petrographical-geochemical comparison between the two areas.

Petrographical-geochemical investigations

Analytical procedures were: thin sections, chemical analyses, optical spectrography, X-ray diffractometry, neutron activation, K/Ar dating.

The main volcanic rock types are andesite, rhyolite, ignimbrite, trachyte and tuff in all studied exposures. Such volcanic association like this, is unknown from the Eocene.

a) *Andesite*

Black, brown or green rock, altered to a different extent. The kaolinitization of large-sized feldspars is very widespread. The originally presumably orthorhombic pyroxene shows completely glauconite-transformed feature. The biotite has limonitized and the ilmenite has suffered rutilization. The rock also contains apatite and rarely garnet. The groundmass consists of second generation plagioclase crystals, with an oligoclase-andesine composition. Secondary minerals are represented by quartz, chalcedony, opal, limonite, pyrite and calcite.

b) *Rhyolite*

Brownish-grey, with flow structure, its amount is less than the andesite. The flowage banding is typically marked by color differencies, the light colored bands are of quartz, opal and the dark colored bands are of biotite, limonite. The biotite phenocrystals, which have suffered magmatic resorption and limonitization show very significant preferred orientation. Also vesicular structure can be identified in some cases. Plagioclase-fragments with oligoclase composition of locally considerable quantity are found, in form of cumulates. Any distinction is not possible

Tab. 1.

All data by neutron activation. Analyst: J. Bérczi, Technical University of Budapest.
***: by the courtesy of Hungarian Geological Institute**

Sample number	1.	2.	3.	4.	(*) 5.	6.	7.	8.	9.	(*) 10.	11.	12.
Rock type Locality	Andesite Kálvária Hill	Andesite Kálvária Hill	Andesite Róka Hill	Andesite János Hill	Andesite Bő-1 Borehole	Ignimbrite Kálvária Hill	Rhyolite Kálvária Hill	Rhyolite Kálvária Hill	Rhyolite Inota	Rhyolite Inota	Rhyolite Inota	Trachyte Inota
La	17,9 ± 0,3	27,1 ± 0,5	20,2 ± 0,3	23,0 ± 0,3	25,0 ± 0,5	32,2 ± 0,4	32,8 ± 0,3	16,9 ± 0,3	17,5 ± 0,4	24,5 ± 0,5	31,9 ± 0,5	17,7 ± 0,5
Ce	49,5 ± 2,5	50,7 ± 1,7	40,2 ± 1,5	59,7 ± 1,8	58,6 ± 3,8	78,1 ± 1,3	37,3 ± 1,2	29,0 ± 1,6	43,7 ± 1,7	42,6 ± 2,0	73,5 ± 1,7	31,3 ± 1,3
Nd	25,6 ± 2,9	24,1 ± 2,0	22,8 ± 2,1	25,5 ± 1,7	25,5 ± 3,2	40,1 ± 2,3	12,4 ± 1,2	8,8 ± 1,4	11,9 ± 1,7	13,4 ± 1,0	25,8 ± 1,9	40,1 ± 2,4
Sm	5,0 ± 0,1	5,1 ± 0,1	6,4 ± 0,1	6,4 ± 0,1	8,5 ± 0,1	5,1 ± 0,1	5,8 ± 0,1	2,0 ± 0,1	2,9 ± 0,1	3,9 ± 0,1	4,0 ± 0,1	5,1 ± 0,0
Eu	0,68 ± 0,10	0,67 ± 0,09	0,47 ± 0,06	0,76 ± 0,07	0,93 ± 0,09	0,95 ± 0,09	0,32 ± 0,05	0,30 ± 0,08	0,48 ± 0,06	0,53 ± 0,04	0,97 ± 0,07	0,95 ± 0,1
Tb	1,2 ± 0,1	1,2 ± 0,1	1,1 ± 0,1	1,6 ± 0,1	1,0 ± 0,1	1,4 ± 0,1	0,6 ± 0,1	0,6 ± 0,1	0,7 ± 0,1	0,6 ± 0,1	1,5 ± 0,1	1,4 ± 0,1
Tm	0,4 ± 0,1	0,3 ± 0,1	0,5 ± 0,1	0,6 ± 0,1	0,3 ± 0,1	0,4 ± 0,1	0,2 ± 0,1	0,1 ± 0,1	0,2 ± 0,1	0,3 ± 0,1	0,8 ± 0,1	0,4 ± 0,1

Yb	3,0 ± 0,3	3,0 ± 0,3	3,0 ± 0,2	5,8 ± 0,2	3,2 ± 0,3	1,5 ± 0,2	2,2 ± 0,2	0,9 ± 0,3	1,5 ± 0,3	2,0 ± 0,2	5,4 ± 0,2	1,5 ± 0,2
Lu	0,40 ± 0,07	0,40 ± 0,06	0,40 ± 0,05	0,81 ± 0,05	0,53 ± 0,05	0,47 ± 0,06	0,11 ± 0,03	0,13 ± 0,04	0,19 ± 0,05	0,28 ± 0,02	0,77 ± 0,05	0,47 0,07
Th	4,2 ± 0,3	4,6 ± 0,3	4,8 ± 0,2	4,4 ± 0,2	11,5 ± 0,6	6,3 ± 0,4	5,3 ± 0,2	3,2 ± 0,2	4,3 ± 0,3	7,6 ± 0,4	3,4 ± 0,2	3,9 ± 0,2
Hf	0,9 ± 0,2	1,0 ± 0,2	1,1 ± 0,1	1,4 ± 0,01	4,5 ± 0,5	0,8 ± 0,2	0,8 ± 0,2	0,6 ± 0,2	0,7 ± 0,2	1,9 ± 0,3	0,5 ± 0,1	0,7 ± 0,1
Ta	0,2 ± 0,1	0,2 ± 0,1	0,2 ± 0,1	0,3 ± 0,2	0,8 ± 0,2	0,5 ± 0,2	0,3 ± 0,2	0,2 ± 0,1	0,5 ± 0,3	0,9 ± 0,1	0,5 ± 0,2	0,4 ± 0,3
Rb	15 ± 8	9 ± 8	15 ± 5	7 ± 6	124 ±20	14 ± 9	15 ± 6	3 ± 6	164 ± 22	190 ± 20	110 ± 10	136 ±12
Cs	3,5 ± 0,4	6,3 ± 0,4	0,7 ± 0,3	0,8 ± 0,3	23,2 ± 0,8	2,8 ± 0,3	2,6 ± 0,3	10,7 ± 0,3	2,0 ± 0,3	4,5 ± 0,3	5,3 ± 0,3	3,1 ± 0,3
Sc					17,0 ± 0,1					3,6 ± 0,1		
Cr					150 ± 7					30,0 ± 4		
Co					7,8 ± 0,3					4,7 ± 0,2		
Fe%					3,96 ± 0,07					2,26 ± 0,07		
U					2,0 ± 0,4					2,2 ± 0,4		

between the rhyolite samples from Inota and Buda Mts. according to the thin-section investigations, because of the great similarities between the two meterials.

c) *Ignimbrite*

Pale green, altered rock. Its relative amount is the same as of the rhyolite. The rock has a pale green matrix containing feldspar fragments (altered to kaolinite 1 T) and big lithic fragments (maximal diameter can be some cm) with typical "fiammé" form. Their material is mainly andesite mentioned above, consequently the ignimbritic volcanism is younger than the andesitic one. In the fluidal texture there are very many glass shards welding together. The chemical character of the rock is mainly rhyolitic. The amount of accesorial zircone and magmatic quartz is considerable locally.

d) *Trachyte*

Black, relatively unaltered rock, in very little amount. Its colour is deep green at Inota. Its common feature is the presence of large-sized feldspar crystals, whose unaltered specimens show a composition of oligoclase-andesine. The presence of augitic pyroxen and biotite is significant, groundmass consists of mainly potassium-feldspar, limonite, carbonate, clay-minerals, etc.

e) *Tuff*

The rock is generally of pale greyish-green colour, altered, fine-grained and made up for the most part by xenomorphic, isometric quartz grains. There are many glauconite-, chalcedony-filled cavities, attaining 5 mm in size. The mafic conponents have been replaced by secondary minerals. The feldspars have been affected by clay-mineralization. The rock also contains apatite and zircone. In some cases potassium-feldspar can be recognized. The limonitic patches are very widespread. On the ground of our investigations this rock is considered as "pietra verde".

The chemical analyses show high-grade alteration and effects of weathering. Therefore these data do not give enough information.

Since some trace elements, especially the rare earths are considered as relatively immobile during alteration and weathering, we have chosen them for the basis of comparison (Tab. 1). The chondrite-normalized (HASKIN et al., 1968) curves of samples (Fig. 4) seem to be very similar at first, independently of the rock type and locality. This qualitative statement can be proved by quantitative, statistical methods. We have used nonlinear mapping (SAMMON, 1969) and cluster analysis. The results are shown by the figures 5 and 6. Interpretations described in this discussion are tentative because of the small number of samples.

There are no characteristic differences among the andesite samples, since they form a well-separated group. Rhyolite samples are also relatively "together". This phenomenon in both cases can be explained by the genetic connection of volcanism in the Buda Mts. and at Inota. The

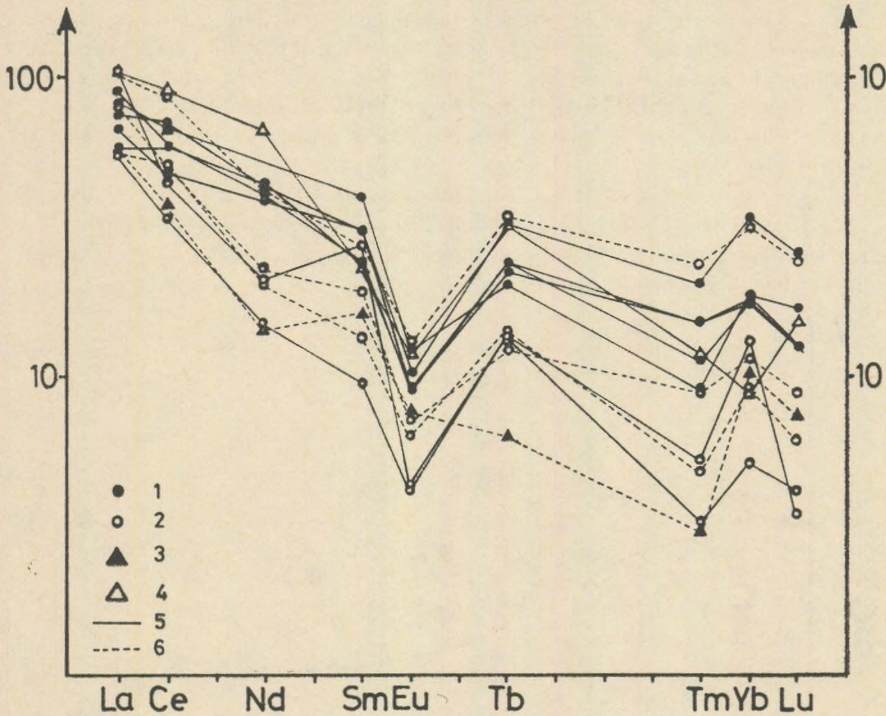

Fig. 4. 1. Andesite; 2. Rhyolite; 3. Trachyte; 4. Ignimbrite; 5. Buda Mts.; 6. Inota.

Tab. 2.

Analyst: K. Balogh, Institute of Nuclear Research of the Hungarian Academy of Sciences Debrecen

Rock name Locality	K (%)	$^{40}Ar_{rad}$ (cm^3/g)(%)		K/Ar age in million years	Notes
Andesite Kálvária Hill	0,45	$6,3205 \cdot 10^{-7}$	3	36 ± 17	Strongly altered
Rhyolite Kálvária Hill	0,142	$4,075 \cdot 10^{-7}$	13	$72,5 \pm 8$	Altered
Andesite Róka Hill	0,466	$2,965 \cdot 10^{-6}$	59	157 ± 7	Altered
Trachyte Inota	4,57	$4,4775 \cdot 10^{-5}$	98	236 ± 9	

11. sample seems to be an exception, it has extremely high concentrations. The high negative Eu-anomaly is very significant in all cases, excepting 12. sample. This can be explained only by a complex, multi-stage magmatic process, according to the presence of neutral and acid lava products together. The volcanism, as a whole, has a calc-alkaline feature with alkaline affinity.

Referring to table 2 the radiometric ages of the studied volcanites are very different. It might have been caused by the alteration and weathering of different extent. In one case (4. sample) the method probably has provided the real age.

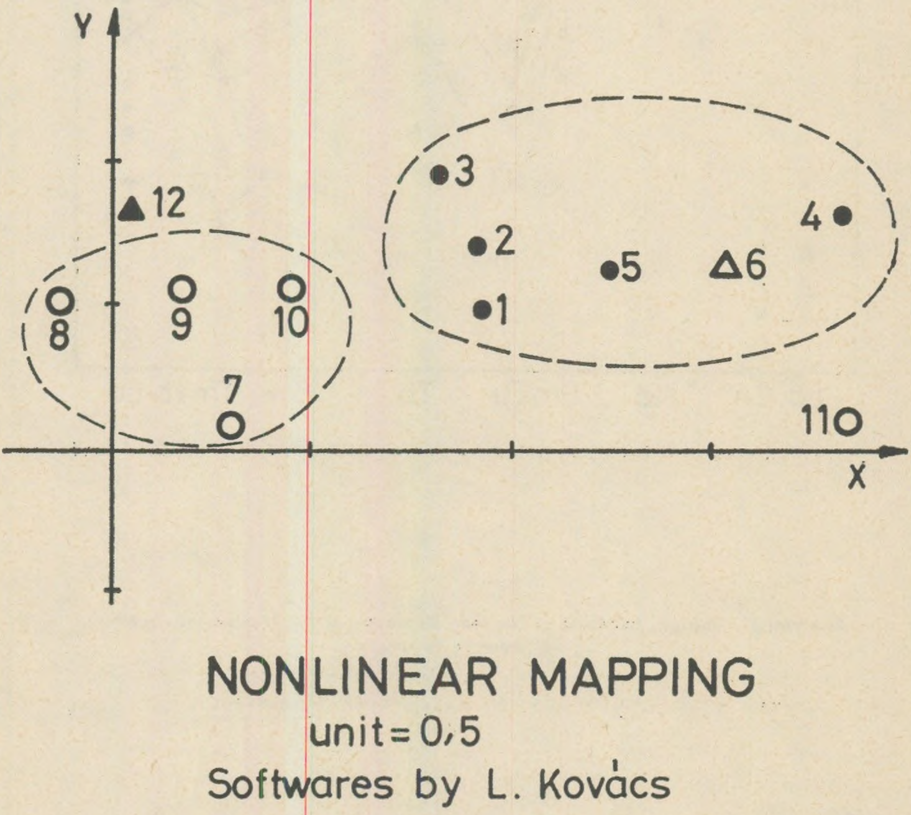

Fig. 5

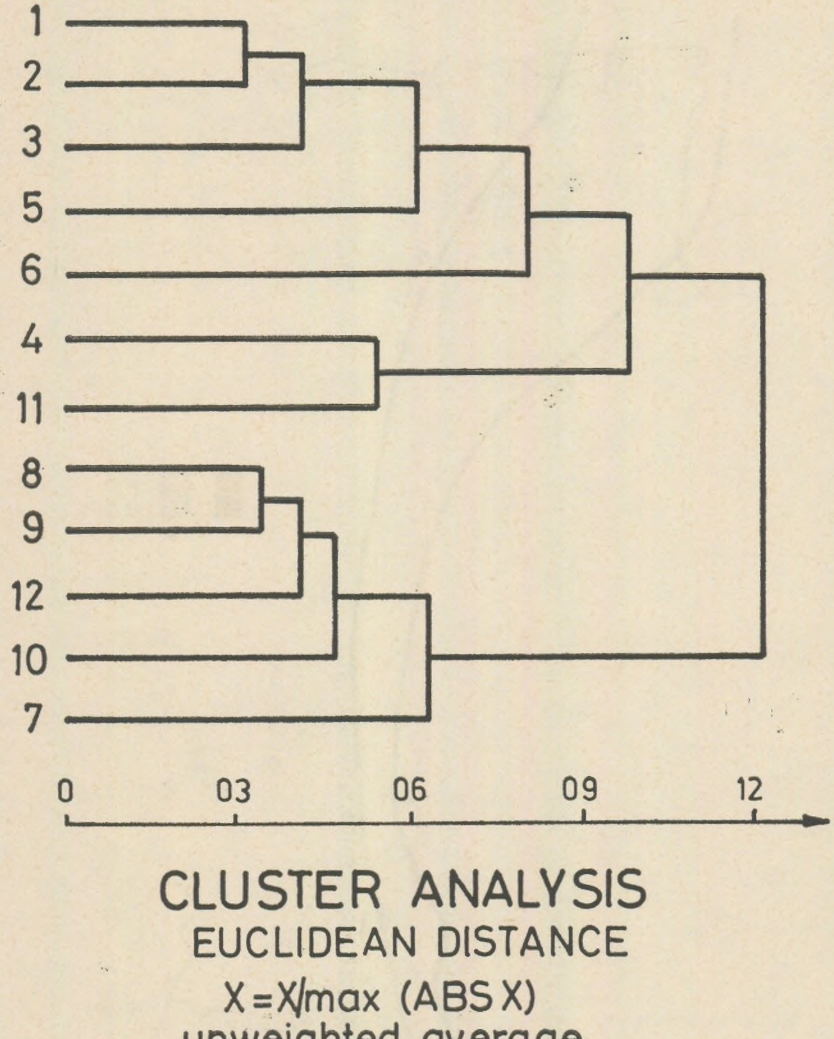

Fig. 6

Tectonic connections

The study of Cros and Szabó (1986) has shown the paleogeographic relations between the Aniso-Ladinian Alpine sequences and the Hungarian provinces in general, on the grounds of the tuffitic characters. According to Kázmér and Kovács (1985) the so-called Bakony-Drauzug unit shifted about 450 km to the east in the Paleogene. Since the studied volcanites

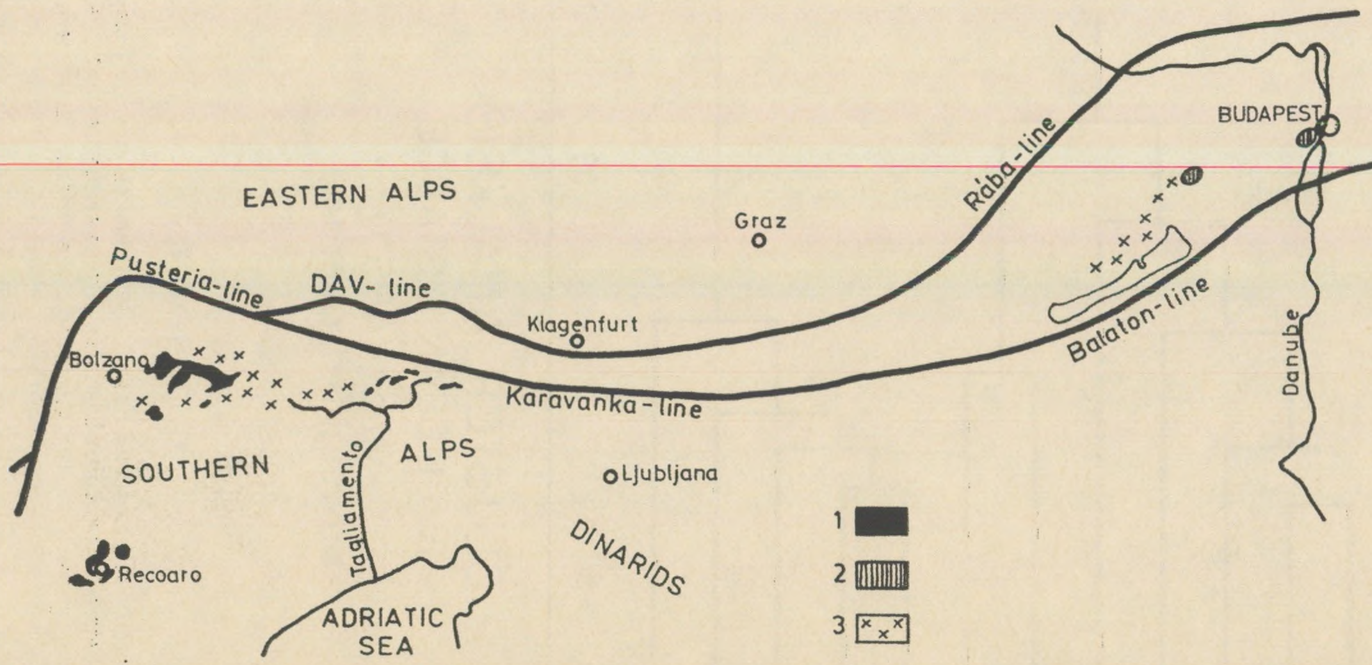

Fig. 7. 1. Middle Triassic magmatites; 2. (buried Middle Triassic magmatites (considered in this study); 3. Middle Triassic tuffs.

are in this tectonic unit, after the restoration the Transdanubian Central Range will be very close to the well-known Middle Triassic magmatic provinces in the Southern Alps (Fig. 7). The data on this magmatism (PISA, 1980) are compatible with the volcanism described in this paper, the genetic relationship between them will be proved later by a detailed comparative investigation.

Conclusions

a) The andesite, rhyolite, ignimbrite, trachyte and tuff pebbles of the Middle and Upper Eocene basal conglomerates in the Buda Mts. are eroded and redeposited products of an Upper Anisian to Lower Ladinian volcanic activity.

b) This is the same volcanism, which has produced the so-called "pietra verde" beds in the Transdanubian Central Range.

c) On the grounds of the investigations of volcanites, these have calc-alkaline feature with alkaline affinity.

Acknowledgements

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REFERENCES

CROS P., SZABÓ I. (1984): Comparison of the Triassic volcanogenic formations in Hungary and in the Alps. Paleogeographic criteria. Acta Geologica Hungarica 27, 3–4, pp. 265–276.

HASKIN L. et al. (1968): Relative and absolute terrestrial abundances of the rare earths. In: L. H. Ahrens (Editor): Origin and Distribution of the Elements. Pergamon, Oxford, pp. 889–912.

HOFFMANN K. (1871): The geological conditions of the Buda-Kovácsi Mts. (in Hungarian). Ann. Rep. Hung. Geol. Inst, 1871, pp. 199–273.

KÁZMÉR M., KOVÁCS S. (1985): Permian-Paleogene paleogeography along the eastern part of the Insubric-Periadriatic lineament system: evidence for continental escape of the Bakony-Drauzug unit. Acta Geologica Hungarica 28. 1–2, pp. 71–84.

KUBOVICS I. (1985): Mesozoic magmatism of the Transdanubian Midmountains. Acta Geologica Hungarica 28. 3–4: pp. 141–164.

NAGY E., NAGY G., SZÉKY F. (1967): The Budaörs–1 key borehole. (in Hungarian). Ann. Rep. Hung, Geol. Inst. 1965, pp. 289–303.

PISA G., CASTELLARIN A., LUCCHINI F., ROSSI P. L., SIMBOLI G., BOSELLINI A., SOMMAVILLA E. (1980): Middle Triassic magmatism in Southern Alps, I. A review of general data in the Dolomites. Riv. Ital. Paleont. 85. 3–4, pp. 1093–1110.

RAINCSÁK GY. (1980): Geological makeup and structure of a Triassic range between Várpalota and Iszkaszentgyörgy (in Hungarian). Ann. Rep. Hung. Geol. Inst. 1978, pp. 187–196.

RAVASZ CS. (1973): Mineralogical-petrographical studies on Middle Triassic tuffs of the Transdanubian Central Mts., Hungary. Acta Mineralogica-Petrographica, Szeged 21. 1, pp. 123–139.

SAMMON J. W. (1969): A Nonlinear Mapping for Data Structure Analysis. IEEE Trans. Computers 18. 5., pp. 401—409.
SZABÓ I., AVASZ CS. 1970): Investigation of the Middle Triassic Volcanics of the Transdanubian Central Mountains, Hungary. Ann. Mus. Nat. Gung., min, geol. pal., 62. pp. 31—51.
SZÉKY—FUX V., BARABÁS A. (1953): The Taransdanubian Upper Eocene Volcanism. (in Hungarian) Földt. Közl., 83, pp. 217—229.
WEIN GY. (1977): The tectoeics of the Buda Mountains, (in Hungarian) MÁFI, special edition, Budapest, pp. 1—76.

THE SOUTHERN BÜKK (N HUNGARY) TRIASSIC REVISITED: THE BERVAVÖLGY LIMESTONE

by

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Abstract

The Bervavölgy Limestone lies north of Eger, in the Southern Bükk Mts. (N Hungary). Its stratigraphic position is unclear; tectonic contacts with Jurassic (?) silty shale and Middle – Upper Triassic (?) cherty limestone were observed. No previous facies investigations have been made on this formation. Its age was determined as Ladinian (Schréter), Middle Carnian, later as Uppermost Carnian – Norian (Balogh).

The recent investigations recognized a Ladinian, Wetterstein-type reef complex, with open lagoon, plateau margin sand dunes and reef. Its flora and fauna (algae, calcareous sponges and foraminifers) are similar to those of the Wetterstein limestone. Up to now only the Ladinian age is proven. The rock texture indicates significant pressure after diagenesis, below the anchimetamorphic grade.

Up to now the Wetterstein limestone was known in a small, Hungarian part of the Silice nappe. This locality is the southernmost occurrence of Wetterstein-type limestone in the Inner West Carpathians.

Introduction

The aim of our work was to study the microfacies one of the limestone complexes of the Bükk Mts., Norththern Hungary, Inner West Carpathians. We have investigated two quarries at Felnémet and at Felsőtárkány between Berva Valley and Mészvölgy Valley and the limestone sequence of borehole F – 8. Some outcrops between the localities have been examined also.

The investigation of the Bervavölgy Limestone was the diplom thesis work for F. VELLEDITS in 1984 and 1985, following the suggestions of P. PELIKÁN. CS. PÉRÓ joined the field work in December, 1984. The study of the literature on carbonate microfacies, the preparation of thin sections, their description, interpretation and the facies analysis was made by F. VELLEDITS.

Sincere thank are due to S. KOVÁCS for the determination of the calcareous sponges and for inspiring discussions, to J. HAAS for his advices in carbonate facies analysis, to P. PELIKÁN for his suggestion of the topic and for useful advices, for O. PIROS for the determination of calcareous algae and to P. ÁRKAI for the X-ray determinations.

Special thanks are due to the geologists of the National Mineral and Ore Company (OÉÁ): L. RADOVITS, for the access to the core material of borehole F – 8, and for supplying data on the Felnémet quarry and his enormous experiences and to J. CSILLAG for his many kind of help.

2. Historical background

The first detailed geological survey and description of the area examined was made by SCHRÉTER (1912, 1935, 1943a, 1943b). Based on fossils (gastropods) he compared the limestone to the South Alpine carbonate facies (Esino, Marmolata). It was correlated with the Cassian beds (by corals, crinoid stems and Cidaris spines).

MÁRTON (1957) was the only one, who stressed the differences between the rocks in Berva and Mészvölgy Valley. BALOGH (1964) in his monograph on the Bükk Mts. considered the Berva Limestone as a heteropic facies of the Fennsík Limestone, being of Carnian age based on faunistic data. In his review on the correlation of the Hungarian Triassic formations (1981), he ranged it into the Uppermost Carnian – Norian.

No detailed, modern facies investigation was made on this area before our study.

3. Stratigraphic and tectonic position

Several different lithologies are found in the investigated region. Following the sequence north-westward from the Bervavölgy Limestone locality the following complexes come one after the other forming 200 – 450 m wide bands:

– Silty shale – shale (Jurassic?), contacting the Bervavölgy Limestone along fault of 65 – 70° dip;

– Cherty, platy limestone (Middle-Upper Triassic?). There is direct contact with the Bervavölgy Limestone on Tűzkövesorom Hill;

– Sandstone, shale with gabbroic intrusions and diabase pillow lavas (Jurassic to Cretaceous?) at Szarvaskő.

Several localities have been found, where different lithologies have tectonic contacts along deeply dipping faults. Towards the south and east the Bervavölgy Limestone is covered by Tertiary basin-filling sediments.

Tectonic position of the Bervavölgy Limestone:

– According to the opinion of SCHRÉTER (1943b) it forms tectonic windows below a scale made of shale-siltstone.

– BALOGH (1964) supposed a continuous sequence between the lower, Lower Ladinian shale and the upper, Upper Ladinian – Carnian limestone.

– KOVÁCS (1985, pers. comm.): The Bervavölgy Limestone might be the remnant of a nappe overthrust over the shale, or an olistothrymma within it.

4. The Felnémet limestone quarry

4.1. Sequence

The quarry is situated in the SW flank of Berva-bérc Hill, at an altitude between 360 and 508 m a.s.l. The rocks are exposed on five floors. The 600 m long quarry walls expose a 350 m thick sequence only, due to the 315/35° dip of the strata. The rock is crossed by several systems of faults, (Plate I. fig. 2.) providing way for intense solution by thermal waters and carbonate mineralization. Due to compressive stresses the original texture shows considerable deformation. The quarry scree covers the walls up to great heights.

A general description of the sequence will follow, and the characterization of some interesting profiles.

The I. group of beds is underlain by a few metres thick, bedded, medium to light grey limestone. It is covered by 85 m white, homogeneous limestone. Rare light grey beds contain frequent synsedimentary fissure infills; these may indicate occasional subaerial exposure. Fossils were observed on weathered surfaces: crinoids, echinoid fragments, mollusc shell fragments, coral debris, gastropods, sphinctozoans and brachiopods. An autochthonous coral colony was observed also. This group have been deposited in a well oxygenated, subtidal environment near a reef.

The II., dark grey group of beds is developed from the white limestone by alternating white and grey beds of 20 – 30 cm thickness, formed of coral debris, or it has been deposited on the uneven surface and in small fissures of the white limestone (Plate I, fig. 1). The appearance of light to dark grey, well-bedded rocks indicate a sudden change in the depositional environment. The sedimentation was continued in a shallower, often restricted lagoonal environment far from the reef. The variability within the basin is well shown by the fact, that the continuous and discontinuous transition between the two environments was obserbved within a distance of 35 metres.

The dark grey limestone is 30 m thick, with alternating 2 – 4 m thick dark grey strata with intraclasts and thinner (1 – 1,5 m), homogeneous beds. Bedding surfaces are frequently stilolitic with thin clay films. Wedges of coarse-grained beds with black brecciated clasts were frequently observed.

The III. group of beds forms more than half of the exposure, being ca. 200 m thick. It shows a gradual transition to the dark grey underlying sediments. Cyclic interfingering of 1 – 3 m thick, light grey and 0,1 – 1 m thick dark grey limestone beds can be observed, with gradual transition (Plate II, fig. 1). The light, homogenous limestone turns into a plastoclastic limestone upwards, made of mixed light and medium grey lime mud. In the upper part of both types an enrichment of black and grey intraclasts of 1 – 5 cm diameter were observed. This is covered by dark grey, partly dolomitic limestone. Two kinds of dolomitization can be obesrved: redeposition of yellowish brown dolomite mud to form 5 – 10 cm lenses or a homogeneous dolomitization during early diagenesis. A yellowish white, microlaminated, fenestral algal mat layer terminates the cycle, with frequently fractured upper parts. There is no terrigenous material on the resorbed surfaces, not counting clay films less than 1 mm in thickness.

The IIIrd group of strata is divided by a white limestone bed (Plate II, fig. 2). This level overlies the resorbed surface of the dark grey limestone (Plate II, fig. 3) or interfingers with it. It is somewhat similar to the white limestone of the Ist group of strata with homogeneous matrix. It contains rounded, white intraclasts, mollusc and echinoderm fragments up to 3 mm in diameter.

It is again overlain by cyclic sediments with somewhat thicker light grey beds with less black intraclasts. The dark grey beds are thinner and the beds with coarse black breccia are of subordinate importance (Plate II, fig. 2). The higher part of the IIIrd group of beds is characterized by darker cycles again; it frequently shows spotty dolomitization.

The IVth group of beds is almost 50 m thick. Large boulders with resedimented coral colonies and coarse (10 – 30 cm) synsedimentary breccia were found in the scree. This facies indicates a sudden change in the sedimentation environment. The sequence of the quarry wall is characterized by cyclic alternation of medium and dark grey limestone beds. Two white limestone beds within the group overlay intraclastic grey limestone with black breccia and frequent dolomitic lenses. The lower, 2,5 to 3 m thick white bed is fine grained limestone with echinoderm fragments. The upper, 9 m thick white limestone bed locally contains abundant coral fragments. The scree of the wall yielded ammonites related to *Ptychites* (Plate VIII, fig. 1 – 2) and the cross-section of a *Megalodon* (?), 10 cm in diameter. (Plate VIII, fig 4). The sequence of the quarry is closed by a medium grey, homogeneous and a medium to dark grey microlaminated limestone (Profile Fn – IV).

4.2. *Facies types in the Felnémet limestone quarry*

Seven main facies types have been distinguished by field observations and laboratory examinations.

Facies I: Algal mat bindstone

Macroscopic description: Alternating, 2 – 8 mm thick yellowish white and 02, – 4 mm thick greyish, parallel laminae. The dark laminae are rarely substituted by 1 × 3 mm holes in rows, filled by sparite (fenestral structure). Locally fragmented due to desiccation (Plate III, figs. 1 – 2).

Microscopic description: The thicker, white laminae are built of micritic substance, secreted or bound by bluish-green algae; locally dolomitized. The darker laminae or lenticles are made of calcite spar. Desiccation cracks are filled by coarse grained calcite. The void-filling calcite crystals display a 45° orientation due to tectonic stress.

Interpretation: Intertidal algal mat facies (e.g. Fn – II, 11,5 – 12,5 m; 16,9 – 17,0 m and Fn – III: 5,0 – 5,25 m; 7,56 – 7,66 m).

Facies II: Oncoid grainstone/rudstone

Three groups were separated within this facies according to the material of the dominant oncoids and to the quality of encrustations.

Macroscopic description: Oncoids and encrusted algal fragments in medium grey matrix. There are 2 – 3 cm thick oncoid layers, with upwards fining grain size (from 8 to 2 mm) (Plate V, fig. 1). Elongation of intraclasts makes an angle of 40 – 45° with the bedding. (Plate VI, fig. 2). Microscopic description: Encrusted grains (4 – 8 mm), among others black, rounded, medium grey mud clasts up to 2 mm in diameter. Mostly algae (Solenoporaceae, Codiaceae) form the cores of the larger coated grains (Plate V, fig. 2, 4). Twenty percent of oncoid cores are formed of micritic mud clasts (never deformed) and recrystallized biogenic fragments. The coating of the grains is intact, regular, showing 2 – 3 layers. Uncoated biogenic fragments also occur in the matrix in subordinate quantities: foraminifers and crinoid plates corroded by algal activity. Interpretation: Wave action constantly kept the grains in motion, making them rounded and coated. The sediment was deposited in an intertidal environment under wave action.

Facies II/a: The oncoids are dolomitic or calcitic; there are multiple oncoids among the formers (Plate VI, fig. 1 – 2).

Interpretation: The occurrence of oncoids indicate a shallow marine, rarely hypersaline environment. If the sediment spent more time under strong wave action, multiple oncoids were formed (e.g. Fn – III: 7,28 – 7,38 m; 10,82 – 11,00 m).

Facies II/b: There are vadose pisoids besides the oncoids. Also stylolitic surfaces occur every 2 – 3 cm, with partly solved clasts.

Interpretation: Components of different origin are mixed here:

1. Grains coated by algae and bacteria were formed in a permanently moving water, in the zone of intense wave action.

2. Vadose pisoids were formed above the intertidal zone, and were resedimented to wave-affected zones. Long, arid periods with hypersaline periods alternated with short periods, when diluting effect of fresh water (meteoric water) is dominant. The unsaturated water solved sediment particles, then the exsolved carbonate precipitated in the deeper part of the vadose zone. This is the explanation for the formation of pisoidic crusts parallel with the bedding (Plate V, fig. 1). Intraclasts and oncoids are coated by similar crusts (Plate V, fig, 3) (Rüdiger, 1984). The clasts partly dolomitized during late diagenetic processes (e. g. Fn – II: 12,50 – 12,70 m; and Fn – III: 6,94 – 7,18 m).

3. Resorbed surfaces indicate zones, which were above the intertidal zone for longer times.

Facies III: Rudstone of mudstone clasts (intraformational breccia)

Macroscopic description: White to grey, mostly sparitic, calcareous matrix contains angular, grey or black intraclasts. Their diameter mostly ranges between 1 – 1,5 cm, but smaller, 0,5 cm and larger, max. 10 cm intraclasts also occur (Plate IV, fig. 1 – 2). Where the yellowish brown, micritic, dolomitic matrix appears, there are some larger (2 – 3 cm) gastropods and bivalves. There are frequent angular voids of 2 – 3 mm in size, filled by calcite. These layers overlay surfaces, which were affected by multiple solution and covered by thin, green clay film, wedging out within a short distance. Some zones contains intraclasts oriented by tectonic stress.

Microscopic description: Intraclasts with sparitic matrix. Intraclasts form 30 – 40% of the rock. The rock was separated into three groups according the colour, quality, quantity and size of the intraclasts.

Facies III/a: The intraclasts are micritic or oncoidic limestone without biogenic fragments.

Facies III/b: There are less than 10% biogenic components (Solenopora, Echinodermata) in the intraclasts.

Facies III/c: There is 5 – 10% bioclast (Solenoporaceae, Codiaceae, Gastropoda, Bivalvia fragments and echinoderm fragments) besides the intraclasts. The larger intraclasts of several cm in diameter are made of two limestone types: the first is more rich in fossils with micritic matrix, the second is fossil-poor, with sparite matrix.

Interpretation: Sediment reworked by wave action and deposited in tidal channels (e.g. Fn – II: 7,25 – 7,40 m; 8,25 – 8,38 m).

Facies IV: Floatstone made of mudstone clasts

Macroscopic description: The matrix is bluish grey limestone. It contains light grey, often dolomitic (1 – 4 mm) and black (1 – 8 mm), flattened intraclasts arranged in bands. (Plate III, fig. 2). The bedding surface shows isometric intraclasts of 0,2 – 1,5 cm diameter. Size range of the clasts commonly grows towards the bedding surfaces, showing less and less rounding. There is a black crust along bedding surfaces and on the bottom surface of the intraclasts, rarely coating the grains.

Microscopic description: The microfacies is varied. Most frequent are the micritic and sparitic lenses arranged in elongated bands. The micritic field contains dark grey and black, strongly flattened intraclasts. Rare echinoderm fragments occur in the matrix; their outline is followed by the parallel micritic and sparitic bands (Plate III, fig. 4). Where the micritic matrix dominates, it forms coherent layers. Its oriented texture and the folding of calcite veins were made by tectonic stresses.

Interpretation: Sediment deposited below wave base, in a quiet lagoonal environment, near the mouth of the intertidal channel.

The facies IV. frequently contains zebra limestone. (Plate VI. fig. 3).

Macroscopic description: Almost parallel, 4 – 5 mm thick, flat fissures occur in the rock every 4 – 5 cm. These are filled by two-generation calcite.

Interpretation (FLÜGEL, 1982): Fissures are formed due to desiccation in the sediments deposited below intertidal zone. Calcite is formed during diagenesis.

Facies V: Plastoclastic floatstone

Macroscopic description: Light grey matrix with violet tint contains plastoclasts of variable size (2 – 15 cm) and quantity. These are brownish grey coloured (Plate III, fig. 3). Their material is similar to Facies type IV.

Interpretation: Unlithified calcareous mud have been redeposited into the depositional environment of the light grey lime mud. Deposited below intertidal zone, in an environment more quiet than that of type IV.

The originally lenticular clasts show chaotic mixing. Tectonic stress caused considerable elongation (e.g. Fn – II: 3,10 – 3,75 m; and at the S end of stage V of the quarry).

Facies VI: Mudstone

Facies VI/a: Homogeneous mudstone.

Macroscopic description: Light grey to grey, homogeneous limestone with a violet tint. A few large (8 – 15 cm) bivalve biomorphs were found; the cast was filled by yellowish brown, marly carbonate material (Plate VIII, fig. 4).

Interpretation: Deposited below wave base, far from the lagoon reef and from the shore, in somewhat more deep environment. (E.g.: Fn – II 0,00 – 1,10 m; 6,32 – 6,60 m; and Fn – IV: 14,80 – 15,50 m). Microlaminated mudstone. Facies VI/b:

Macroscopic description: Microlaminated limestone made of alternating 3 – 5 mm thick light and dark grey laminae.

Interpretation: Deposited below wave base, in a quiet environment.

This rock forms the uppermost beds exposed by the quarry. (Fn – IV 15,50 – 17,50 m).

Facies VII: Bioclastic floatstone – rudstone

Facies VII/a: Mixed bioclastic floatstone-rudstone. Macroscopic description: Light grey limestone with white rounded spots of 0,5 – 2 cm diameter (possibly recrystallized coral fragments). The matrix contains mm-size mollusc shell fragments and tiny echinoderm fragments. Microscopic description Bioclasts without any ordering, contacting each other (40 – 50% of the thin section), in micritic – rarely grainstone – matrix. In order of frequency: Solenoporaceae, Codiaceae, echinoderm plates, gastropods, bivalves, sphinctozoans, and other sponges (Plate VII, fig. 1 – 4).

Interpretation: Deposited near a reef, in a lagoon; besides the autochthonous fossils large quantities of allochthonous biogenic clastics have been deposited. The *Stylothalamia dehmi* OTT (described by S. KOVÁCS) found in this facies indicates a Ladinian-Carnian age (Plate VII, fig. 3 – 4). The most fossil-rich level was observed at the lower third of the Ist group of beds, in the Ist stage of the quarry (360 m a.s.l.).

Facies VII/b: Coral fragment floatstone-rudstone. Macroscopic description: Alternating 2–40 cm thick beds with coral fragments and 5–10 cm thick micritic layers. The former is white to light grey limestone, with a frame made of parallel oriented, 0,5×4 cm sized coral branch fragments contacting each other. Its micritic matrix contains 1–2 mm sized coated intraclasts and mollusc fragments. The clasts are coated by a tenth of a millimetre thick white crust.

Interpretation: The large quantity of coral debris was transported into the lagoon by a strong current coming from the reef. This level contains the allochthonous ammonoids.

Its sole occurrence is at the upper part of the sequence, in the Fn–IV profile between 5,4–14,4 m.

4.3. *Facies types in the Felnémet quarry*

This sequence of ca. 350 m thickness has been deposited on a permanently subsiding platform, surrounded by coral and sponge reefs and moving calcareous sand dunes, lying far from any dry land. It is indicated by the very low terrigenous content and the rare occurrence of marly rocks and clay films. The reef protecting the lagoon is poorly exposed: its sequence is described from its fragments intercalating with the lagoon sediments and from the exposed sequences of the surrounding area (borehole F–8, Mész valley, Felsőtárkány quarry).

The I. group of beds is very weakly bedded, white, homogeneous limestone. It was deposited in a near-reef, lagoonal subtidal environment, supported by the appearance of redeposited fiossils (see under 4.1.).

The II. and III. group of beds were deposited in the far-reef environment of the lagoon. The conspicuous cyclicity was caused by frequent change of sediments deposited below wave base, in the intertidal and in the supratidal zones (see 4.1.). The grey colour of the beds becomes more enhanced upwards, the intraclasts grow upwards in size become less rounded and show greater enrichment upwards. Also the dolomite content increases upwards. All these features are caused by the gradual decrease of water depth. The intertidal zone is indicated by algal mats, intertidal channels and (in the lower part of the group of beds) by intercalation of calcareous sand. The supratidal periods are characterized by resorbed surfaces, desiccation cracks, with synsedimentary and/or sparitic infill and vadose levels.

The II. group of of beds is more variable sediment, had been raised to the supratidal zone more frequently, while most of the III. group of beds is a more "regular" cyclic sediment. These groups of beds are poor in fossils. A violet-tinted light grey facies, deposited in a quiet, subtidal zone is frequent.

In the lower part of the IV. group of beds we can observe again the results of a sedimentation similar to the more shallow water, and more variable characters of the II. group of beds. A sudden change in environmental factors is indicated by the appearance of coarse brecciated, limestone, then by a limestone rich in coral fragments (see under 4.1.). This might have been caused by the destroy of the coral reef which previously protected the lagoon from intense wave action. This hypothesis is further corroborated by the occurrence of "exotic" ammonites.

The uppermost beds of the sequence indicate the recovery of the quiet, subtidal lagoonal environment.

5. Felnémet-8 borehole

Locality: eastern side of Berva-bérc and Cseres-bérc, in the saddle between points 512 and 508. The continuous carbonate sequence is between 78 – 198,6 m

5.1. Facies types of Felnémet – 8 borehole

Facies I: Grainstone/rudstone with algal and mudstone intraclasts

Dominant rock type in this sequence.

Description: A light to medium grey matrix contains 1 to 10 mm flattened, slightly rounded intraclasts, with a thin light grey crust at the upper part of the borehole. At the lower part of the borehole (below 140 m) frequent black coating of the grains were observed. The intraclasts are mostly graded – rarely show reverse grading – some cm thick cycles may be observed, frequently bearing stylolitic boundaries. Thin, homogeneous intercalations were observed too (Facies III). Dip of the beds changes between 0 to 30°, indicating cross-bedding. Rare algal and molluscan cross-sections were observed, too.

Microscopic description: A sparite matrix contains dark grey, micritic, rounded mud lumps of less than 2 mm in diameter and rounded intraclasts and biogenic detritus of 2 to 4 mm in diameter (40 – 60%). 60% of the larger intraclasts are made of algae, while 40% are made of micritic limestone (Pl. XI, fig. 1). Frequent micritic coating, indicating the activity of boring organisms, were observed. The fossil content ranges from 5 to 20%: algae (Solenoporaceae, Codiaceae), Echinodermata, Gastropoda, Foraminifera, Mollusca, Ostracoda and echinoid spines. Dogtooth cement coating the intraclasts was observed frequently, as well as geopetal structures. The rock bears an oriented texture due to pressure load (Pl. XI, fig. 1).

Interpretation: The sediment was deposited under constant wave motion: the strong current activity winnowed the micrite from among the grains (6. facies of WILSON). It was a calcareous sand dune moving on a plateau margin. The reverse grading was made by the effect of the "kinetic mesh" (FLÜGEL, 1982) (e.g.: 107 – 108,60 m; 120,40 – 121,50 m; 146,0 – 153,0 m; 169,5 – 173,0 m; 181,5 – 188,5 m)

Between 103,0 – 169,3 m a late diagenetic dolomitization of facies type II was observed. CaO – MgO ratio varies from 34 : 19 to 52 : 3 in the samples.

Macroscopic description: The groundmass is yellowish brown to brownish grey, the fissures are filled by a micritic, marly sediment of yellow to pink tint. The larger intraclasts are coated by one- or multi-layered yellowish crust.

Microscopic description: The groundmass is dolomitic in spots. The larger intraclasts (1 to 2 cm) are surrounded by dolomite rhombohedra less than 1 mm in size (Pl. XI, figs. 2–3).

Interpretation: The dolomitized section indicates a hypersaline environment, due to a late rise of the sediments. Mg-rich solutions percolated in the sediment, dolomitizing the porous calcareous sand.

Facies II: Grainstone with mudstone intraclasts

Macroscopic description: Grey, homogeneous limestone. Light grains, less than 1 mm in size can be found in the matrix. Several birdseye voids have been observed, ranged in 45° angles.

Microscopic description: Mud lumps, less than 0,2 mm in diameter, in sparite cement, displaying close packing. (Plate XI, fig. 2). Only 1–2% fossil fragments: gastropods, algae, molluscs and echinoderms.

Interpretation: Deposited in an environment similar to that of facies I, but current activity was weaker (e.g. 87,2 m).

Facies III: Homogeneous mudstone

Light grey to grey limestone, enclosing thick-shelled, double-valved Bivalvia sections (7–8 cm diameter) and some gastropods. Rarely clasts, smaller than 1 mm, are enriched in some levels, showing transition towards facies type II. In the lowermost part of the borehole, below 180 m, frequent violet-tinted light grey, homogeneous limestone occurs.

Interpretation: Quiet lagoon sedimentation below wave base; unfrequent changes in environmental energy. (E.g. 115,5–115,75 m; 160,75–161,05 m; 180,30–181,35 m;

Facies IV: Bioclastic, intraclastic rudstone/floatstone

Macroscopic description: Yellowish brown, dolomitic limestone: Alternating 1–3 cm thick sparitic and micritic layers, separated by discordance surfaces. 20–30% yellowish brown to brownish grey, dolomitic, angular intraclasts occur (2 mm to 2 cm in diameter) (Pl. XII, fig. 1). In some 5–20 cm thick beds sudden enrichment of cm-sized fossil fragments were observed (thick-shelled bivalves, corals, algae), together with the enrich ment of intraclasts.

Microscopic description: Fossil and micritic limestone fragments in micritic or sparitic matrix. The biogenic components are mostly algae: *Griphoporella gümbeli* (Salomon)Pia, other daysycladaceans, *Parachaetetes*(?), but some gastropods, foraminifers and corals also occur. The micritic groundmass contains 1–2 mm sparitic void infills arranged in bands.

Interpretation: Deposited in a well protected area between moving calcareous sand ranges and the reef, below tide level. The fossil *Gripho-porella gümbeli* (SALOMON)PIA indicates Ladinian age. The dolomitic layers rich in fossil fragments probably indicate storm events overrunning the reef and transporting its material to the lagoon. (E.g. 78,0 – 79,0 m; 114,4 – 114,5 m).

5.2. Facies changes in Felnémet – 8 borehole

Most of the profile is dominated by grainstone, rudstone and floatstone. There are no

- algal mats,
- deposits of intertidal channels,
- vadose pisoids,
- and levels rich in reef detritus.

Most of the profile have been deposited in the environment of calcareous sand banks (WILSON 6;). The depositional environment has been shifted to deeper, more quiet environments between the sand banks and the reef, for short times. This occurred mostly above and below the dolomitic section. The group of layers below 170 m is similar to the clastic layers of Felnémet quarry. The layers made of 1 – 2 cm bioclasts and intraclasts were transported by storm tides. There are dolomitic layers frequently together with synsedimentary breccias between 103,0 – 169,3 metres. These beds indicate repeated regression. The area emerged above sea level repeatedly, indicated by thin, violet-red clay films on stylolitic surfaces (120 – 135 m), and by late diagenetic dolomitization.

Age: Ladinian, indicated by the alga *Griphoporella gümbeli* (SALOMON) PIA 1920, found between 114,4 – 114,5 m. (Plate XII, fig. 4).

6. Felsőtárkány quarry

The quarry is situated NW of the village of Felsőtárkány, at the southern entrance of Mész Valley (Mészvölgy). The exposures are poor, the quarry walls are mostly covered by scree.

6.1. Sequence of the Felsőtárkány quarry

Cycle members observed in the profiles frequently wedge out within a distance of 4 – 5 m. There are two rock types on the profiles, alternating with each other.

Facies I: Coral framestone with wackestone-floatstone matrix

Macroscopic description: Light grey. fossil-rich limestone of 1 to 4,5 m thickness. The fossils are mostly coral fragments; rarely 30 × 15 cm autochthonous coral colonies can be observed. (Plate XII, figs, 1 – 3). Frequent 1 × 1,5 cm echinoid spines, sponges (Pl. XIII, figs. 1 – 2), gastropod and other mollusc fragments. Characteristic 1 × 2 cm angular voids occur, filled by two generations of calcite cement.

Microscopic desription: 70 - 80% of the biogenic components in the micritic matrix are recrystallized corals. Besides the fossils mentioned in the macroscopic description there are ostracods, algae, brachiopods and foraminifers.

Interpretation: Typical reef facies with coral frame.
Fossils:

Sphinctozoa:

Stylothalamia dehmi OTT, Ladinian-Carnian
Colospongia dubia?
Colospongia sp.
Cryptocoelia sp (Pl. XIII, fig. 3.)
Cryptocoelia n.sp. (Pl. XIII, fig. 4)

Algae
Griphoporella gümbeli (?) (SALOMON)PIA, Ladinian(?)

Facies II: Rudstone with reef fragments

Dark grey to grey, coarsely brecciated limestone, of 1,2 to 4 m thickness. The dark grey matrix contains light grey to grey, unsorted, angular intraclasts. Rarely the grain size of the clasts decrease upwards. Clast size: 2 to 20 cm, rarely 40×60 cm clasts and one 200×75 cm clast occur. The clasts form 25 to 65% of the rock. The space among the intraclasts is filled by dark grey, occasionally synsedimentary, coarse grained calcareous material with frequent slumps. Margins of the larger (10 – 15 cm in diameter) voids are formed of black, radial calcite, while the inner parts are filled by white, coarse calcite crystals (Pl. XV, fig. 2). The components are ranged into two groups:

1. Intraclasts:

a) Bioclastic wackestone: Micritic matrix contains rare biogenic fragments and micritic mud lumps. Fossils: echinoderm fragments, bivalve, gastropod, echinoid spine, coral branch.

b) Bioclastic-peloidic grainstone/wackestone. The groundmass is mostly sparitic, rarely micritic. The components: 20 – 40% peloids of 0,1 to 0,2 mm in diameter, echinoderm fragments, alga, dasycladacean, small gastropod, bivalve.

2. The space among the intraclasts is filled by sparitic calcite.

6.2. Facies interpretation of the Felsőtárkány quarry

Its facies is different from the Felnémet quarry and the Felnémet – 8 borehole. The two facies types described above alternates in 1 – 4 m thick, wedge-shaped layers. The members of the cycle are thicker than in the lagoonal facies. Two interpretations are discussed below:

a) Reef.

BRANDNER and RESCH (1981) describe a cyclic reef growth. The cycle begins after a sudden subsidence followed by scree deposition. This is followed by an autochthonous reef body. Its growth is intercepted by the next, sudden transgression.

b) Sediment of the outer reef slope

There is no great difference in depth between the reef and the bottom of the slope, since no pelagic sediments have been observed. The life of the autochthonous fossil community (facies I) is regularly intercepted by debris flows (facies II).

We propose to accept the first version.

7. Exposures in the surroundings of the two quarries.

Mész valley gorge: (Localities 1 to 7): White to light grey limestone fossils enriched in some levels (corals and somewhat less echinoderm fragments). Autochtonous coral colonies were observed on several larger (a few m^2) surfaces. Cm-sized, angular intraclasts are enriched in frequent spots. Irregular voids, filled by dark grey calcite are frequent too.

The scree at the foot of the wall contains large amounts of corals, bivalve and gastropod fragments.

The localities at Mész valley gorge were deposited in a reef (reef core plus the surrounding reef detritus) environment.

Above Mész valley, cuts of a forest road 150 to 200 m W of the valley (localities 121 to 126):

White to light grey, homogeneous, weakly bedded limestone with a few coral, echinoderm and sponge fragments. The bed-parallel coral fragments reach their greatest abundance at locality No. 124: ca. 70%, but their amount gradually decreases towards north and suddenly decreases towards south.

Road cuts of the forest road between Alsó-Nyergeskő-lápa and Finomszerelvény-gyár factory (localities 12 to 21):
Facies:

– Grey limestone with 2 – 3 cm large angular intraclasts, and 4 – 5 cm dark grey, sparite filled voids among them.

– White to light grey, fossil-rich limestone (mostly autochthonous corals, sphinctozoans, bivalves, gastropods and echinoderm fragments). Few 5 – 7 sm sized voids filled by sparite cement.

– Fossil-poor, light grey, homogeneous limestone.

Road cuts between the "Valley of spoil-banks" to Bervabérc and Cseresbérc, eastern slope (localities 22 to 27:

The exposures are similar to the moving sand dune facies of Felnémet - 8 borehole.

Ridge between Bervabérc and Cseresbérc (localities 28 and 29):

Dark grey to grey limestone with intraclasts up to 3 – 4 cm. Fossils: frequent 2 – 4 cm gastropods, rare corals and bioclasts. Lagoon with quiet water.

Ridge of Bervabérc at the NE corner of Felnémet quarry (localities 101 to 103 and borehole F – 6):

The light grey to grey limestone of lagoonal facies is frequently of lighter colour, with rounded intraclasts (less than 5 mm). Rare fossils: echinoderm and coral fragments, gastropods.

The steep NW slope of Bervabérc and Cseresbérc (localities 109 to 112 and 114) and Nyergeskő-orom (localities 129 – 132):

White to light grey, homogeneous, thick-bedded limestone, extremely poor in fossils.

Ridge of Bervabérc and Cseresbérc and Hosszú Galyatető (localities 104 – 107):

White to light grey, homogeneous, thick-bedded limestone; frequent coral and echinoderm fragments, gastropods. At localitiy No. 107 reef core with abundant coral colonies was observed in the thick scree. It may be a patch reef.

300 m to the lower entrance of Berva valley, south of the former lime-kiln (locality 120):

Dark grey, bioclastic and intraclastic limestone. Most of the bioclasts are algal debris (see under point 10).

8. Geochemistry

The strongly deformed texture indicates the possibility of a very low grade metamorphism. X-ray examination of five samples from Felnémet and five samples from Felsőtárkány was made by P. ÁRKAI.

Insoluble residue of the rocks are mostly below 0,5%. The samples are almost totally made of $CaCO_3$.

The minerals of the insoluble residue in decreasing abundance: quartz, plagioclase, sericite, kaolinite, pyrite, goethite, K-feldspar and chlorite. Illite was found in two samples only. These samples contain illite-kaolinite. Crystallinity degree of illite is 0,808° 2 Θ, indicating the diagenetic stage. It is also supported by the relatively high quantity of kaolinite.

While textural features show strong deformation, the rock did not suffer even very low grade metamorphism.

9. Palaeoenvironmetal reconstruction

The facies types were figured on a map and the following palaeoenvironmental model was established. Four facies types can be distinguished in the region.

a) *Felnémet quarry*

The first group of beds (0 to 85 m): barely bedded, white, bioclastic limestone was deposited in a lagoon, near the reef. The 85 – 355 m section of the quarry profile show cyclic deposition. There was almost no terrigenous influence. (See chapter 8). The sequence was deposited on a submarine plateau far from the dry land, first in a relatively deep, than a shallower than again in a somewhat deeper environment. Water depth changed between zero and some tens of metres.

On the ridge, NNE from the quarry, above the level of the fossil-rich, near-reef lagoonal facies (localities 101 – 107), there is a conspicuously fossil-poor, homogeneous sequence of considerable thickness (localities 108 to 132).

b) *Felnémet – 8 borehole and localities 22 to 26.* Calcareous sand moving on a plateau margin (Wilson 6). Water depth is generally above the normal wave base, in the breaker zone. The calcareous sand dunes might have reached the supratidal zone in a hypersaline environment for a short time. The exposures belonging to this facies belt surround the lagoon in a north – south belt. The northernmost exposures are in the surroundings of borehole F – 8. Its thin beds were observed in Felnémet quarry.

c) *Localities 1 to 7 and 12 to 21* indicate reef (Wilson 5) facies. These exposures are ranged in a several km long belt oriented north to south. The reef facies is represented by white to light grey rocks rich in corals, echinoderms, foraminifers and gastropods. Reef-core intraclasts are enriched in some levels.

d) *Felsőtárkány quarry*

Reef (Wilson 5) or fore-reef (Wilson 4) facies. This facies shows a conspicouous similarity to the cyclic reef evolution model of Brandner and Resch (1981).

The dark grey to grey reef detritus was deposited from debris flows arriving from the direction of the reefs, while the light grey, fossil-rich layers represent the autochthonous reef slope formed in quiet periods.

10. Fossils and age of the Bervavölgy Limestone Formation

10.1. Biostratigraphy

The list of fossils collected by our field work is listed by the localities, in the order of the facies types. The algae were determined by Olga Piros, the foraminifers by Anna Oravecz – Scheffer, the sponges by Sándor Kovács.

Lagoonal facies, southernmost exposure, locality No. 120 (see chapter 7):

Algae

Dasycladaceae

Teutloporella herculea (Stoppani) Pia 7
Diplopora annulata Schafhäutl 2
Griphoporella gümbeli (Salomon) Pia
? *Physoporella* sp.

Codiaceae
Solenoporaceae
Echinodermata
Gastropoda

I. group of beds in Felnémet quarry (see under 4.1.)

Algae

Solenoporaceae

Thaumatoporella parvovesiculifera (RAINERI)
(Pl. VII, fig. 1)

Porifera
Calcispongea
Sphinctozoa
Stylothalamia dehmi OTT 2
(Pl. VII, fig. 3–4)

Anthozoa
Echinodermata
Ostracoda
Gastropoda
Bivalvia
Brachiopoda

II. group of beds in Felnémet quarry (see under 4.1.)

Algae

Codiaceae (Pl. V, fig. 4)
Solenoporaceae (Pl. V, fig. 2)
Echinodermata
Gastropoda

IV. group of beds in Felnémet quarry (see under 4.1.):

Bivalvia

Megalodontida (?) section (Pl. VIII, fig. 4)*q*
Cephalopoda
Ammonoidea (Pl. VIII, fig. 2)
Ptychites group, section (Pl. VIII, fig. 1)
Ridge NE from Felnémet quarry (see under 7):

Ridge NE from Felnémet quarry (see under 7):

Algae

Dasycladaceae
Macroporella beneckei PIA
Macroporella spectabilis BYSTRICKY
Griphoporella sp.

Codiaceae
Solenoporaceae

Protozoa

Foraminiferida
Aulotortus sinuosus WEYNSCHENK 3
Gsolbergella spiroloculiformis (ORAVECZ – SCHEFFER)
Trocholina sp.
Ophthalmipora dolomitica ZANINETTI et BRÖNNIMANN
Earlandinita cf. *soussi* SALAJ

Hydrozoa

Anthozoa fragment
Echinodermata fragment
Gastropoda section
Ostracoda section

Felnémet – 8 borehole (see under 5.1.):

Algae

Dasycladaceae
Griphoporella gümbeli (SALOMON)PIA 1920
Pl. XI, fig. 1 2
Codiaceae
Solenoporaceae
Parachaetetes (?)

Protozoa

Foraminiferida
Triadodiscus eomesozoicus (OBERHAUSER)
Aulotortus sinuosus WEYNSCHENK 3
Ammobaculites cf. *corpulentus* EFIMOVA
Diplotremina astrofimbriata KRISTAN-TOLLMANN
Diplotremina sp.
Trochammina alpina KRISTAN – TOLLMANN
Duostomidae
Glomospira sp.
Glomospirella sp.
Ophtalmidium sp.

Anthozoa
Echinodermata
Echinoidea
Ostracoda
Gastropoda
Bivalvia

From the reef facies of Felsőtárkány quarry (see under 6.1.):

Algae

Dasycladaceae

Griphoporella gümbeli (?) (SALOMON)PIA

Porifera

Calcispongea

Sphinctozoa

Stylothalamia dehmi OTT

Cryptocoelia sp.

Cryptocoelia n. sp.

Coelospongia dubia (?)

Anthozoa

Gastropoda

Among the above listed fossils algae, foraminifers and sponges help to determine the age of deposition. The algae determined to the species level *(Diplopora annulata, Griphoporella gümbeli, Teutloporella herculea* and *Macroporella beneckei)* are characteristic for the Ladinian stage. The sponges *(Stylothalamia dehmi, Coelospongia dubia* (?) and *Cryptocoelia)* are Ladinian to Carnian and are the characteristic fossils of Wetterstsein reefs.

The foraminifer fauna indicates Ladinian age, but several species occur in the Carnian as well. The species *Earlandinita* cf. *soussi* SALAJ occurs in large numbers in the Carnian Tisovec Limestone, but rarely occurs in the Ladinian also. There is no species characteristic solely for the Carnian.

10.2. Former faunistic data

SCHRÉTER (1935) has described a rich fossil assemblage from Bervabérc and assigned it to the Ladinian.

BALOGH (1964) completed aerlier collections and ranged the fauna to Upper Ladinian – Carnian. After partial revision of the fauna (BALOGH, 1981), he ranged it to the Norian.

Compiling all available data we can say that the Bervavölgy Limestone Formation is of Ladinian age. There is no fossil proving Carnian age. The collected fossils are typical for the Westterstein Limestone, the Bervavölgy Limestone is herein ranged among the Wetterstein-type reefs.

10.3. Evolution

There is no enough data to reconstruct the detailed history of the Bervavölgy reef complex, therefore we propose a theoretical model only.

There are no Anisian formations in the examined region. The reef complex existed already in the Ladinian. This is unanimously proven by our biostratigraphical data (see under 10). The Ladinian age is also supported by SCHRÉTER (1935) and BALOGH (1964). According to Wetterstein-type analogues we suggest the existence of an underlying Anisian Steinalm limestone an an overlying Lower Carnian Wetterstein Limestone. The actual occurrence of these formations is to be proved as yet.

Up to now the only occurrence of Wetterstein Limestone is in the Silica Nappe of Bükk unit. Scholz (1972) and Kovács (1979) described an Anisian – Lower Carnian outer reef slope – reef – open lagoon complex. The Bervavölgy Limestone described in the present paper is the first Wetterstein Limestone occurrence of the Bükk Mts. and the southermost occurrence of the Inner West Carpathians.

11. Further tasks

1. Detailed survey of the region; age determination of the lowermost and uppermost parts of the sequence.

2. Tectonic investigations to determine the contact between the limestone and the surrounding formations.

3. Comparison of the Bervavölgy Limestone with the other limestone occurrence in the Southern Bükk Mts. (Subalyuk, Hór-valley, Répáshuta) of probably similar age and facies. It is to be determined that these parts of a carbonate shelf when did part and what kind of tectonic events positioned them in their present-day place. After the stratigraphic and structural investigations of the whole Mesozoic sequence in the Bükk Mts. the Wetterstein limestone can be placed to its proper position in the history of the Bükkium.

REFERENCES

Árkai P. (1983): Very low- and low-grade Alpine regional metamorphism of the Paleozoic and Mesozoic foramtions of the Bükkium, NE Hungary. – Acta Geol. Hung. 26/1 – 2, 83 – 101.

Balogh K. (1964): Die geologischen Bildungen des Bükk-Gebirges. – Annales Inst. Geol. Publ. Hung. 48/2, 245 – 719.

Balogh K. (1981): Correlation of the Hungarian Triassic. – Acta Geol. Hung. 24/1, 3 – 48.

Brandner, R. – Resch, W. (1981): Reef development on the Middle Triassic (Ladinian and Cordevolian) of the Northern Limestone Alps near Innsbruck, Austria. – Toomey, D. F. (ed.): European Fossil Reef Models, SEPM Spec. Publ. 30, 203 – 231.

Flügel, E. (1982): Microfacies Analysis of Limestones. – Springer, Berlin, 633 p.

Fischer, A. G. (1964): The Lofer cyclothems of the Alpine Triassic. – Kansas Geol. Surv. Bull. 169, 107 – 149.

Kovács S. (1979): Geological buildup of the Hungarian part of the South Gemerian Alsóhegy (Silica nappe, Western Carpathians). – Őslénytani Viták 24, 33 – 58.

Márton Gy. (1958): Ipari mészkőkutatás a Felnémet – Bervavölgy és Felsőtárkány – Mészvölgy közé eső területen, összefoglaló földtani jelentés- és készletszámítással. – Gyöngyös – Mátrai Ásványbánya Vállalat, 37 p.

Rüdiger, H. K. (1984): Facies, dolomitization and karstification of lagoonal carbonates: Triassic of the Northern Alps. – Facies 11, 109 – 156, Erlangen.

Scholle, P. A. et al. (1983): Carbonate Depositional Environments. – AAPG Memoir 33, 345 – 559, Tulsa.

Sholz, G. (1972): An Anisian Wetterstein limestone reef in North Hungary. – Acta Min. Petr. Szeged 20/2, 337 – 362.

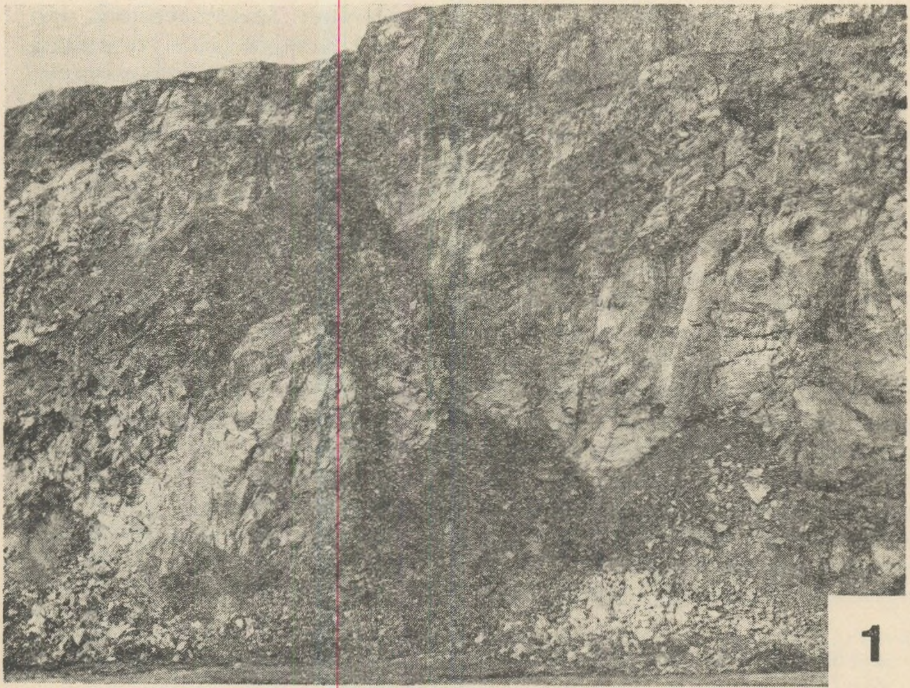
Schréter Z. (1913): Die geologischen Verhältnisse der Umgebung von Eger. Jahresbericht Ung. geol. Anstalt für 1912, 144 – 162.

Schréter Z. (1935): Über die Triasbildungen des Bükk-Gebirges. – Földtani Közlöny 65, 90 – 105.

Schréter Z. (1943a): Bericht über die geologische Reambulation des SW-lichen Teiles des Bükkgebirges. – M. Kir. Földt. Int. Évi Jel. 1939 – 40-ről, I, 381 – 392.

Schréter, Z. (1943b): A Bükkhegység geológiája. – Beszámoló a M. Kir. Földtani Int. Vitaüléseinek Munkálatairól 5/7, 378 – 411.

Wilson, J. L. (1975): Carbonate Facies in Geologic History. – Springer, Berlin.



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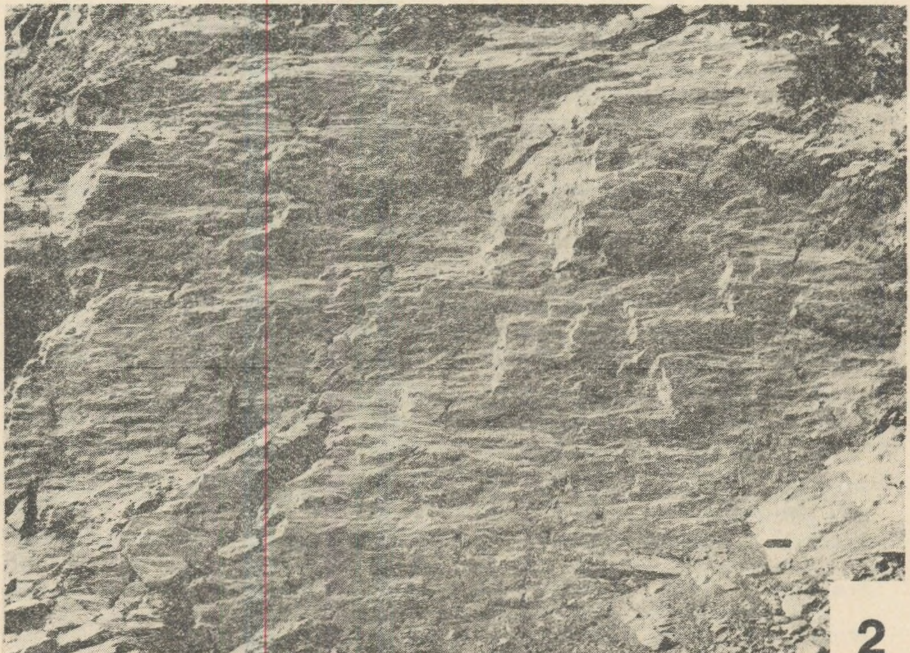

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PLATE I.

Felnémet quarry

1. Boundary of the homogeneous, light (I.) and the dark, cyclic (II.) group of layers. Middle of the 2nd level in the quarry. Height of the quarry wall: 40 m.
2. Large fault surface indicating horizontal displacement. Dip: 140/60°. Northern end of the 5th level of the quarry.

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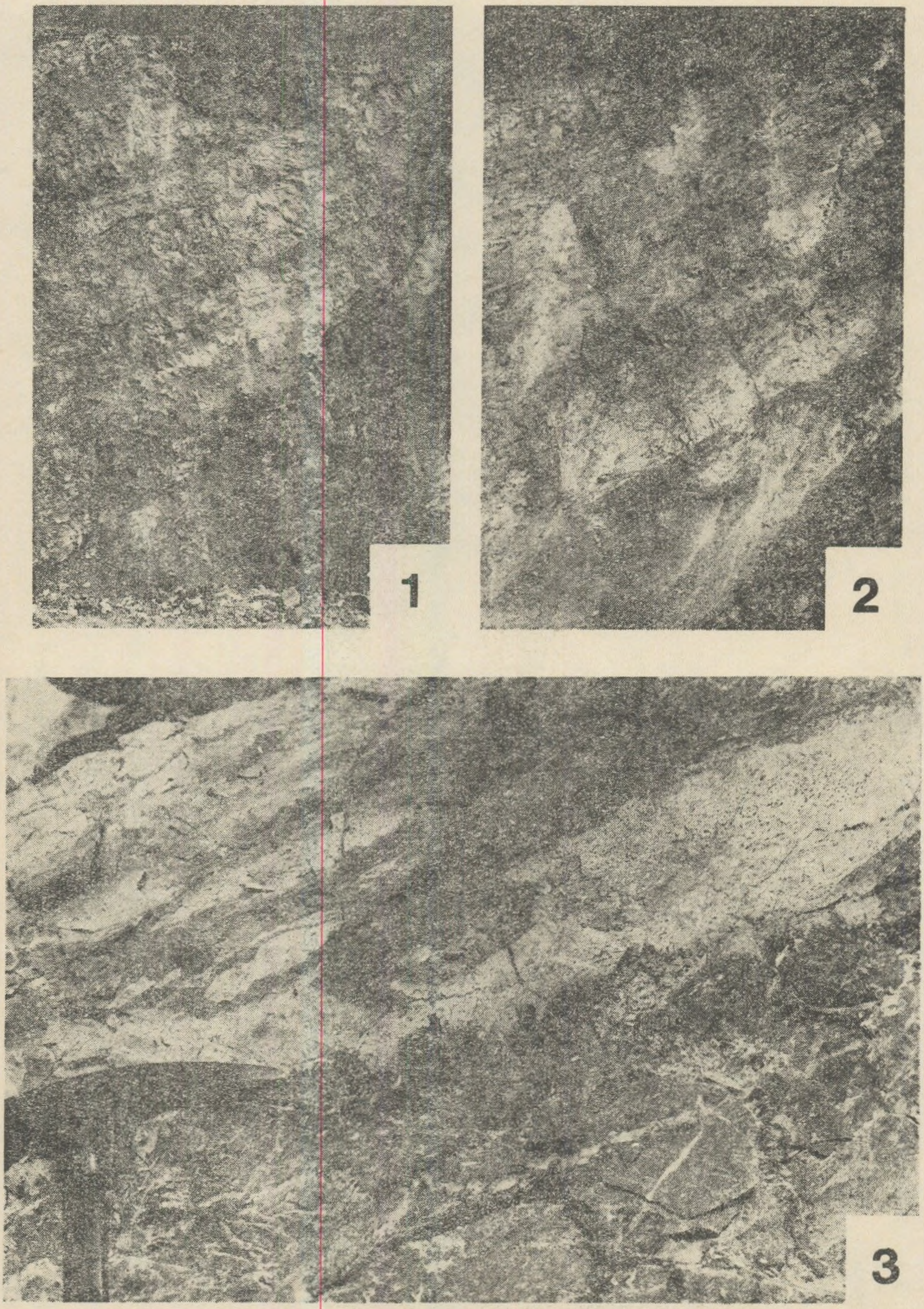

PLATE II.

Felnémet quarry

1. Cyclic sequence characteristic for the deeper part of III. group of layers. Norther end of the 2nd quarry level. Height of the wall: 40 m.
2. Higher part of III. group of layers; the cycles are thicker and their colour is lighter than on fig. 1. Middle of 4th quarry level. Height of the quarry wall: 30 m.
3. The bed with small, black intraclasts (IV. facies) is overlain by algal mat, following a stylolitic surface (emersion?) (I. facies). Detail of fig. 2.

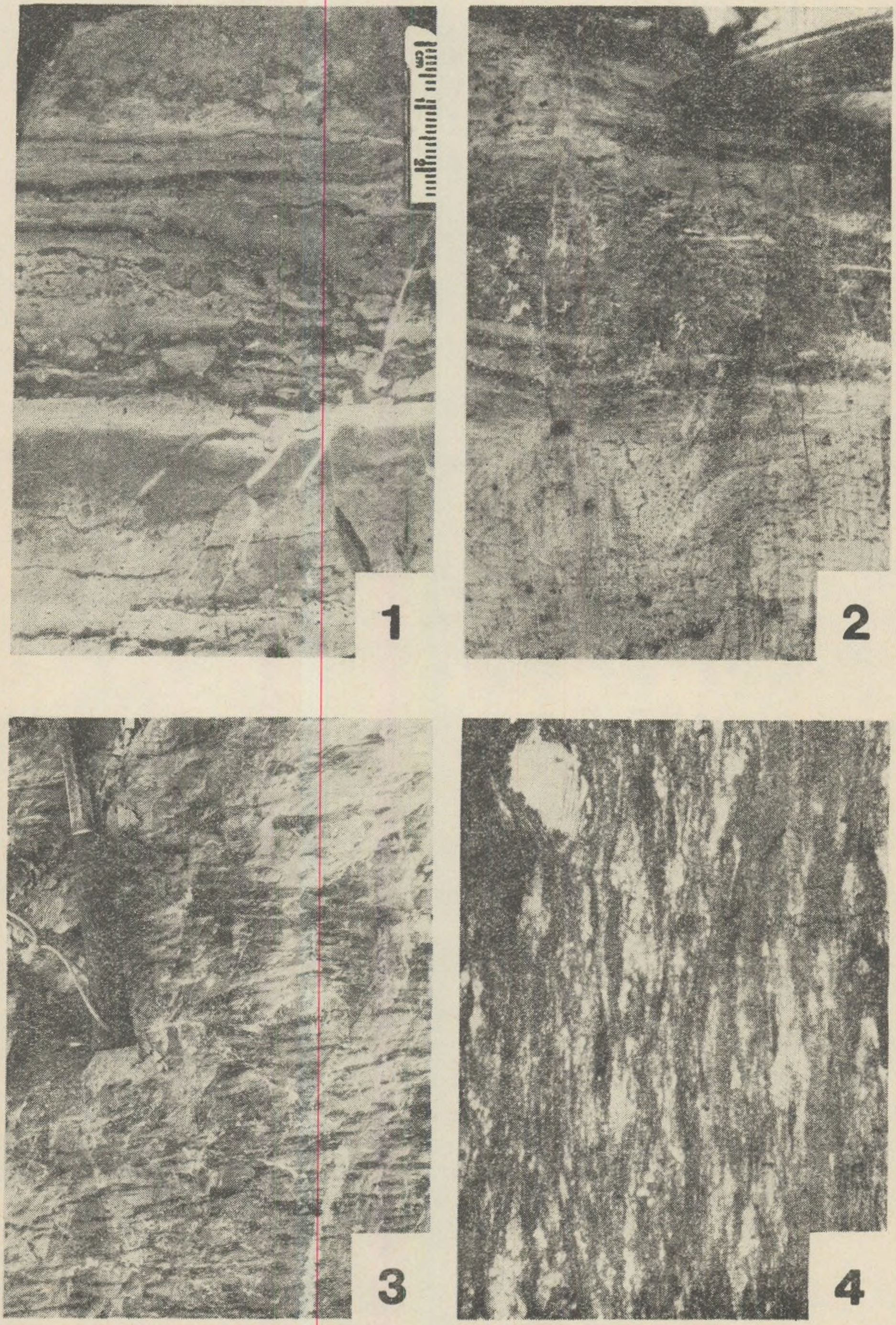
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PLATE III.

Facies types in Felnémet quarry

1. Algal mat (facies I.), with brecciated levels, indicating emersion. III. group of beds. Locality: northern part of 2nd level in the quarry.
2. Algal mat (facies I) overlain by black intraclastic (IV) then by plastoclastic (V) layers, due to gradual deepening of the depositional environn.ent. III. group of beds. Northern end of 5th level in the quarry. Scree.
3. Plastoclastic limestone (facies V). Mixture of unconsolidated sediments of a subtidal lagoon. III. group of beds. Southern end of 5th level of the quarry.
4. Black intraclastic limestone (facies IV, see Pl. III. fig. 2) . The components are deformed due to tectonic stress, 12x

4

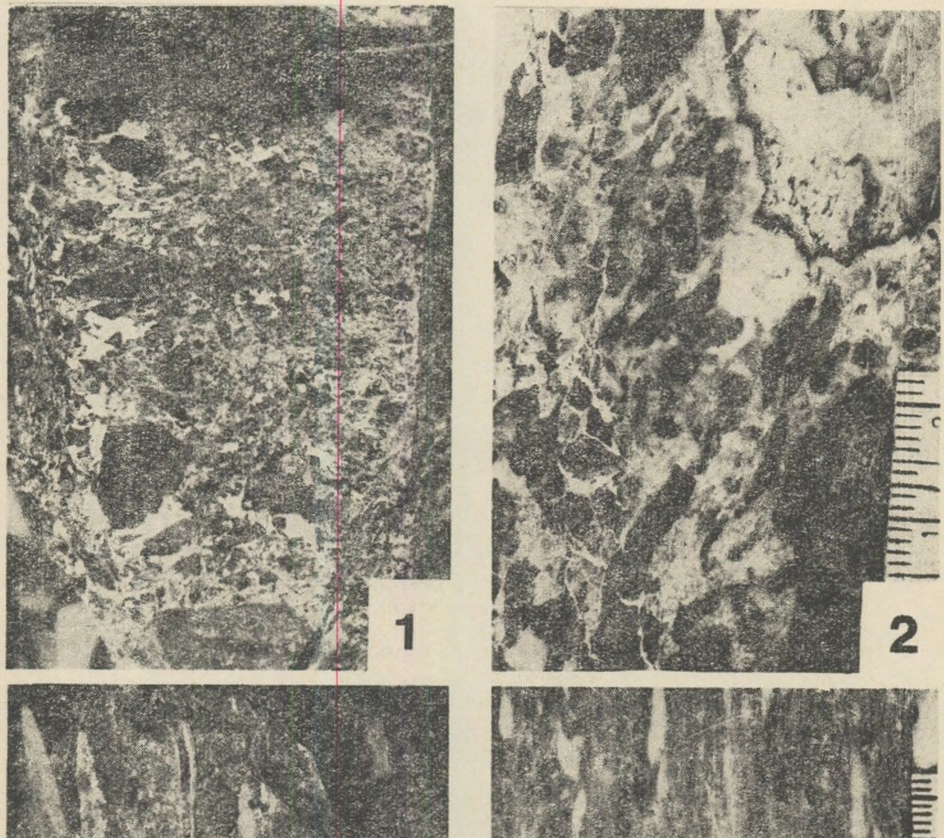

PLATE IV.

Facies types in Felnémet quarry

1 – 2. Intraformational breccia with sparitic cement. Deposit of an intertidal channel (facies III). III. group of beds. Southern part of the 5th level of the quarry, scree.

3. Different intraclasts in micritic matrix. The originally flat intraclasts (from an intertidal environment) have been further flattened due to tectonic stresses. III. group of beds, scree.

4. Different intraclasts in micritic matrix; quiet environment. II. group of beds, southern end of 5th quarry level.

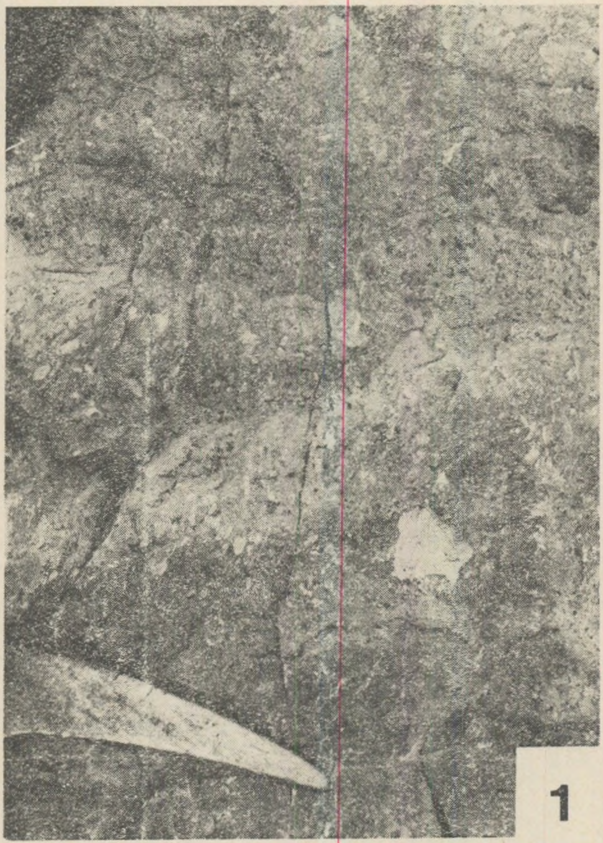
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PLATE V.

Facies types of Felnémet quarry

1. Vadose pisoidic crusts, precipitated in the deeper part of the vadose zone. (facies IIb, profile Fn-III, southern part of 3rd quarry level).
2. Solenoporaceae (facies IIa) (III. group of beds, middle part of 2nd quarry level, scree). 8x
3. Solenoporaceae fragment with vadose pisoidic crust. (IIb facies, III. group of beds, 2nd level in the middle of the quarry, scree). 8x
4. Coated Codiaceae fragment (IIa facies, III. group, 2nd quarry level, scree). 8x

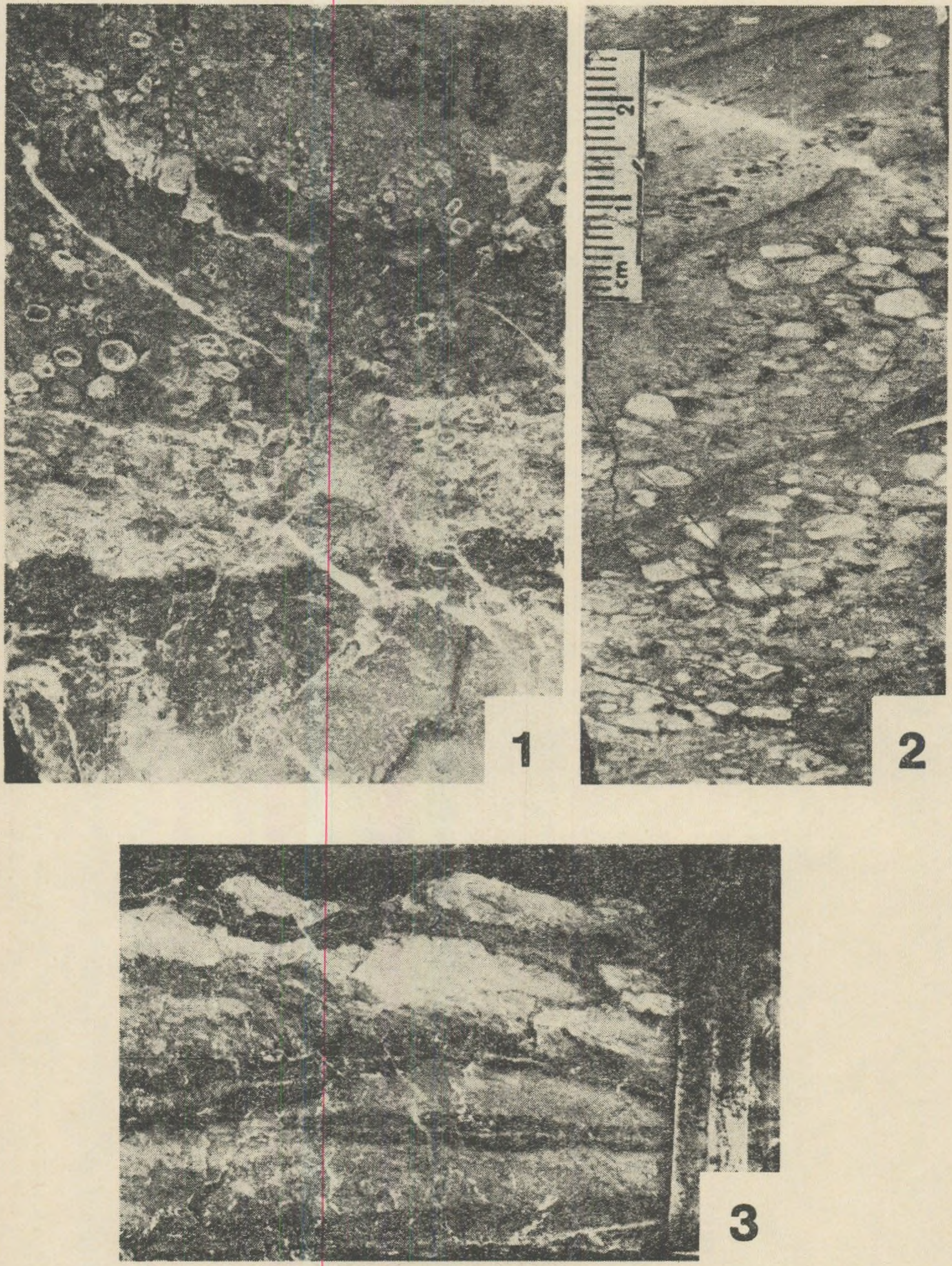
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PLATE VI.

Facies types of Felnémet quarry

1. Slightly graded beds made of rounded intraclasts with dolomitic coating. (III. group of beds, 5th quarry level, southern part, scree). Natural size
2. Tectonic strain directions of ooids enclose an acute angle with graded bedding. (facies IIa, III. group of beds, 2nd quarry level, middle part, scree).
3. Zebra limestone (IV. facies, III. group of beds, 5th quarry level, southern end).

7

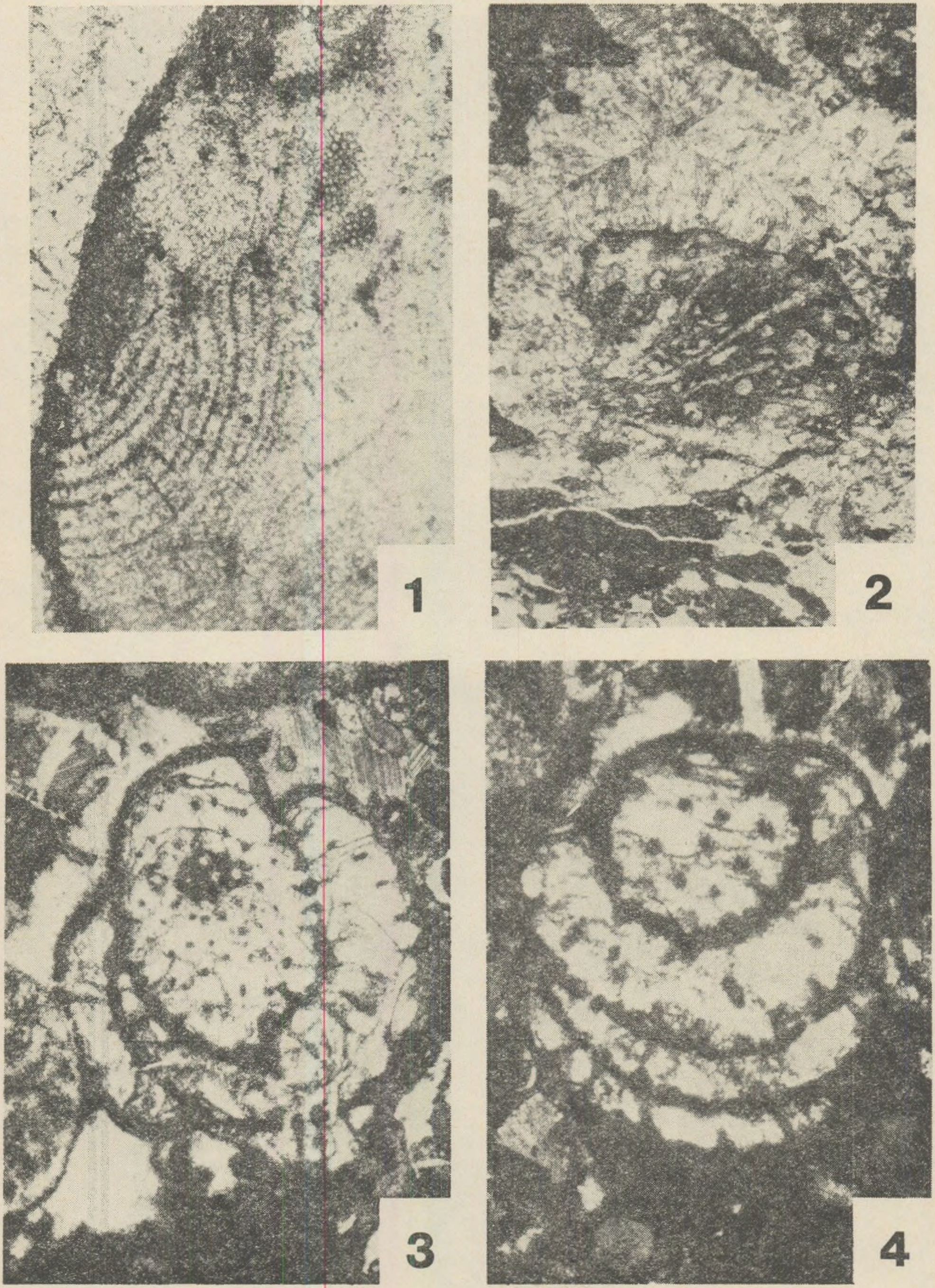


PLATE VII.

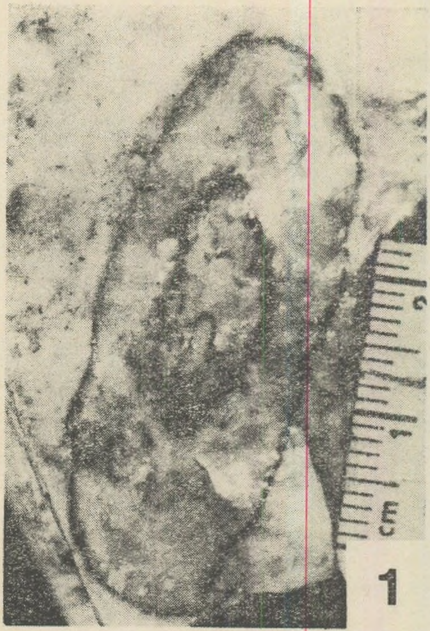
Fossils from Felnémet quarry

(VII. facies, I. group of beds, one-third of lst quarry level)

1. *Thaumatoporella parvovesiculifera* (RAINERI). 16x
2. Coral fragments in sparitic cement. 9x

3–4. *Stylothalamia dehmi* OTT. 13x

8



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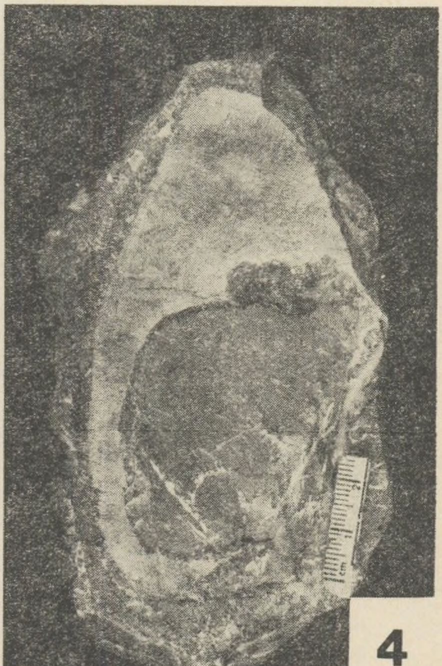

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PLATE VIII.

Fossils from Felnémet quarry

1. Ammonites section (Ptychites group). (From the light grey limestone of IV. group of beds, northern end of 4th quarry level, scree.)
2. Ammonites section from the dolomitic lenses of the IV. group of beds. Northern end of 4th quarry level.
3. Redeposited coral colony from the breccia level of IV. group of beds. Northern end of 5th quarry level.
4. Megalodontidae (?) section. The exsolved shell was filled by calcite spar then by dolomitic, micritic mud. (From the grey limestone of IV. group of beds, norhern end of 4th quarry level.)

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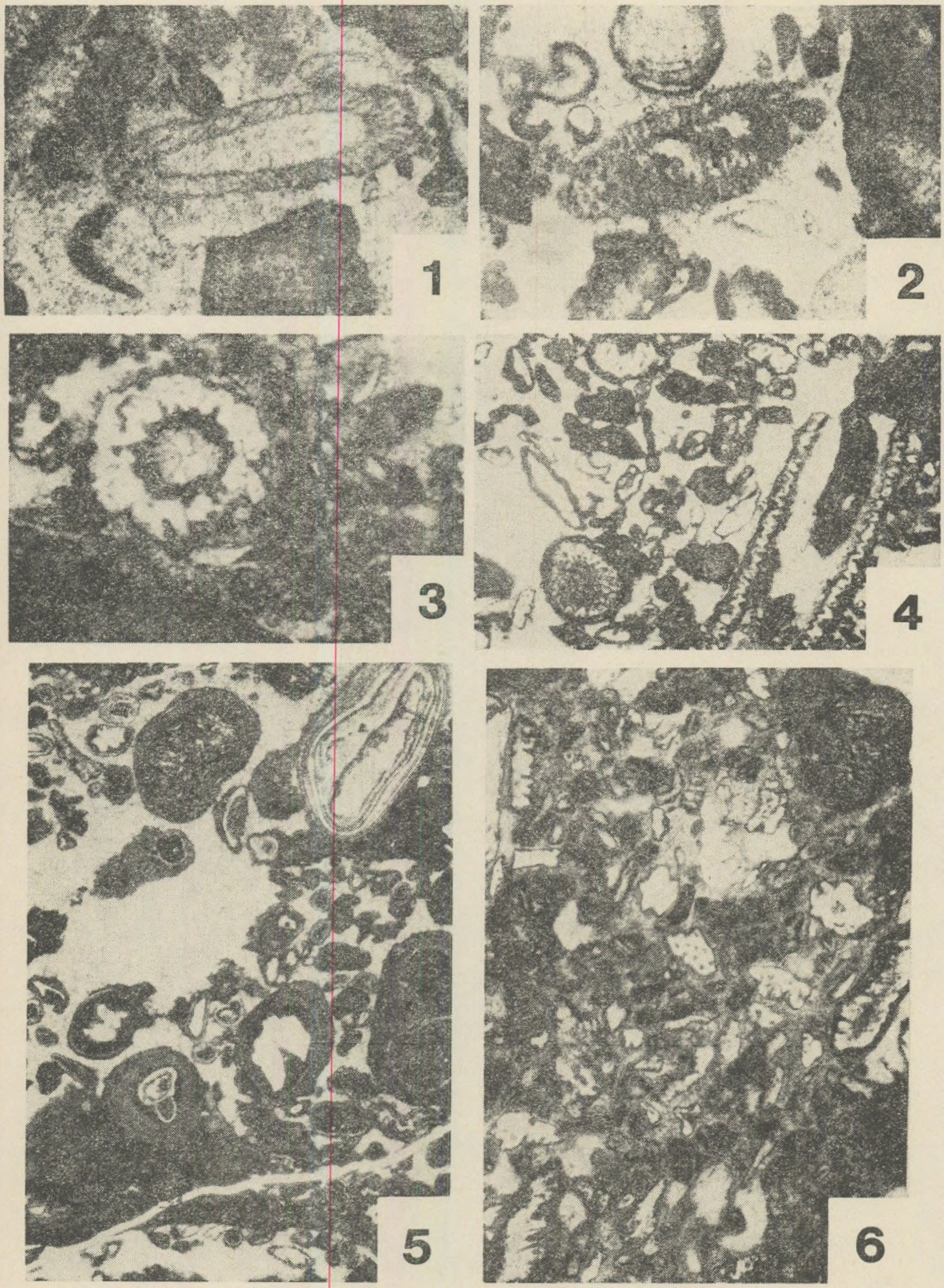

PLATE IX.

Algae of the normal lagoonal facies

1. *Macroporella beneckei* PIA; locality 106. 8x
2. *Macroporella spectabilis* BYSTRICKY; locality 106. 8x
3. ? *Physoporella* sp. *Teutloporella herculea* (STOPPANI). Locality 120. 11x
4. *Griphoporella gümbeli* (SALOMON) PIA. Locality 120. 7x
5. Multiple coated bioclasts, mostly algal fragments. Locality 120. 8x
6. Angular algal fragment. *Thaumatoporella herculea* (STOPPANI), Codiaceae. Locality 120. 5x

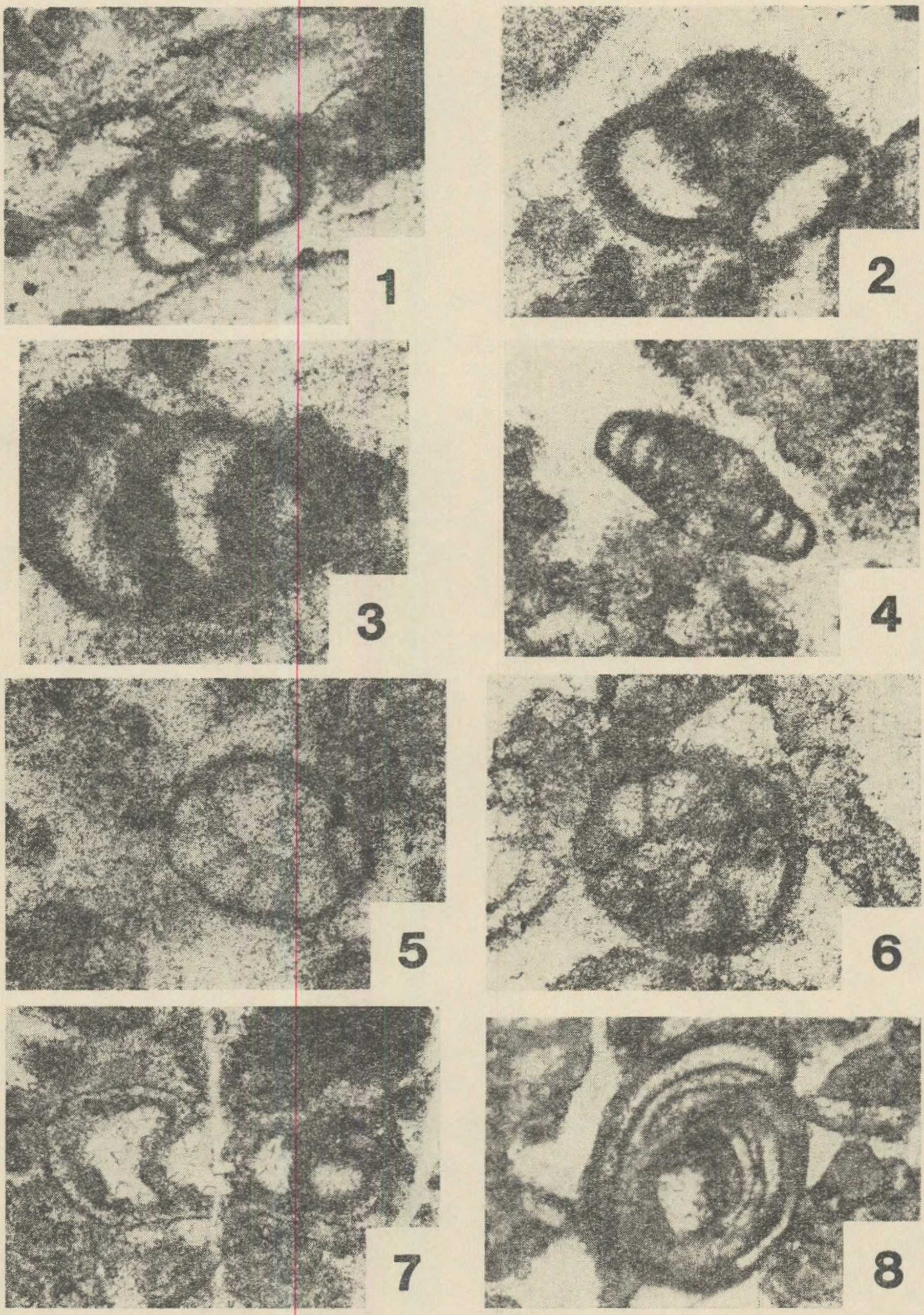
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PLATE X.

Foraminifers

Foraminifers of the lagoonal facies

1. *Gsollbergella spiroloculiformis* (ORAVECZ – SCHEFFER). Locality 104a. 9x
2. *Ophtalmipora dolomitica* ZANINETTI et BRÖNNIMANN. Locality 106. 30x
3. *Earlandinita* cf. *soussi* SALAJ. Locality 106. 35x

Foraminifers of the plateau margin calcareous sand.

4. *Triadodiscus eomesozoicus* (OBERHAUSER). Locality: borehole F – 8. 114,4 – 114,55 m. 50x

5 – 6. Duostominidae. Borehole F – 8. 114,4 – 114,55 m. 50x

7. *Ammobaculites* cf. *corpulentus* EFIMOVA. Borehole F – 8. 114,4 – 114,55 m. 32x
8. *Ophtalmidium* sp. Borehole F – 8. 114,4 – 114,55 m. 11x

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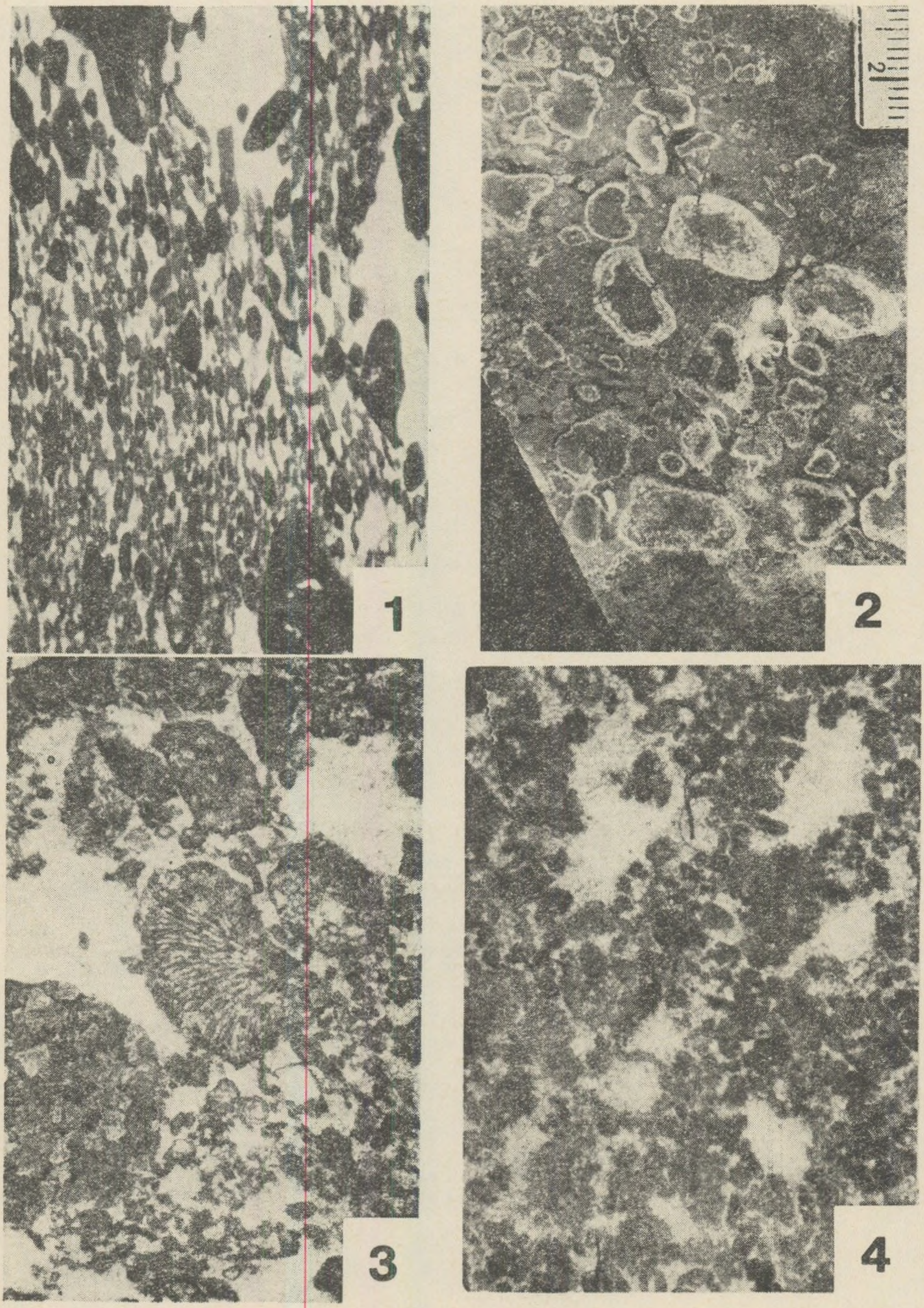

PLATE XI.

Borehole Felnémet – 8.

Plateau margin calcareous sand facies

1. Micritic mud lumps and biogenic fragments in sparitic matrix. II. facies, 180,8 m. 13x
2. Large rounded biogenic fragments (mostly algae) with dolomtic coating. I. facies, 103,0 m.
3. Thin section of fig. 2. 9x
4. Small micritic mud lumps in sparitic matrix. II, facies, 87,2 m. 19x

12

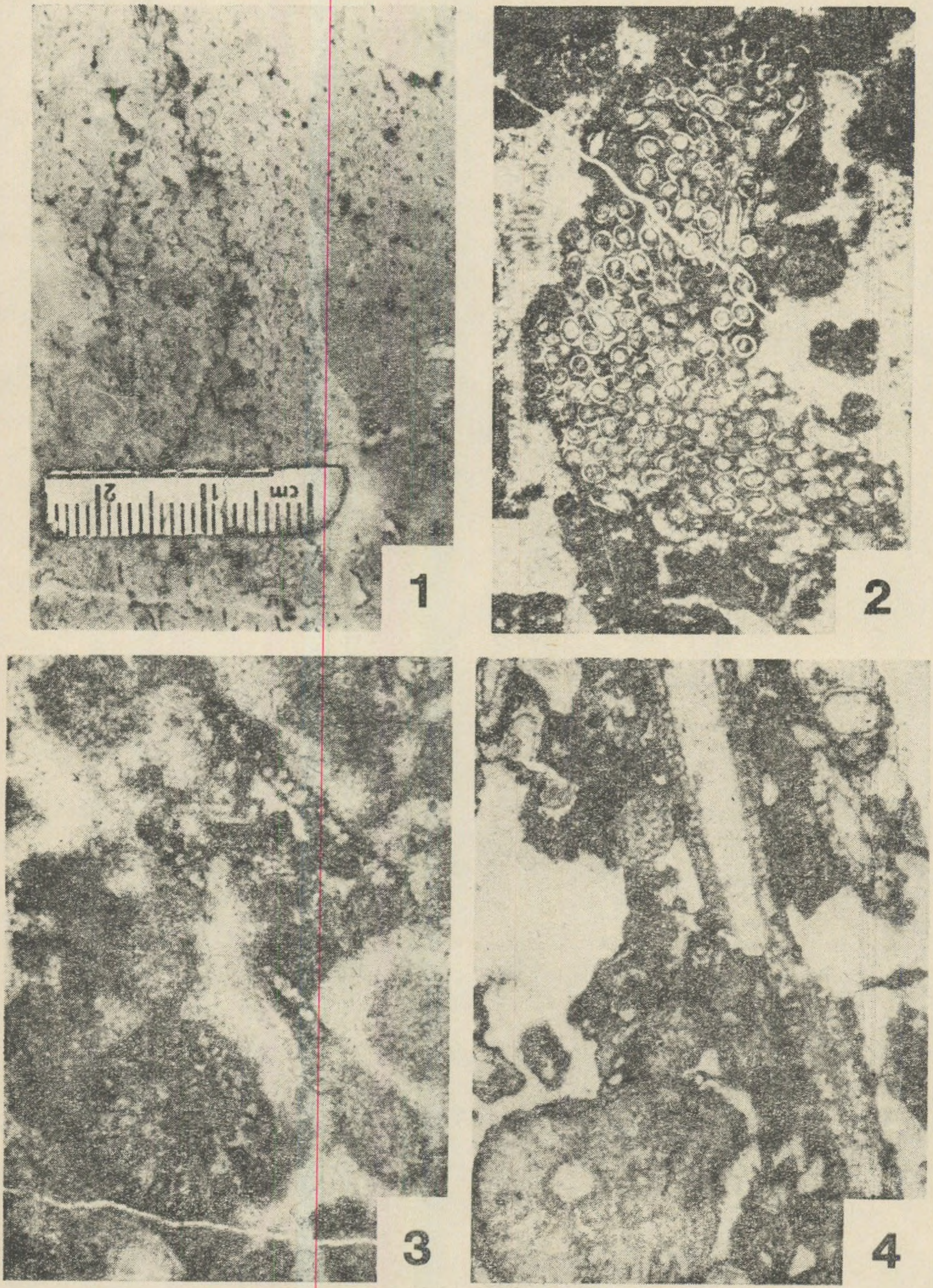

PLATE XII.

Fossils from Felnémet – 8 borehole

1. Rudstone with algal fragments, IV. facies F – 8, 114,4 – 114,55 m.
2. Microproblematicum? F – 8. 174,5 m. 8x
3. *Griphoporella* sp. Codiaceae. F – 8. 197,4 m. 13x
4. *Griphoporella gümbeli* (Salamon) Pia, F – 8, 114,4 – 114,55 m. 9x

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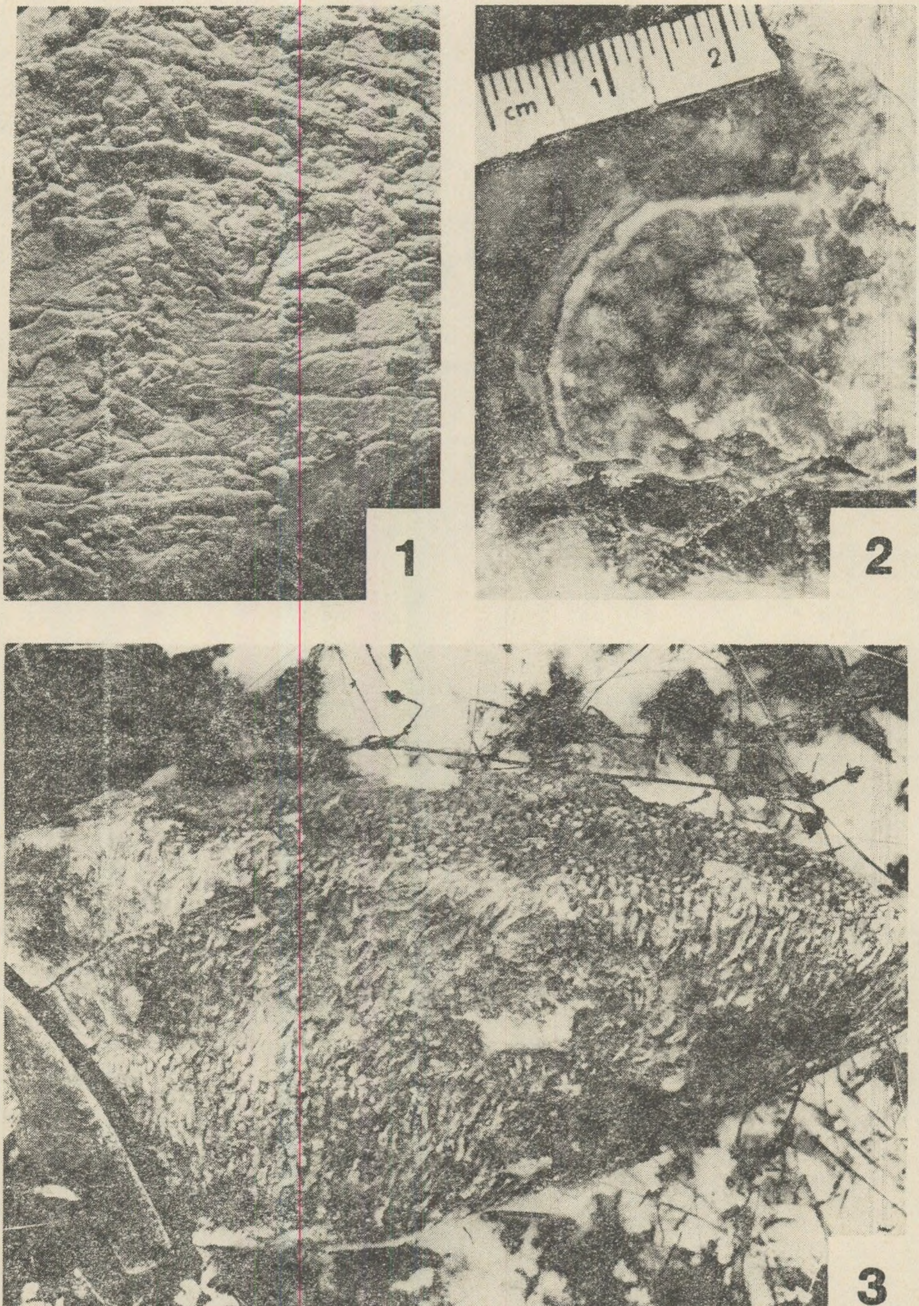

PLATE XIII.

Fossils of Felsőtárkány quarry
Reef facies

1. and 3. Coral colonies from the E part of Mészvölgy, from the northern part of the one-time quarries, Scree. (Fig. 1: natural size)
2. Algal-coated coral colony from the scree of the quarry.

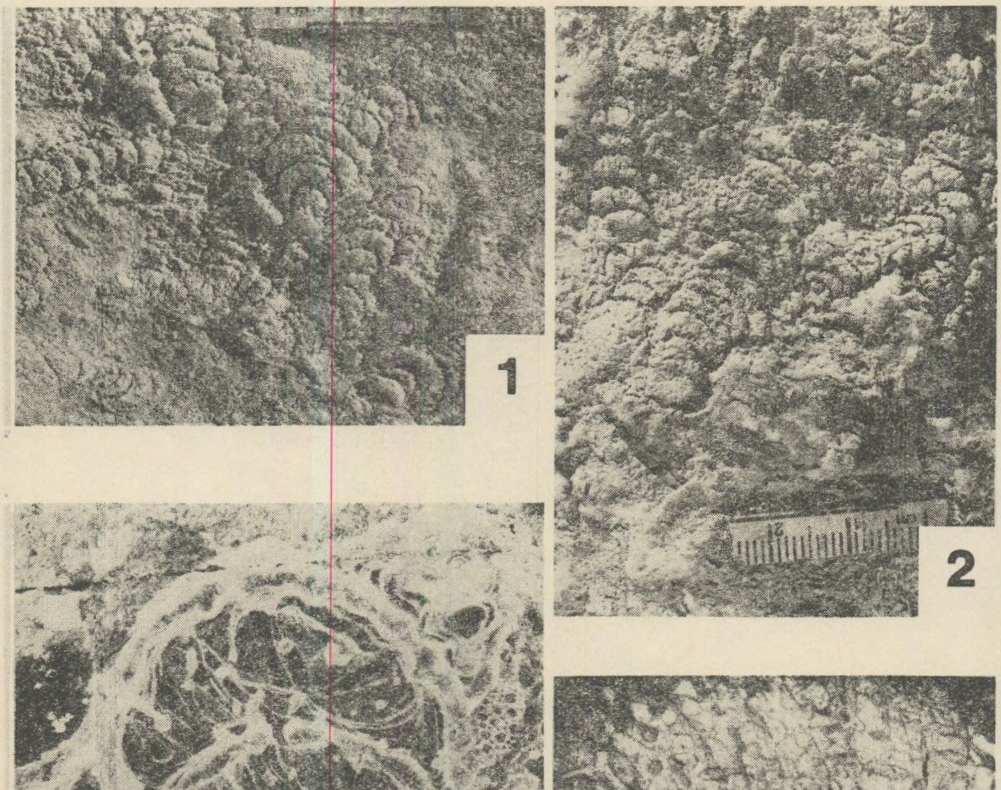
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PLATE XIV.

Fossils of Felsőtárkány quarry

Reef facies

1 – 2. Sphinctozoa colony. E side of Mészvölgy, N end of the one-time quarries, scree.
3. *Cryptocoelia* sp. From quarry scree. Photographic negative. 8x
4. *Cryptocoelia* n. sp.? From quarry scree. 5x

15

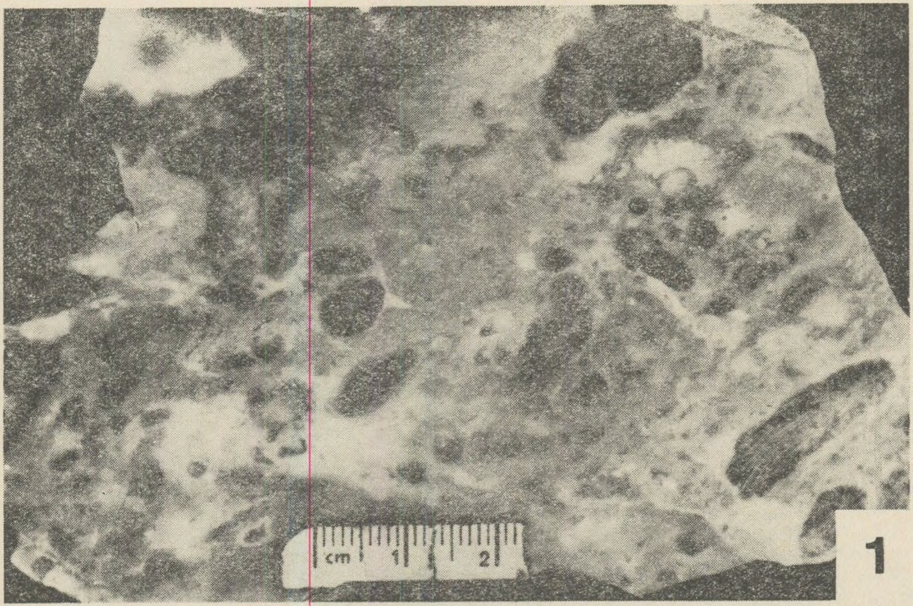

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PLATE XV.

Felsőtárkány quarry

1. Reef facies with corals.
2. Autochthonous reef facies intercalated with graded, coarse reef detritus.

UPPER JURASSIC AMMONITE BIOSTRATIGRAPHY IN THE TRANSDANUBIAN CENTRAL RANGE (HUNGARY). PRELIMINARY RESULTS

by

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Abstract

The examined ammonite fauna has been collected from red nodular limestone of Kimmeridgian and Tithonian age from the Bakony Mts. (Transdanubian Central Range). Dominance of Phylloceratina and Lytoceratina, and occurrence of some genera of Ammonitina indicate a Mediterranean character. Ammonitina – forming one-third of the fauna – made possible to recognize Mediterranean biozones.

Introduction

Jurassic rocks of Hungary are comprehensively discussed in several recent reviews (FÜLÖP 1971, GALÁCZ 1985).

In Hungary the main Jurassic occurrences are as follows:

– Largest continuous outcrops are in the Transdanubian Central Range, especially in the Bakony and Gerecse Mts.

– From southern Hungary an extensive Jurassic sequence is known in the Mecsek and Villány Mts.

– In the Bükk Mts. in North-east Hungary the thick clayey-shaley sequence, and in western Hungary, the unfossiliferous, slightly metamorphosed succession are regarded also as Jurassic, but their exact stratigraphic position is unknown.

While the series and the ammonite fauna of the Transdanubian Central Range shows Mediterranean characters, the sequence of the Mecsek Mts. has a strong similarity to NW-European formations.

Although Upper Jurassic formations are known from each large unit, I would like to focus on the outcrops of the Transdanubian Central Range, especially of the Bakony Mts.

Here, the Triassic carbonates are overlain by Lower Jurassic "Ammonitico Rosso" type limestones which are followed by heterochronously appearing cherty, radiolarian-rich siliceous marl which belongs to the Middle Jurassic. Subsequently – in the Upper Jurassic –, the "Ammonitico Rosso" limestones reappear. These ammonite-rich limestones are covered by a white, thinly-bedded limestone and marl of Biancone facies (Upper Tithonian – Lower Berriasian), or by paraconformable Middle Cretaceous (Aptian) limestones.

Regarding the whole Transdanubian Central Range, it could be pointed out, that in the "Upper Ammonitico Rosso" not only the Tithonian, but the Kimmeridgian and Oxfordian stages are represented as well.

Not counting the ammonite studies of G. VIGH, subdivisioning of Upper Jurassic formations and drawing of the Jurassic/Cretaceous boundary has been carried out mostly by microfacies and micropaleontological investigations.

The studies of ammonites revealed that in single profiles the particular stages are usually represented partially, the individual sequences are commonly more or less incomplete. The hiatuses rather vary in time and space.

From the Oxfordian up to the Tithonian the thickness of the succession increases, which is – partly – due to that upwards in the sequences the spans of stratigraphic hiatuses are decreasing.

Richest ammonite assemblages were yielded by the Kimmeridgian and Tithonian. The large Upper Jurassic ammonite fauna collected by the Hungarian Geological Survey, numbers thousands of specimens. These were investigated by G. VIGH. Unfortunately he could not finish his work because of his untimely death. The following comprehensive review was made by using the data of G. VIGH.

The Sümeg profile

Among the examined outcrops this is the most southern. The Oxfordian, Kimmeridgian and Lower Tithonian are very poor in ammonites, thus further subdivision is problematic. The Middle and Upper Tithonian fauna is richer. According to the investigations of G. VIGH (1984) the fauna of the profile shows similarity with Spanish faunas from the Betics.

Within suborder Ammonitina, beyond the generally frequent haploceratids, the most characteristic Lower Tithonian genera are *Semiformiceras, Paraulacosphinctes, Simoceras, Sublithacoceras*. In the Upper Tithonian the Himalaytinae family has a relatively large specimen and species number.

The taxonomy of the represented *Himalayites, Durangites* and *Djurjuriceras* have not worked out yet, but they proved to be very useful index forms in the upper part of the Middle Tithonian.

The Lókút profile

The Jurassic sequence of the Lókút Hill is considered as one of the most complete successions of the Bakony Mts. Among the current 11 Jurassic stages 7 were documented with ammonites and the remaining 4 can be inferred on the basis of facies similarities.

The Middle Jurassic radiolarite is overlain by a thick series of limestones.

According to the partly published, preliminary ammonite investgiations of G. VIGH the succession consists of a few limestone beds belonging to the Oxfordian, a nearly complete Kimmeridgian and a Tithonian sequence.

In the Kimmeridgian, *Taramelliceras*, *Nebrodites*, *Lithacoceras* and the aspidoceratids are frequent and characteristic. Typical Tithonian genera are *Simoceras*, *Lithacoceras*, *Usseliceras*, *Lemencia*, *Paraulacosphinctes*, *Himalayites*.

On the basins of the rich ammonite fauna it can be stated that all of the zones of the Kimmeridgian and Tithonian are represented in Lókút.

The profile of the Közöskút-ravine

In the Közöskút-ravine, the Upper Jurassic sequences crop out in beautiful exposures.

Although the Kimmeridgian beds are very incomplete here (only the uppermost Beckeri Zone is represented), the Lower and Middle Tithonian are better developed. The common presence of the Hybonotum and Darwini Zones is verified by the occurrence of genera *Neochetoceras*, *Pseudolissoceras*, *Physodoceras* and *Virgatosimoceras*. The Semiforme and Fallauxi Zones are indicated by the zonal indices. A few beds bearing several species of *Simoceras*, were ranged into the Ponti Zone.

The upper part of the succession yielded a Berriasian fauna, so future investigations will furnish data on the Jurassic/Cretaceous boundary, too.

The Szilas-ravine profile

Here the Upper Jurassic fossiliferous limestones occur in the side of a valley. In the trench, excavated by the Geological Survey, the Middle Jurassic radiolarite was also exposed.

The ammonite fauna of the succession is very similar to that in the above mentioned Közöskút-profile. In the Szilas-ravine the H. beckeri beds are overlain by a fairly complete Lower and Middle Tithonian series, which is rich in ammonites.

The investigations are not finished yet, but the upper beds of the profile seems to be range around the Tithonian/Berriasian boundary.

In the Lower and Middle Tithonian the *Neochetoceras*, *Virgatosimoceras*, *Simoceras*, *Subplanitoides*, *Burckhardticeras* genera are characteristic.

In the Tithonian/Berrasian boundary beds several big *Himalayites*, *Corongoceras*, *Malbosiceras* and numerous, very poorly preserved *Berriasella*-like ammonites were found.

The Rendkő profile

Another representative outcrop of the Upper Jurassic limestones is known from the "Rendkő-tető". Here the Ammonitico Rosso type limestones form spectacular cliffs. Detailed, bed by bed collection was not carried out, however it appears, that most of the Kimmeridgian and Lower Tithonian are missing, or at least their presence coud not be demonstrated with fauna. The Middle Tithonian beds are richer in ammonites. The topmost part of the profile is a light coloured, thinly – bedded limestone with poorly preserved *Berriasella*-like ammonites. Probably these beds belong to the Berriasian.

The general character of the Bakony ammonite fauna

The conclusions are based on the study of thousands of ammonites, wich were collected from the five mentioned sections.

The large proportion of the Lytoceratidae and Phylloceratidae in the fauna could be regarded as a typical Mediterranean character.

Most of the Phylloceratidae belong to *Ptychophylloceras*, namely to *P. semisulcatum*.

In the Lytoceratinae subfamily most common is the genus *Protetragonites*, but some large-sized species (usually ranged into the genus *Pterolytoceras)* are also common.

Regarding the Ammonitina, the high frequency of the Haploceratidae is very conspicuous. In some cases 25 – 50% of the Ammonitina is taken by these forms.

In the upper part of the Lower Tithonian (Verruciferum Zone) good specimens of *H. verruciferum* are very characteristic (pl. II. fig. 4.). It is worth mentioning, that a new large-sized verruciferum like species, which was mentioned hitherto only from the Subbetics by Oloriz (1978) also occurs in the Bakony.

Disregarding haploceratids it could be stated that the other (sub) families of the Ammonitinae show a high genus and species diversity, which could be regarded as a Mediterranean character also.

Several ammonite species are particularly Mediterranean, while a number of other species occur also in the Sub-Mediterranean area.

From the rich ammonite assemblage *Semiformiceras* and *Simoceras* are of particular interest.

The most characteristic *Semiformiceras* is *S. semiforme*. The rich and well-preserved material shown the large intraspecific varibility and the slow gradual morphological change which were observed on the Spanish material by Oloriz (1978) and Enay, 1982). The two figured specimens (both belongs to *S. semiforme)* show considerable differences in coiling, umbilical width and in the character of the marginal tubercules (pl. I. fig. 2. 3.).

It is important that not only the type species, but other congeneric forms are also represented in the Bakony fauna, so the whole phylogenetic linage of the genus (outlined by Enay (1982) could be traced.

Simoceratids are characteristic ammonites of the Mediterranean Lower Tithonian. Among them, there are a few zonal indices too.

In the Bakony material occurred a few well-preserved specimens of *S. volanense* (s. l.), *S. schwertschlageri*, (pl.I.,II. fig. 1., 5.) and fragments of *S. biruncinatum* and *S. admirandum*. The diversified material suggests, that these classical species need revision.

The small characteristic specimens of a *Lytogyroceras* occurred in a single bed of one profile (pl. II. fig.3.).

S. subbeticum, which was recently described from the Spanish material, also occur in Hungary.

Fragments of a few large-sized *Simoceras*-like ammonites have still a problematic taxonomy.

Probably, the future investigations of simoceratids will increase the stratigraphic importance of these well-recognisable group.

Paleoecological evaluation of the associated fauna

The biggest part of the Kimmeridgian and Tithonian megafauna was the ammonites, but during the large collection work a few other fossils were also found. It is interesting that while thousands of ammonites were found in the sequences, only a few other fossils occurred. The non-ammonite fauna is quite poor, only the pygopid brachiopods are common in certain beds.

In the Szilas-ravine sequence, for example, 3554 specimen of ammonites, 274 brachiopods, 27 echinoids, 25 belemnites, 22 bivalves and only one gastropod was found.

On the basis of this material a rich nectonic-planktonic, and a poor benthonic community could be outlined.

In the first group ammonites are most common, and some nearly undeterminable coleoid phragmocones (found in the Rendkő section) belong also here. (pl. III. fig.3).

Among the benthonic forms pygopid brachiopods are most common (Pl. III. fig. 4. 5. 6., but a few *Nucleata* specimens also occurred.

Gastropods are very rare in the Upper Jurassic limestones. Only a single specimen of the genus *Conotomaria* was found in the Tithonian of the Rendkő Hill (pl. III. fig. 1, 2).

In the quite poor bivalve fauna there are shallow and probably deep burrower forms (pl. II. fig. 2.), but some *Inoceramus*-like specimens also occurred.

Common worm tubes (found in the ammonites) suggest, that worms were significant members of the in- and epifauna. It is probable that other groups were living within the sediment, resulting bioturbation.

Hardly determinable irregular echinoids were members of the infauna too (pl. II. fig. 1.).

Conclusions

– The Upper Jurassic fauna of the Bakony Mts. shows significant similarity to the faunas of the Spanish (Subbetic) and in some cases with other Mediterranean and Sub-Mediterranean areas. So the Upper Jurassic ammonite zonation worked out previously in these areas proved to be useful base for the Hungarian Upper Jurassic biostratigraphy.

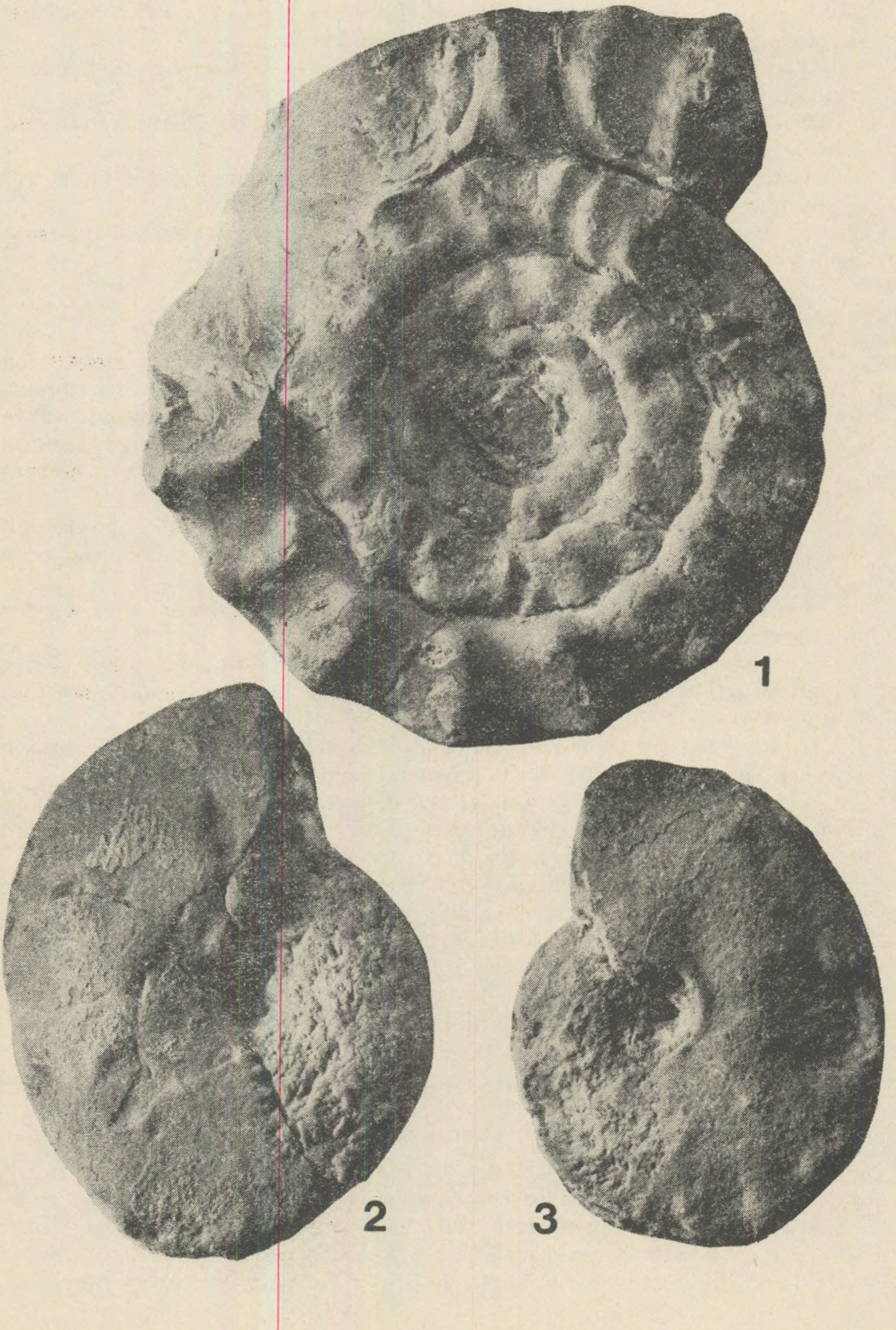
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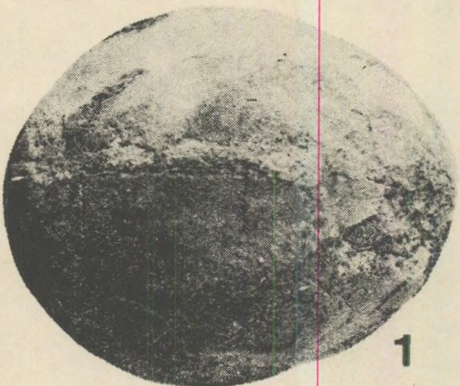
PLATE I.

Fig. 1. Simoceras aff. *volanense* (OPPEL 1863), Közöskút-ravine, Lower Tithonian, 1x
Fig. 2. Semiformiceras semiforme (OPPEL 1865), Közöskút-ravine, Lower Tithonian, 1x
Fig. 3. Semiformiceras semiforme (OPPEL 1865), Szilas-ravine, Lower Tithonian, 1x



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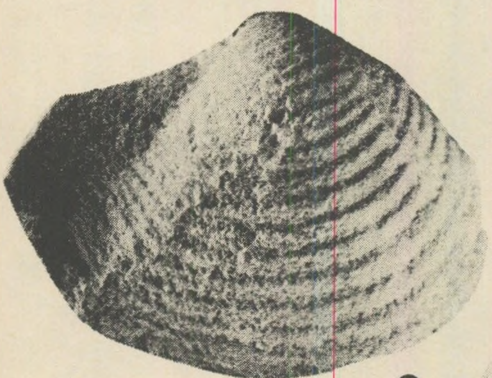

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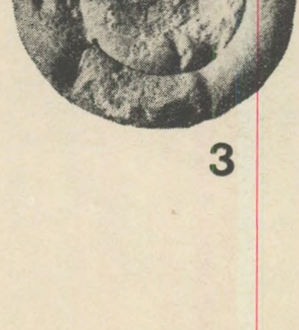

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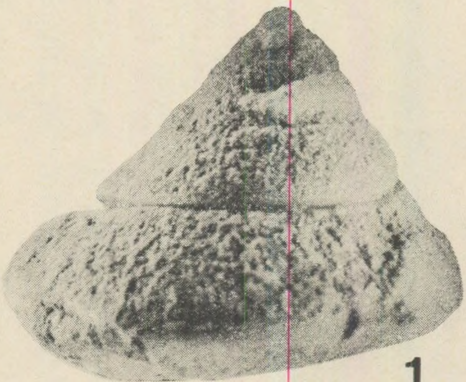
PLATE II.

Fig. 1. Irregular echinoid from the Rendkő Hill: Upper Tithonian, 1x
Fig. 2. Burrower bivalve from the Rendkő Hill: upper part of the Lower Tithonian, 3x
Fig. 3. *Lytogyroceras* sp.: Közöskút-ravine, Lower-Tithonian 1x
Fig. 4. *Haploceras verruciferum* MENEGHINI in ZITTEL 1870, Szilas-ravine, Lower Tithonian, 1x
Fig. 5. *Simoceras schwertschlageri* (SCHNEID 1914), Közöskút-ravine, Lower Tithonian, 1x



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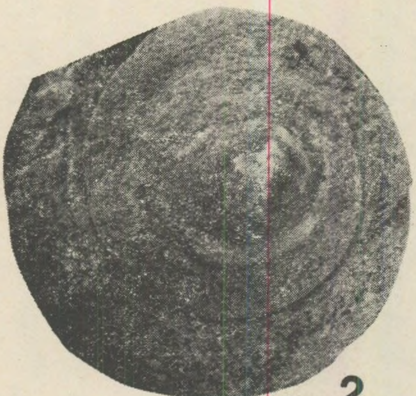

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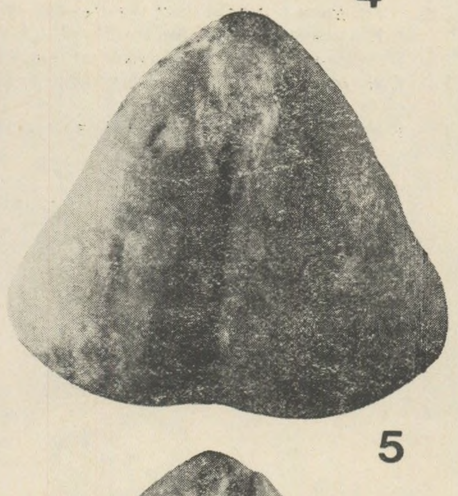

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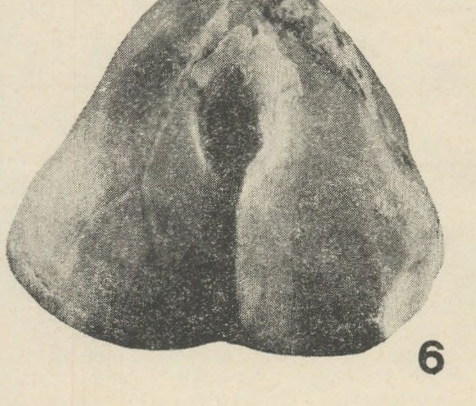

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PLATE III.

Fig. 1, 2. Conotomaria sp. from the Rendkő Hill. Upper Tithonian, 2x
Fig. 3. Coleoid phragmocone from the Rendkő Hill. Middle Tithonian, 1x
Fig. 4, 5. Pygope diphya (BUCH 1834) from the Rendkő Hill. Middle Tithonian, 1,5x

– The biostratigraphic study of the five profiles indicates, that the boundary between the Middle Jurassic radiolarite and the Upper Jurrassic limestones is heterochronous. This is in accordance with the previously outlined facies-genetic framework (see GALÁCZ and VÖRÖS 1972).

REFERENCES

ENAY, R. (1982): Spéciation phylétique dans le genre d'Ammonite téthysien Semiformiceras Spath du Tithonique inférieur des chaines bétiques (Andalousie, Espagne). Colloques internationaux du C.R.N.S. No 330 Modalites, Rythmes et Mécanismes de l'evolution biologique pp. 115 – 123.

FÜLÖP, J. (1971): Les formations Jurassiques de la Hongrie. Ann. Inst. Geol. Publ. Hung. LIV, 2, pp. 31 – 46.

GALÁCZ, A. and VÖRÖS, A. (1972): Jurassic history of the Bakony Mountains and interpretation of the principial lithological phenomena. Földt. Közl. CII, 2, pp. 122 – 135. (In Hungarian with English abstract)

GALÁCZ, A. (1985): Jurassic of Hungary: a review. Acta. Geol. Hung. 27. 3 – 4. pp. 359 – 377. Budapest

OLORIZ, F. (1978): Kimmeridgiense-Tithonico inferior en el Sector Central de las Cordilleras Béticas (Zona Subbética) Paleontologia, Bioestratigraphia. Test. Doct. Fac. Cienc. Univ. Granada. 184. pp. 1 – 758.

VIGH, G. (1984): Die biostratigraphische Auswertung einiger Ammoniten-Fauna aus dem Tithon des Bakonygebirges sowie aus dem Tithon-Berrias des Gerecsegebirges. Ann. Inst. Geol Publ. Hung. LXVII., pp. 1 – 125.

A MIDDLE EOCENE NAUTILOID FROM DUDAR (TRANSDANUBIAN CENTRAL RANGE, HUNGARY)

by

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Abstract

Collection from the extremely rich faunal assemblage of the Middle Eocene calcareous sandstone of Dudar (Bakony Mountains, Transdanubian Hungary) yielded a well-preserved nautiloid specimen. Gastropods and bivalves are well-known and partly monographed from this locality, however cephalopods are practically unknown. Thus the specimen, a *Cimomia crassiconcha* (VOGL, 1908), its preservation history and morphologic description is given.

Introduction

Tertiary nautiloids are rare fossils, even in assemblages of rich mollusc faunas. Exceptions are known (see MILLER, 1947) and one of these is probably of the Eocene marls of Piszke and Buda, both in the Transdanubian Central Range. The nautiloids of these formations have been treated by VOGL (1908; 1910a; 1910b), but subsequent records of Hungarian Tertiary cephalopods are only items in fossil lists published sporadically. Therefore it seemed reasonable that description of a recently collected, stratigraphically well localized specimen would warrant more than usual interest.

The here described specimen was collected by geology student G. VÁRNAI, on an excursion to Dudar in 1982. The specimen was found on the waste-dump of the coal mine, the usual site of collecting the extremely rich Middle Eocene fossils. The example is deposited in the collection of the Paleontological Department of the Hungarian Natural History Museum, Budapest, as No. M. 85. 1.

Locality and stratigraphy

The first results of detailed studies on the Eocene occurrences around Dudar were published by TOMOR–THIRRING (1934; 1935). His faunal lists contain the first reference to nautiloids, quoting *Nautilus* sp. from the "Bartonian" marls. At the same time coal exploration has started in the Dudar area, and in the 1940s the subsurface mining activity made it possible to outline the Eocene succession (SZŐTS, 1948). From the beginning of mining the waste dumped around the shafts has been an

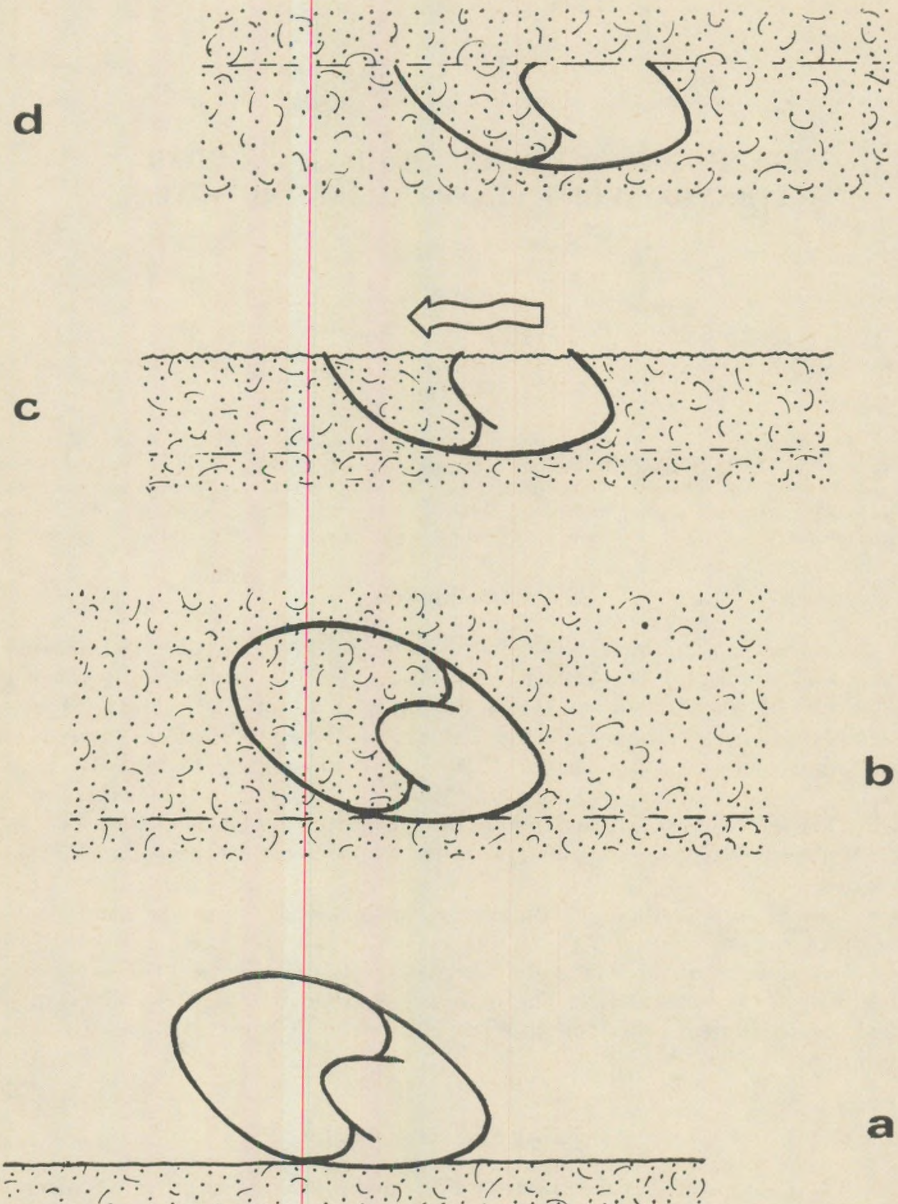

Fig. 1. Phases of the preservation history of the here described *Cimomia crassiconcha* (VOGL, 1908) specimen.

excellent source of beautifully preserved fossils, mainly molluscs. In spite of the fact, that the fossils of several distinct horizons are mixed in the material, the specimens can be easily ranged into the original levels, because their preservation and matrix is sufficiently different.

The most fossiliferous Eocene horizon of Dudar is the greyish-brown nummulitic calcareous sandstone overlying immediately the upper coal seam. The richness of the fauna is well-documented by the monograph of STRAUSZ (1966), who described 155 species of nearly 90 genera of gastropods, and the preliminary and far incomplete list of bivalves given by SZŐTS (1956), which contains 36 genera. Other macrofossil groups are subordinate, but corals, worms, bryozoans, brachiopods, echinoids and marine vertebrates are also represented.

SZŐTS (1956, p. 43) and MONOSTORI (1972) pointed out that the 2 m thick nummulitic, mollusc-bearing sandstone is a typical coastal sediment, with washed, transported faunal elements commonly embedded fragmentarily. Nevertheless, the individual preservation is sometimes exceptional: gastropods with original coloration are well-known items of the collections. The preservation of the here described nautiloid illustrates the deposition history clearly (Fig. 1). The specimen sank to the bottom, it was partially loaded with bottom sediment, then the moving sand eroded the exposed parts, so the resulting fossil is a half-cut partial mould. The preserved portion retained the original shell, however during the collection it was peeled off and lost. However, original color pattern could not be seen.

Detailed analysis on the age of the beds was made by STRAUSZ (1966, pp. 82–84). His dating as Lower Lutetian is convincing and unequivocally supported by the mass occurrence of characteristic *Nummulites* species (KECSKEMÉTI, 1980).

Systematic description

Subclass N A U T I L O I D E A AGASSIZ, 1847
Order NAUTILOIDA AGASSIZ, 1847
Superfamily N a u t i l a c e a e BLAINVILLE, 1825
Family Nautilidae BLAINVILLE, 1825
Genus *Cimomia* CONRAD, 1866

Cimomia crassiconcha (VOGL, 1908)

Plates I., II; text-figure 2.

1908. *Nautilus (Hercoglossa) crassiconcha* n. sp. – VOGL, p. 647; text-figs. 6, 7.

non 1910. *Nautilus (Hercoglossa) crassiconcha* VOGL – VOGL, p. 198, text-figs. 7, 8.

Description: The specimen is a large internal mould with partially preserved shell fragments. Because of subsequent erosion and slight oblique crushing, measurements may be misleading. The maximal preserved diameter is ca. 150 mm, but parts still preserved indicate that actual size might have been ca. 250 mm. At 150 mm the width of the whorl is about 100 mm ($\sim$67%), the whorl-height is 95 mm ($\sim$63%), and the umbilical width is ca. 10 mm ($\sim$7%). The specimen is an adult phragmocone, as indicated by sutural crowding and shell thickening around the umbilicus. At least one half whorl of body chamber was broken off. The whorl-section is lenticular, with evenly-rounded flanks, highly-arched venter and steep umbilical wall meeting the flank in rounded, but distinct umbilical shoulder. Position of the siphuncle is unknown.

The suture-lines are clearly shown by several consecutive sutures (Fig. 2). These cross the external part radially, then form wide, moderately deep lateral lobe, and round into high, narrow lateral saddle near the umbilical margin. There are some minor differences between individual sutures, but the described features seem fairly general.

Remarks: VOGL (1908, p. 647) established his ,,*Nautilus (Hercoglossa) crassiconcha*" on a well-preserved phragmocone from the "perforata beds" (Middle Eocene) of Tatabánya (Transdanubian Central Range). His short, incomplete description and figures indicate a relatively compressed form with highly-arched venter. The sutures are well visible in the photograph (fig. 6), and this is a solid basis for ranging the species into the genus *Cimomia*. The same conclusion was drawn by KUMMEL (1956, p. 450).

Subsequently VOGL (1910b, p. 221) described a form from the Piszke Marl (Middle Eocene), which he ranged into this species. However, the cross-section and the suture-line figures (figs. 7 and 8 in VOGL) indicate a strongly compressed from with different septal sutures. Detailed studies on VOGL's originals may reveal further information, but the real specific state of his *C. crassiconcha*, as well as the exclusion of his subsequently described specimen can be ascertained even on the basis of his figures.

Comparisons: As that of most Tertiary nautiloids, the systematics of European *Cimomia* species is in a rather diffuse state, calling for detailed revision. Many names are available, but being based usually on single specimens, the specific variability, hence the possible synonyms are dificult to decipher.

Cimomia burtini (GALEOTTI, 1837), the genotype, of which type figure is reprinted by MILLER (1947, pl. 26, fig. 1) and KUMMEL (1956, pl. 24) is a form with closed umbilicus and extremely high lateral saddle following a very wide lateral lobe. The forms described by SCHAFHÄUTL (1863) are all different: his *C. parallela* (pl. LVI, figs. 1. a–c) is a compressed form with wide umbilicus; *C. macrocephala* (pl. LIV, figs. 2. a–c) is a very wide species with shallow lobe and low saddle in the suture line; his *C. elliptica* (pls. LVII, LVIII) has a widely-rounded venter and a suture line which lacks the radial portion around the ventrolateral shoulder, while has a characteristic, shallow external lobe.

OPPENHEIM (1901, pp. 252–253, pl. XVIII, figs. 1, 1a) gave the original diagnosis and measurements of *C. leonicensis* (DE ZIGNO), and figured a specimen from DE ZIGNO's original material. These show wide, low outer whorl, nearly triangular in cross-section. The general apperance is very similar to that of *C. macrocephala* (SCHAFHÄUTL). *C. imperialis* (SOWERBY) seems as the most closely allied form, but it has wide, evenly-rounded low whorls. A good specimen of this species was described and figured by FRAUSCHER (1895, p. 193, pl. I, figs. 1 – 2) as "*Nautilus Seelandi* PENECKE" (see SCHULTZ, 1976, pp. 9 – 10).

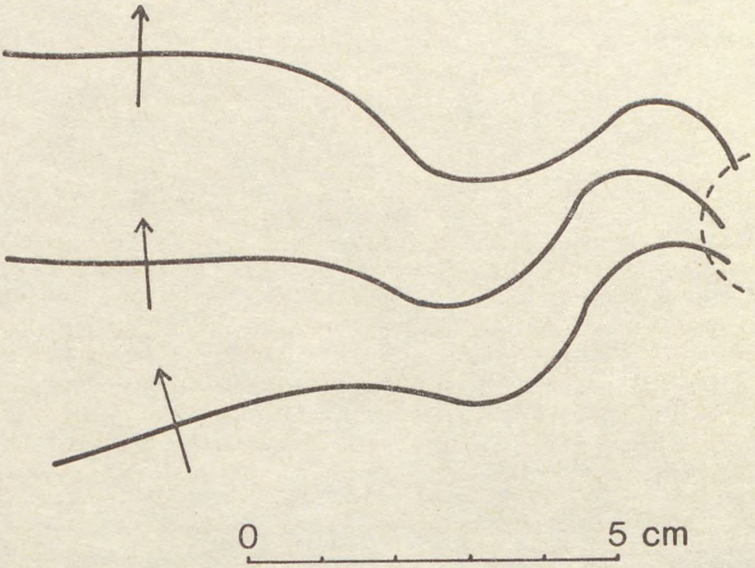

Fig. 2. Consecutive suture-lines of *Cimomia crassiconcha* (VOGL, 1908)

Conclusively, *C. crassiconcha* (VOGL) appears to be a distinct, well-characterised Eocene species of *Cimomia*, of which studies on further relations with allied forms and other aspects can reveal interesting results.

*

Tertiary nautiloids – a most neglected field of the recent European invertebrate paleontology – seems a rather interesting topic for further investigations. The results may solve taxonomic problems and can cast light on paleobiogeographic connections.

REFERENCES

FRAUSCHER, K. (1895): Nautilusse von Guttaring. Jb. Naturhist. Landes-Mus. Kärnten, *23:* 185 – 199.

KECSKEMÉTI T. (1980): Aperçu paléobiogéographie sur la faune du Nummulites du Bakony. Földt. Közl., *110,* 3 – 4: 432 – 449 (In Hungarian with French summary).

KUMMEL, B. (1956): Post-Triassic nautiloid genera. Bull. Mus. Comp. Zool. Harvard Coll., *114,* 7: 324 – 494.

MILLER, A. K. (1947): Tertiary nautiloids of the Americas. Geol. Soc. Amer., Mem., *23:* 1 – 234.

PLATE I.

Cimomia crassiconcha (VOGL, 1908), Dudar, Middle Eocene. Lateral view. (natural size)

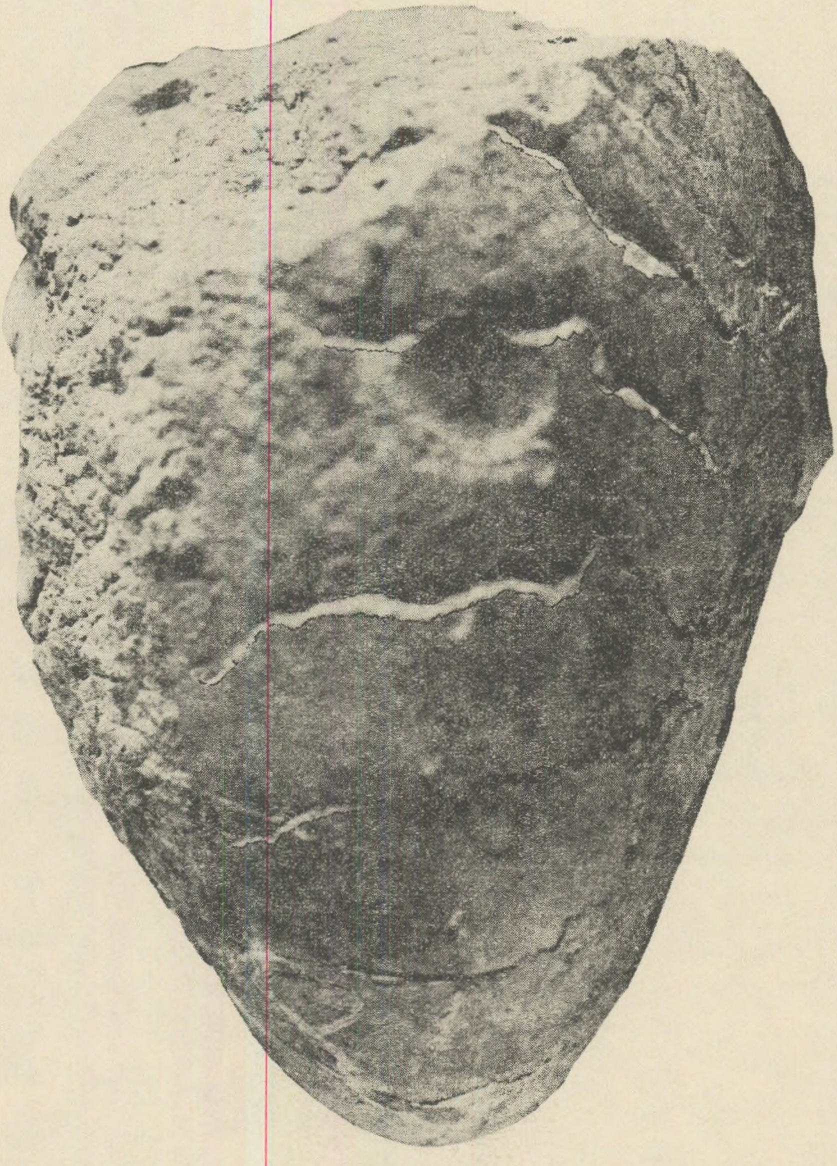

PLATE II.

Cimomia crassiconcha (Vogl, 1908). Dudar, Middle Eocene. Ventral view. (natural size)

MONOSTORI M. (1972): Faciological evaluation of Eocene ostracods from Dudar, Hungary. Ősl. Viták, *20:* 47 – 57. (In Hungarian with English abstract).

OPPENHEIM, P. (1901): Die Priabonaschichten und ihre Fauna in Zusammenhange mit gleichalterigen und analogen Ablagerungen. Palaeontographica, *47:* 1 – 344.

SCHAFHÄUTL, K. E. (1863): Süd-Bayerns Lethaea Geognostica. Der Kressenberg und die südlich von ihm gelegenen Hoch-Alpen, geognostisch betrachtet in ihnen Petrefacten. L. Voss, Leipzig. 487 p.

SCHULTZ, O. (1976): Nautiloidea tertiaria et Dibranchiata tertiaria. In: Zapfe, H.: Catalogus Fossilium Austriae. H. VI f/3. Österr. Akad. Wiss., Wien: 1 – 32.

STRAUSZ L. (1966): Die Eozängastropoden von Dudar in Ungarn. Geol. Hung., Ser. Palaeont., *33:* 1 – 200 (In Hungarian and German).

SZŐTS E. (1948): Die Eocengebilde des nördlichen Bakony. Földt. Közl., *78:* 39 – 58 (In Hungarian).

SZŐTS E. (1956): L'Eocène (Paleogène) de la Hongrie. Geol. Hung., Ser. Geol., *9:* 1 – 320 (In Hungarian and French).

TOMOR-THIRRING J. (1934): Geologische und paläontologische Verhältnisse des Dudar Oszlop-er Sürü Gebirggruppe. Földt. Szemle Suppl.: 1 – 47 (In Hungarian with German abstract).

TOMOR-THIRRING J. (1935): Stratigraphie und Tektonik des Eozäns in nördlichen Bakony-Gebirge. Földt. Közl., *65:* 2 – 15.

VOGL V. (1908): Über Eozäne Nautiliden. Földt. Közl., *38:* 634 – 649.

VOGL V. (1910a): Neuere Beiträge zur Kenntnis der alttertiären Nautiliden Ungarns. Centralbl. Min., Geol. Pal., Jahrg. 1910, *21:* 707 – 710.

VOGL V. (1910b): Die Fauna des sogenannten Bryozoenmergels von Piszke. MÁFI Évk., *18,* 3: 194 – 228.

LOWER LIASSIC FACIES ZONES IN THE BAKONY UNIT OF HUNGARY

by

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Abstract

Contrasting lithology, highly varied sediment thickness and differences in the timing of pelagic sedimentation provide a threefold division of the Bakony unit in Hettangian and Sinemurian. A deep basin in the Zala region with variable topography, containing black marls, corresponds to the Lombardian basin of the Southern Alps. A carbonate platform in the Bakony Mts. corresponds to the Trento plateau and a contemporaneous pelagic basin (Gerecse Mts.) with highly condensed sedimentation to the Belluno trough.

Introduction

The Bakony unit is situated in the NW part of the Pannonian basin. It is bordered by two strike-slip faults, which are parts of the Periadriatic lineament system, to the NW and to the SE (KÁZMÉR, 1986) (Fig. 1). It has been displaced from the Alps to its actual position by an Oligocene continental escape (KÁZMÉR and KOVÁCS, 1985). Its Jurassic formations, among others, are closely similar to those of the Southern and Eastern Alps (GALÁCZ and VÖRÖS, 1972, and references therein). The marked differentiation of the Southern Alps into distinct facies zones: e.g. the Friuli platform, the Belluno trough, the Trento plateau, and the Lombardian basin with several internal swells and troughs (WINTERER and BOSELLINI, 1981, with further references) made us to look for similar features in the Bakony unit. This paper summarizes the results for the Lower Liassic (Hettangian-Sinemurian, occasionally Pliensbachian) stages.

Ten published Hettangian-Sinemurian surface profiles with good biostratigraphical control ranging from the western end of the Bakony Mts. through Vértes Mts. to Gerecse Mts. (Fig. 2) are correlated with each other (Fig. 4) emphasizing lithology and sediment thickness. Six, partly unpublished subsurface profiles from the Zala region at the westernmost end of Bakony unit in Hungary, representing the whole Liassic due to less accurate or no biostratigraphic control are added. Lithology, sediment thickness and fossil content are interpreted in the framework of a basin and plateau topography very briefly, due to space limitations. A more detailed treatment will be published later.

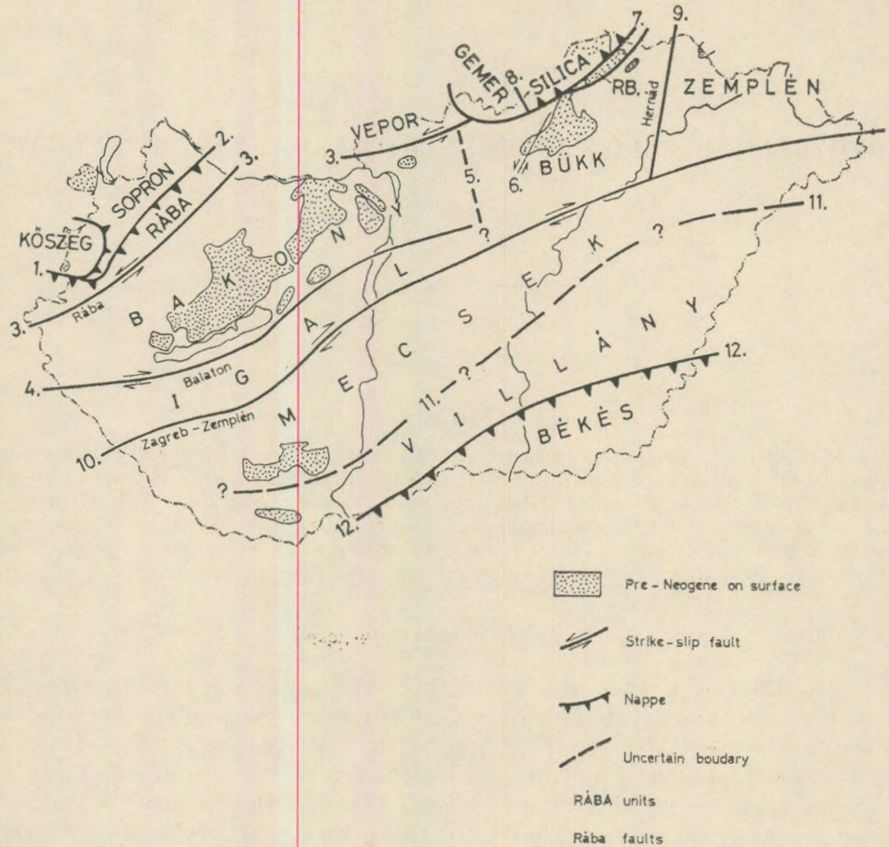


Fig. 1. Tectonic units of Hungary (Kázmér, 1986), Stippled: pre-Neogene formations of the surface. RB = Rudabánya unit.

Stratigraphy (Fig. 3)

Standard stratigraphic review papers of Bakony unit also provide evidences for the depositional environments (FÜLÖP, 1971), for a Mediterranean-type dissected submarine topography (GALÁCZ and VÖRÖS, 1972), for basin evolution (GALÁCZ, 1984). GALÁCZ et al. (1985) interpreted the Jurrassic Bakony unit as part of the southern, distensional passive margin of the Tethys.

A brief description of Lower Liassic formations is given here; for further references see KÁZMÉR (1986).

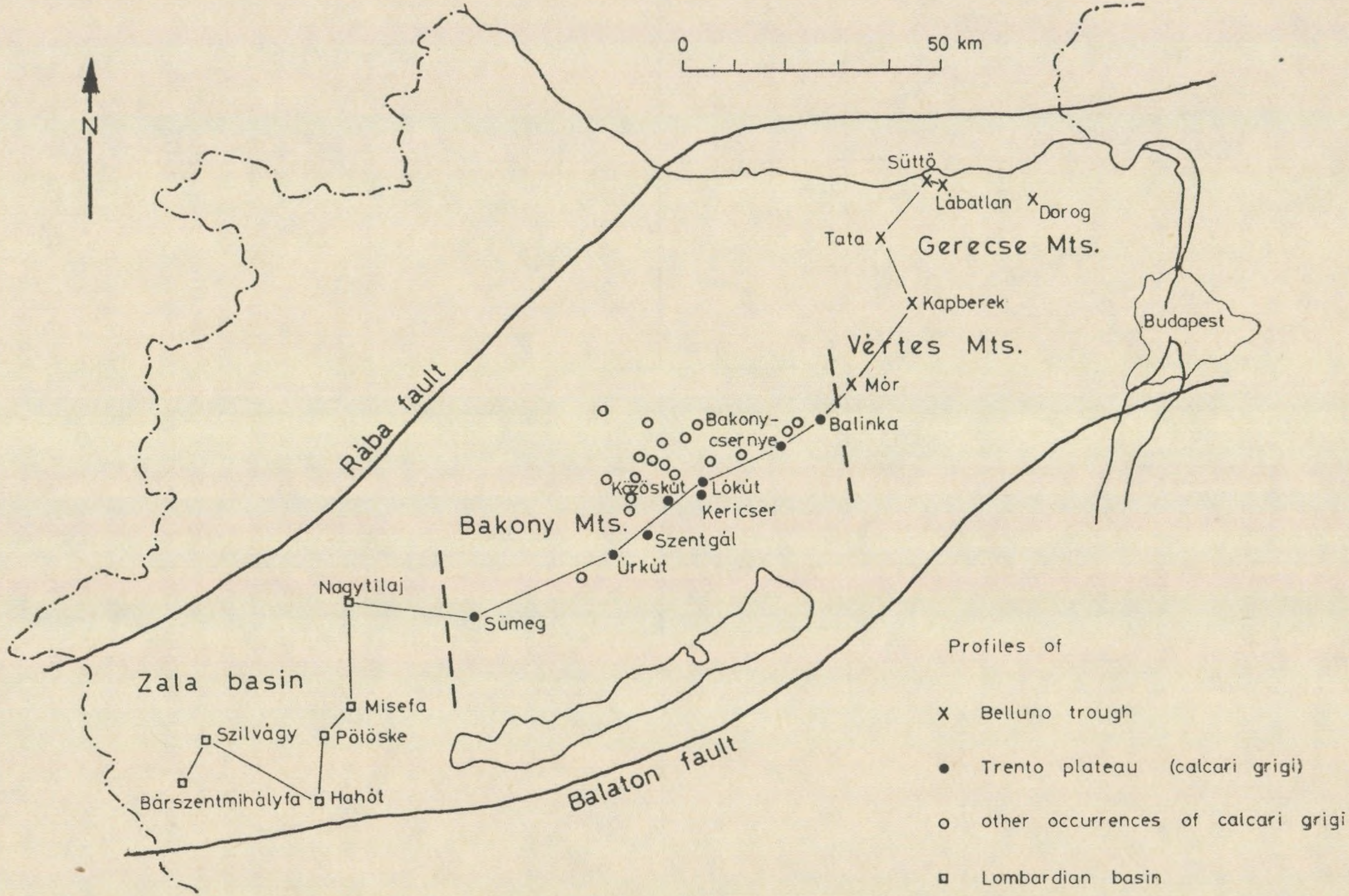


Fig. 2. Location of Lower-Middle Liassic profiles in the Bakony unit. The long profile is shown on Fig. 4. The dashed line indicates the approximate position of the boundaries between the two basins to the W and E and the plateau in the middle.

Dachstein Limestone (Norian-Rhaetian)

Well-developed Lofer cyclothems (HAAS, 1982; HAAS and DOBOSI, 1982) and locally frequent Megalodontaceae (VÉGH-NEUBRANDT, 1982) characterize this formation, deposited in an open platform environment. The Triassic–Jurassic boundary is traditionally drawn at a minor facies change within the platform limestone. Lofer cyclothems, Megalodontaceae and the foraminifer *Triasina hantkeni* MAJZON disappear, and locally brachiopods and oncoids appear. The latter, Jurassic formation is the

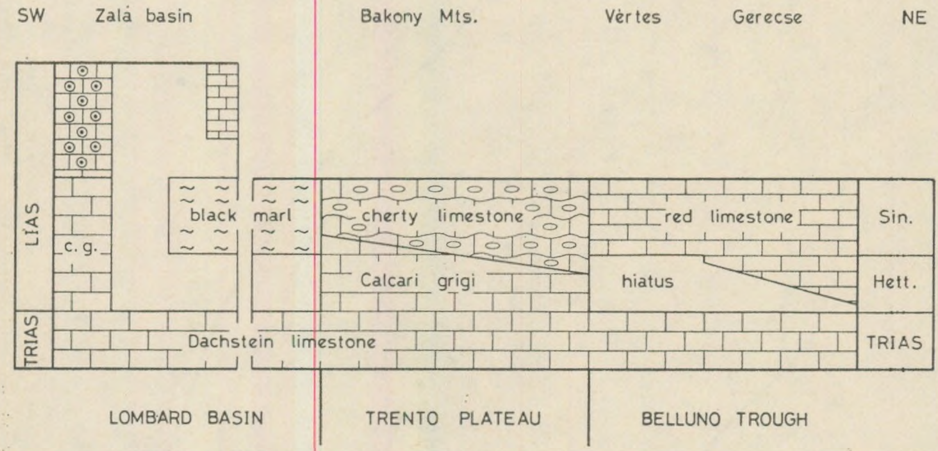


Fig. 3. Age relationships of Lower Jurassic formations in the Bakony unit. Hierlatz Limestone (crinoid-brachiopod grainstone) is not indicated within Bakony, Vértes and Gerecse Mts., being frequent, but of local importance.

Kardosrét Limestone (= Calcari grigi) (Hettangian-Lower Sinemurian)

GALÁCZ et al. (1985) interpreted it as a limestone resedimented from neighbouring platform areas onto a drowned platform, like the Vajont Oolite in the Southern Alps (BOSELLINI et al., 1981). But the only available up-to-date description of HAAS et al. (1984) provided opposing evidences. While the Triassic Dachstein Limestone is biomicrite and pelmicrite with grainstone intercalations, the Kardosrét Limestone is mostly pelmicrosparite, with rare oncoids. Its uppermost part is oncomicrosparite (HAAS et al., 1984). The predominance of the micritic matrix makes a redeposition process highly improbable.

Lower Sinemurian brachiopods (VÖRÖS in HAAS et al., 1984) have been found in the upper part of the formation. Its age, thickness (up to 150 m) and shallow marine depositional environment make the Kardosrét Limestone similar to the Calcari grigi of the South Alpine Trento platform; that's why the latter name is applied in Fig. 3.

Cherty limestone (Hettangian-Sinemurian)

This lithological name is applied in a rather general way to the formations overlying the Lower Liassic platform limestones. It contains mostly grey or red spiculitic cherty limestones, forming most of the sequence in thickness; minor quantities of red, compact limestones and (partly Hierlatz-type) crinoid limestones belong tp this group (Fig. 5). All these types pass into the Rosso Ammonitico sequence upwards (GÉCZY, 1961; KONDA, 1970). For further references see KÁZMÉR (1986).

Red limestone (Hettangian-Sinemurian)

Compact, mostly red, rarely grey limestone (Adneth Limestone). Locally Hierlatz-type crinoid limestones occur (FÜLÖP, 1976). Further references in KÁZMÉR (1986).

Crinoid limestone (Liassic) in the Zala region

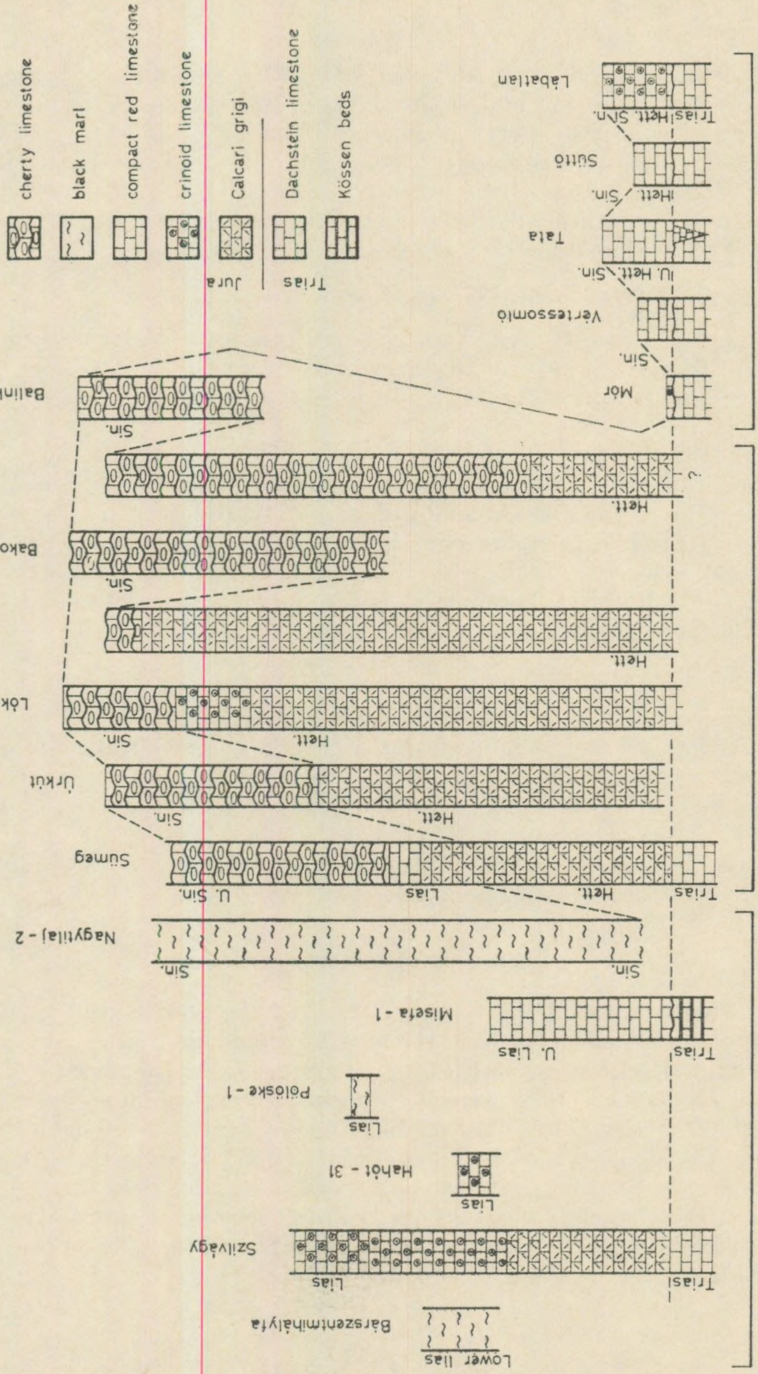
Separately indicated in the sequence of the Szilvágy oilfield. Its relatively great thickness (65 m; unfortunately, dip data are not available) deserves its separate treatment; however, it frequently occurs in other localities, surface or subsurface, in minor quantities (BÉRCZI–MAKK, 1980). In Hahót–31 borehole it is the only Liassic sediment (KŐRÖSSY L., 1986, pers. comm.).

Black marl (Sinemurian)

Grey marl, clayey limestone, black marly shale with foraminifers and ostracods. The brachiopods *Rhynchonella palmata* and *R. fraasi* (det.: J. NOSZKY) indicate Sinemurian age (VÖRÖS, 1986, pers. comm; KŐRÖSSY, 1965; 1986, pers. comm.; MAJZON, 1966). It occurs in Nagytilaj–2 borehole only. Less known occurrences of Liassic black marl and dark nodular limestone in boreholeas Bárszentmihályfa and Pölöske were kindly mentioned by KŐRÖSSY (1986, pers. commn.).

Beginning of red sedimentation

The occurrence of the first red (or grey; i.e. not white) pelagic sediments over the platform limestones is indicated in Fig. 5. Apparently it shows high diachronism, but it partly may be due to the absence of characteristic fossils. All ages were determined by ammonites, except in the Nagytilaj–2 and Lókút Hill profiles, where brachiopods gave good evidences. The sequence of borehole Balinka–271 is ranged on lithological grounds only. At the first glance we can conclude, that the red, pelagic sedimentation started about an age later in the zone named Trento plateau (except Lókút Hill profile) than in the neighbouring profiles. For references see the captions of Figs. 4. and 5.



cherty limestone
black marl
compact red limestone
crinoid limestone
Calcari grigi
Dachstein limestone
Kössen beds
Jura
Trias
Lábatlan
Süttő
Tata
Vértessomló
Mór
Balinka - 271
Bakonycsernye
Lókút
Úrkút
Sümeg
Nagytilaj - 2
Miseta - 1
Pölöske - 1
Hahót - 31
Szilvágy
Bárszentmihályfa
Lower lias
Trias
Hett.
Sin.
U. Hett.
U. Sin.
Lias
U. Lias
BELLUNO TROUGH
TRENTO PLATEAU
LOMBARDIAN BASIN
(m)
150
100
50
0

Facies zones

The lithological variations (Fig. 4), the significant thickness variations (Fig. 4) and the differences in the beginning of red, pelagic sedimentation (Fig. 5) enable us to differentiate three facies zones in the Bakony unit of Hungary. The analogue is the Southern Alps, therefore names of that region are applied here.

"Lombardian basin"

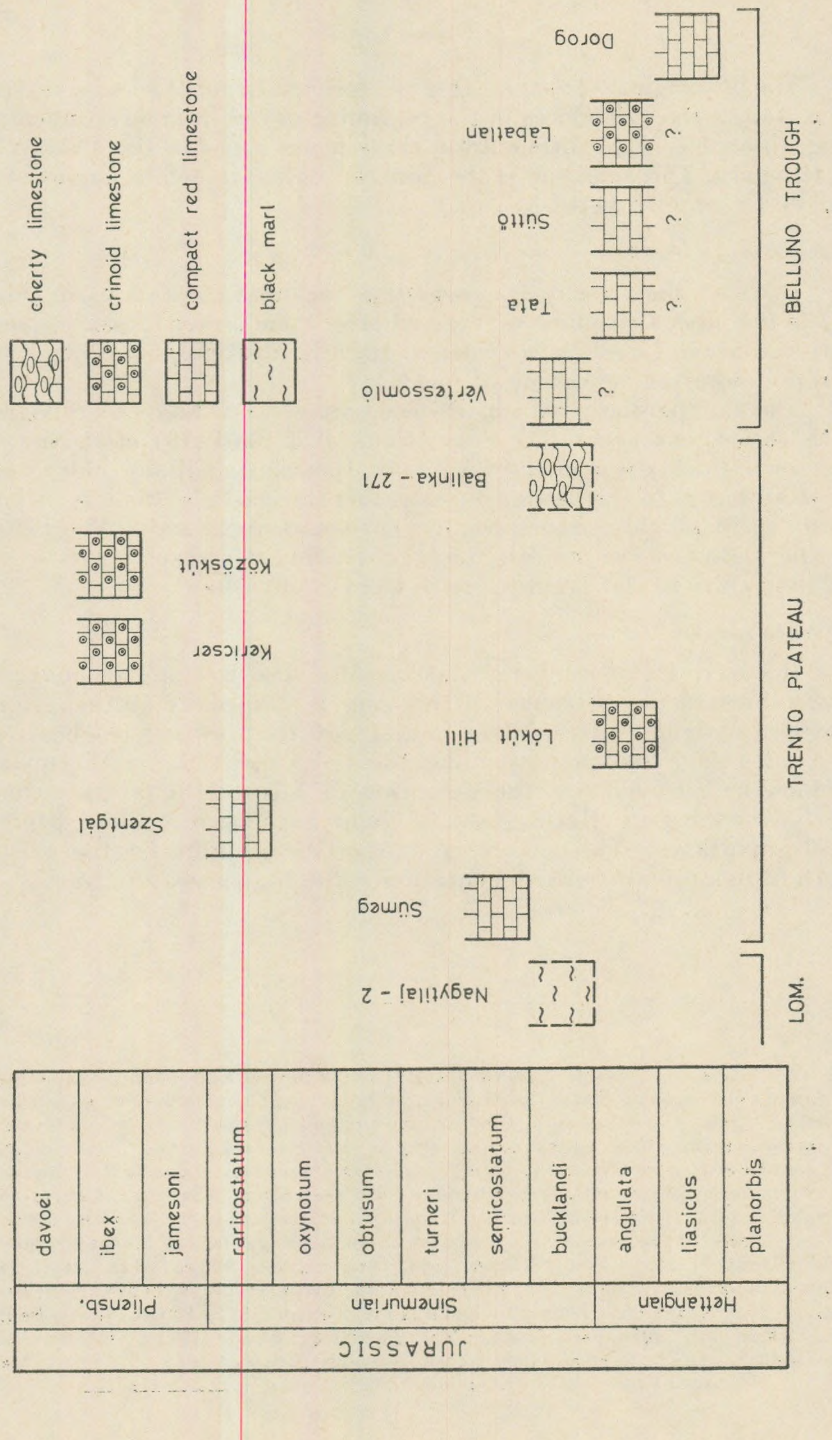
It covers the present-day geographic region of the Zala basin (Fig. 2). While the other two zones are defined after their Lower Liassic sequences, here the whole Liassic is considered, since biostratigraphic control rarely permits more precise dating of rocks.

The Lombardian basin in Hungary displays a dissected topography with varied rock types. The Sinemurian black marl (134 m at Nagytilaj, unknown thicknesses at Pölöske and Bárszentmihályfa) indicates the greatest depths of the basin, concentrating the clastic sediments. All other localities in all three zones contain carbonate rocks only. The Szilvágy profile might be a local swell in the Lombardian basin, displaying a sequence highly similar to the Trento zone of the Bakony Mts.

"Trento plateau"

It covers the present-day Bakony Mts. The Hettangian (and partly Lower Sinemurian) sequence of this zone is formed by Calcari grigi-like platform carbonates (Kardosrét Limestone). Its thickness reaches 150 m. The red, pelagic sedimentation, e.g. the break-up of the platform started in the Sinemurian (with the exception of Lókút Hill profile, where it started in the Late Hettangian. It might have been a minor trough of local importance.) The occurrence of the Calcari grigi, i.e. the existence of Hettangian platform sedimentation is the unique feature of this zone.

Fig. 4. Stratigraphic columns of Lower Liassic profiles in the Bakony unit. Biostratigraphic control of sedimentation in the "Lombardian basin" is insufficient; therefore all profiles described as "Liassic" were included. The "Belluno trough" is characterized by condensed pelagic sedimentation; thick, neritic Calcari grigi is characteristic for the "Trento plateau"; and variable sequences with conspicuous, thick, pelagic black marls occur in the "Lombardian basin". Sources: Bárszentmihályfa: Kőrössy (1986, pers. comm.); Szilvágy: Bérczi – Makk (1980), Kőrössy (1986, pers. comm.); Hahót – 31 and Pölöske – 1: Kőrössy (1986, pers. comm.); Misefa – 1: Kőrössy (1965; 1986, pers. comm.); Nagytilaj – 2: Krössy (1965; 1986, pers. comm.), Majzon (1966), Vörös (1986, pers. comm.); Sümeg: Haas et al. (1984); Urkút: Fülöp (1971); Lókút: Fülöp (1971), Géczy (1972a, 1972b), Konda (1970); Bakonycsernye, Tűzköves ravine: Telegdi – Roth (1934), Géczy (1961), Fülöp (1971); Balinka – 271: Bernhardt (1986, pers. comm.); Mór, Csókahegy: Fülöp (1971); Vértessomló, Kapberek – 43/K – I: Fülöp et al. (1965); Tata, Kálvária Hill: Fülöp (1976); Süttő, Asszonyhegy: Fülöp (1971); Lábatlan, Tölgyhát quarry: Fülöp (1971).


cherty limestone
crinoid limestone
compact red limestone
black marl
JURASSIC
Hettangian
Sinemurian
Pliensb.
planorbis
liasicus
angulata
bucklandi
semicostatum
turneri
obtusum
oxynotum
raricostatum
jamesoni
ibex
davoei
Nagytitaj - 2
Sümeg
Szentgál
Lókút Hill
Kericser
Közöskút
Bálinka - 271
Vértessomló
Tata
Süttő
Lábatlan
Dorog
?
LOM.
TRENTO PLATEAU
BELLUNO TROUGH

"Belluno trough"

It covers possibly the Vértes Mts. (the extremely reduced sequences at Mór and Vértessomló) and certainly the Gerecse Mts. Instead of platform limestones in the Hettangian we find hiatus, overlain by red, pelagic limestones. Also, the Hettangian – Sinemurian sequence is extremely reduced (its thickness is 2 to 20 m instead of up to 220 m in the Trento plateau). It is probable due to strong current activity.

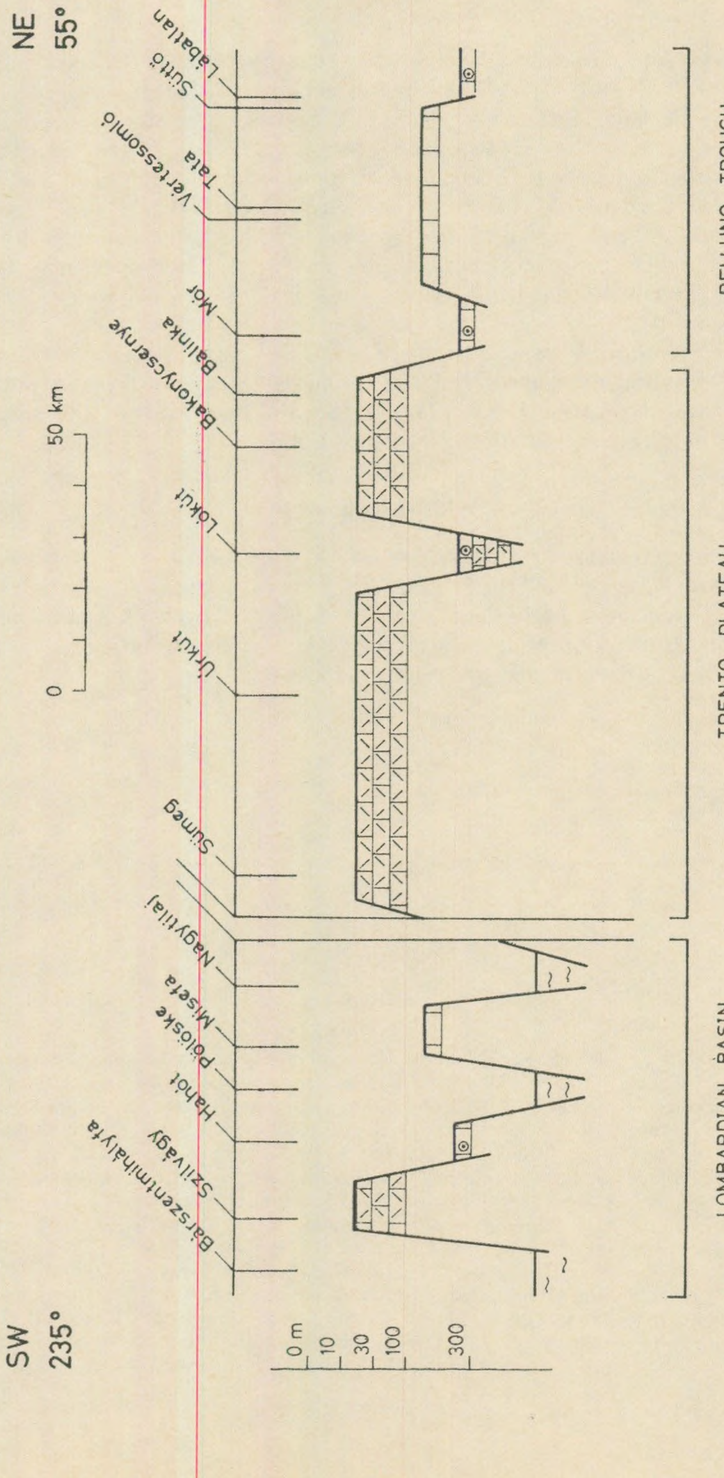
A possible palaeogeographic section emphasizing topographic differences during Hettangian time is shown in Fig. 6. The boundaries between the zones are considered to be faults, since no transition between them has been observed.

This basin and swell structure of the Lower Liassic Bakony unit provides further evidences for the palaeogeographic reconstructions of KÁZMÉR and KOVÁCS (1985) placing the Bakony unit in the immediate northern neighbourhood of the Southern Alps.

Acknowledgements

The preparation of this paper would have been impossible without the generous support of DR. LÁSZLÓ KŐRÖSSY. ATTILA VÖRÖS helped with his knowledge on brachiopod stratigraphy; ANDRÁS GALÁCZ provided papers on ammonite zones and took part in discussions on particular points. Their help is gratefully acknowledged herein.

Fig. 5. First occurrences of red, pelagic sediments (timing of the fragmentation of the carbonate platform) in the Lower Liassic of Bakony unit, as shown by biostratigraphic data. Dashed contours indicate that not the zone, but the stage in known only. Underlying sediments of the Nagytilaj black marl (Lombardian basin) are unknown; in the Trento plateau all profiles are underlain by thick Calcari grigi; in the Belluno trough no Calcari grigi occurs, but all sediments have been deposited on a hardground formed on Triassic Dachstein limestone. Ammonite zones after URLICHS (1977). Sources: Nagytilaj – 2: KŐRÖSSY (1986, pers. comm.), VÖRÖS (1986, pers, comm.); Sümeg, Mogyorósdomb: HAAS et al. (1984); Szentgál, Tűzköveshegy: VADÁSZ (1911), GÉCZY (1974); Lókút, Lókút Hill: GÉCZY (1972a, 1972b); Lókút, Kericser: GÉCZY (1971a); Hárskút, Közöskút ravine: GÉCZY (1971b); Balinka – 271: BERNHARDT (1986, pers. comm.); Vértessomló, Kapberek: FÜLÖP et al. (1965); Tata, Kálvária Hill: SZABÓ (1961), FÜLÖP (1976); Süttő, Asszonhegy: FÜLÖP (1971); Lábatlan, Tölgyhát quarry: FÜLÖP (1971); Dorog, Nagykőszikla: VIGH (1913; correlation of ammonite zones: GÉCZY, 1976, after DEAN et al., 1961).


SW
235°
NE
55°
0
50 km
0 m
10
30
100
300
Bárszentmihályfa
Szilvágy
Hahót
Poloske
Miseta
Nagytilaj
Sümeg
Úrkút
Lókút
Bakonycsernye
Balinka
Mór
Vértessomló
Tata
Süttő
Lábatlan
LOMBARDIAN BASIN
TRENTO PLATEAU
BELLUNO TROUGH

REFERENCES

BÉRCZI-MAKK, A. (1980): Triassic to Jurassic microbiofacies of Szilvágy, southwestern Hungary. – Földtani Közlöny 110/1, 90 – 103, Budapest

BOSELLINI, A., MASETTI, D., SARTI, M. (1981): A Jurassic "Tongue of the Ocean" infilled with oolitic sands: The Belluno trough, Venetian Alps, Italy. – Marine Geology 44, 59 – 95. Amsterdam

DEAN, W. T., DONOVAN, D. T., HOWARTH, M. K. (1961): The Liassic ammonite zones and subzones of the North-West European province. – Bull. British Mus. Nat. Hist., Geol. 4, 437 – 506, London

FÜLÖP, J. (1971): Les formations jurassiques de la Hongrie. Annales Inst. Geol. Publ. Hung. 54/2. 31 – 46, Budapest

FÜLÖP, J. (1976): The Mesozoic basement horst blocks of Tata. – Geologica Hungarica series Geologica 16, 229 p., Budapest

FÜLÖP, J., KNAUER, J., VIGH, G. (1965): Ein Juraprofil im Vértesgebirge. – Földtani Közlöny 95/1, 54 – 61, Budapest (Hungarian with German abstract)

GALÁCZ, A. (1984): Jurassic of Hungary: A review. – Acta Geologica Hungarica 27/3 – 4, 359 – 377, Budapest

GALÁCZ, A., HORVÁTH, F., VÖRÖS, A. (1985): Sedimentary and structural evolution of the Bakony Mountains (Transdanubian Central Range, Hungary): Palaeogeographic implications. – Acta Geologica Hungarica 28/1 – 2, 85 – 100, Budapest

GALÁCZ, A., VÖRÖS, A. (1972): Jurassic history of the Bakony Mountains and interpretation of principal lithological phenomena. – Földtani Közlöny 102/2, 122 – 135 (Hungarian with English abstract)

GÉCZY, B. (1961): Die jurassische Schichtreihe des Tűzköves-Grabens von Bakonycsernye. – Annales Inst. Geol. Publ. Hung. 49/2, 393 – 443, Budapest

GÉCZY, B. (1971a): The Pliensbachian of Kericser Hill, Bakony Mountains, Hungary. – Annales Univ. Sci. Budapest., Sect. Geol. 14, 29 – 52. Budapest

GÉCZY, B. (1971b): The Pliensbachian of the Bakony Mountains. – Acta Geologica Acad. Sci. Hung. 15/1 – 4, 117 – 125, Budapest

GÉCZY, B. (1972a): The Sinemurian in the Bakony Mountains. – Acta Geologica Acad. Sci. Hung. 16, 251 – 265, Budapest

GÉCZY, B. (1972b): Ammonite faunae from the Lower Jurassic standard profile at Lókút, Bakony Mountains, Hungary. – Annales Univ. Sci. Budapest., Sectio Geologica 15, 47 – 77, Budapest

GÉCZY, B. (1974): The Lower Jurassic ammonite faunas of the Southern Bakony (Transdanubia, Hungary). – Annales Univ. Sci. Budapest., Sectio Geologica 17 (1973), 181 – 190, Budapest

GÉCZY, B. (1976): Les ammonitines du Carixien de la Montagne du Bakony. – Akadémiai Kiadó, Budapest, 223 p.

Fig. 6. Schematic palaeogeographic profile of Bakony unit in Hettangian time. Apparent differences in depositional environment are emphasized. Names of the zones are those of their Southern Alpine counterparts (KÁZMÉR and KOVÁCS, 1985). The Belluno trough displays condensed sedimentation, mostly with hiatuses in the Hettangian. The Trento plateau is a thick, shallow marine carbonate platform. In the Lombardian basin – due to the lack of more accurate data – the oldest Liassic (not necessarily Hettangian) sequences are figured. Also these ones indicate the dissected, predominantly deep marine character of the basin. Legend: see Fig. 4. Scale on the left indicates presumed water depth: 0 – 10 m: littoral; 10 – 30 m: above wave base; 30 – 100 m: euphotic; 100 – 300 m: shelf; below 300 m: slope or talus (after J. DERCOURT and H. FUNK, 1986, pers. comm.). Vertical dimensions are not to scale. Localities of Liassic profiles are projected on a 235° – 55° line representing the long axis of the Bakony unit.

HAAS, J. (1982): Facies analysis of the cyclic Dachstein limestone Formation (Upper Triassic) in the Bakony Mountains, Hungary. – Facies 6, 75–84. Erlangen

HAAS, J., DOBOSI, K. (1982): Investigation of Upper Triassic cyclic carbonate rocks in key sections in the Bakony. – Annual Report of the Hungarian Geological Institute for 1980, 135–168, Budapest

HAAS, J., JOCHA-EDELÉNYI, E., GIDAI, L., KAISER, M., KRETZOI, M., ORAVECZ, J. (1984): Sümeg és környékének földtani felépítése. (Geology of Sümeg and its surroundings.) – Geologica Hungarica series Geologica 20, 353 p., Budapest

KÁZMÉR, M. (1986): Tectonic units of Hungary: Their boundaries and stratigraphy (A bibliographic guide). – Annales Univ. Sci. Budapest., Sectio Geologica 26, 45–120, Budapest

KÁZMÉR, M., KOVÁCS, S. (1985): Permian-Paleogene paleogeography along the eastern part of the Periadriatic lineament: Evidence for continental escape of the Bakony-Drauzug unit. – Acta Geologica Hungarica 28/1–2, 69–82, Budapest

KONDA, J. (1970): Lithologische und Fazies-Untersuchung der Jura-Ablagerungen des Bakony-Gebirges. – Annales Inst. Geol. Publ. Hung. 50/2, 161–260, Budapest

KŐRÖSSY L. (1965): Stratigraphischer und tektonischer Bau der westungarischen Becken. – Földtani Közlöny 95/1, 22–36, Budapest (Hungarian with German abstract)

MAJZON, L. (1966): Foraminiferavizsgálatok. (Foraminifer Investigations.) – Akadémiai Kiadó, Budapest, 939 p. (Hungarian)

SZABÓ, I. (1961): A tatai mezozóos rög jura kifejlődései. (Jurassic facies of the Mesozoic horst at Tata.) – Annales Inst. Geol. Publ. Hung. 49/2, 469–474, Budapest (Hungarian)

TELEGDI-ROTH, K. (1934): Daten aus dem nördlichen Bakony-Gebirge zur jungmezozoischen Entwicklungsgeschichte der „Ungarischen Zwischenmasse". – Mathematischer und Naturwissenschaftlicher Anzeiger der Ungarischen Akademie der Wissenschaften 52, 205–252, Budapest

URLICHS, M. (1977): The Lower Jurassic in Southwestern Germany. – Stuttgarter Beiträge zur Naturkunde B 24, 41 p., Stuttgart

VADÁSZ, M. E. (1911): Die Juraschichten der südlichen Bakony. – Resultate der wissenschaftlichen Erforschung des Balatonsees. I. Band, II. Teil, Anhang: Palaeontologie der Umgebung des Balatonsees, III. Band, Teil IX, 89. p., Hölzel, Wien.

VÉGH-NEUBRANDT, E. (1982): Triassische Megalodontaceae. Entwicklung, Stratigraphie und Paläontologie. – Akadémiai Kiadó, Budapest, 526 p.

VIGH, GY. (1912): Liasschichten am doroger Nagykőszikla. – Földtani Közlöny 43, 502–506, Budapest

WINTERER, E. L., BOSELLINI, A. (1981): Subsidence and sedimentation on Jurassic passive continental margin, Southern Alps, Italy. – American Association of Petroleum Geologists Bulletin 65/3, 394–421.

A LOWER CRETACEOUS SUBMARINE FAN SEQUENCE IN THE GERECSE MTS., HUNGARY

by

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Abstract

The Barremian coarse clastics of Köszörűkőbánya quarry (Lábatlan, Gerecse Mts.) are deposits of a proximal submarine fan, displaying channel-filling conglomerates transported by fluidized grain flow, proximal turbidites and contourite sandstones. This formation is the top of an upward shoaling Lower Cretaceous sequence, containing Berriasian to Hauterivian distal turbidites, and Barremian sandy flysch. Contrasting results of palaeocurrent measurements urge more detailed studies.

Introduction

The clastic Lower Cretaceous (Berriasian to Barremian) formations in the Gerecse Mts. (Fig. 1) considerably differ from other – mostly carbonate – complexes of the Bakony unit of similar age (KÁZMÉR, 1986). While most of the soutwestern Bakony unit is characterized by thin, condensed limestone beds (FÜLÖP, 1964), the northeastern region bears a more than 300 m thick shale-sandstone sequence with conglomerate and breccia intercalations. Stratigraphy and lithology are shown Fig. 2.

Contrasting opinions on the origin and depositional environment of these formations are in circulation. Following general studies of several geologists made through a century FÜLÖP (1958) published the first and only detailed description on the Lower Cretaceous formations in the Gerecse Mts. (with full references to previous works). His main points were the followings:

- the Gerecse Lower Cretaceous formations were deposited in a shallow marine embayment with alternating marl and sand sedimentation,
- the Köszörűkőbánya conglomerates are the nearshore regressive deposits of the Neocomian sedimentary cycle,
- the Köszörűkőbánya quarry exposes the ancient shore-line, with reworked frame-building organisms (Urgonian limestone) embedded in the conglomerate,
- the regressing sea eroded older sandstone beds,
- the quartzite and chert pebbles suffered long fluvial transport before sedimentation in the marine environment,

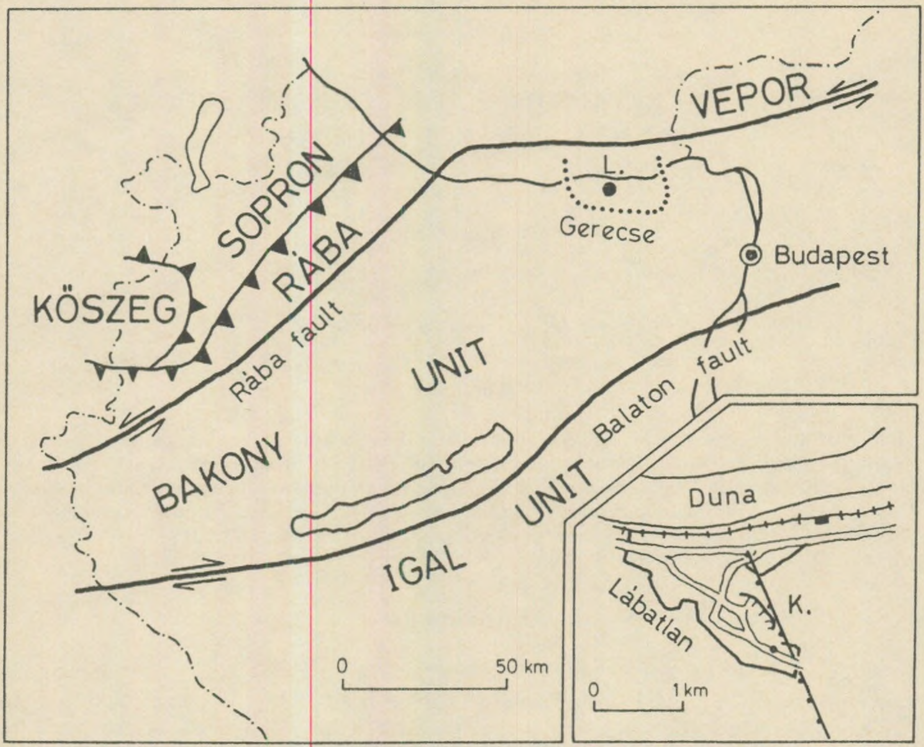
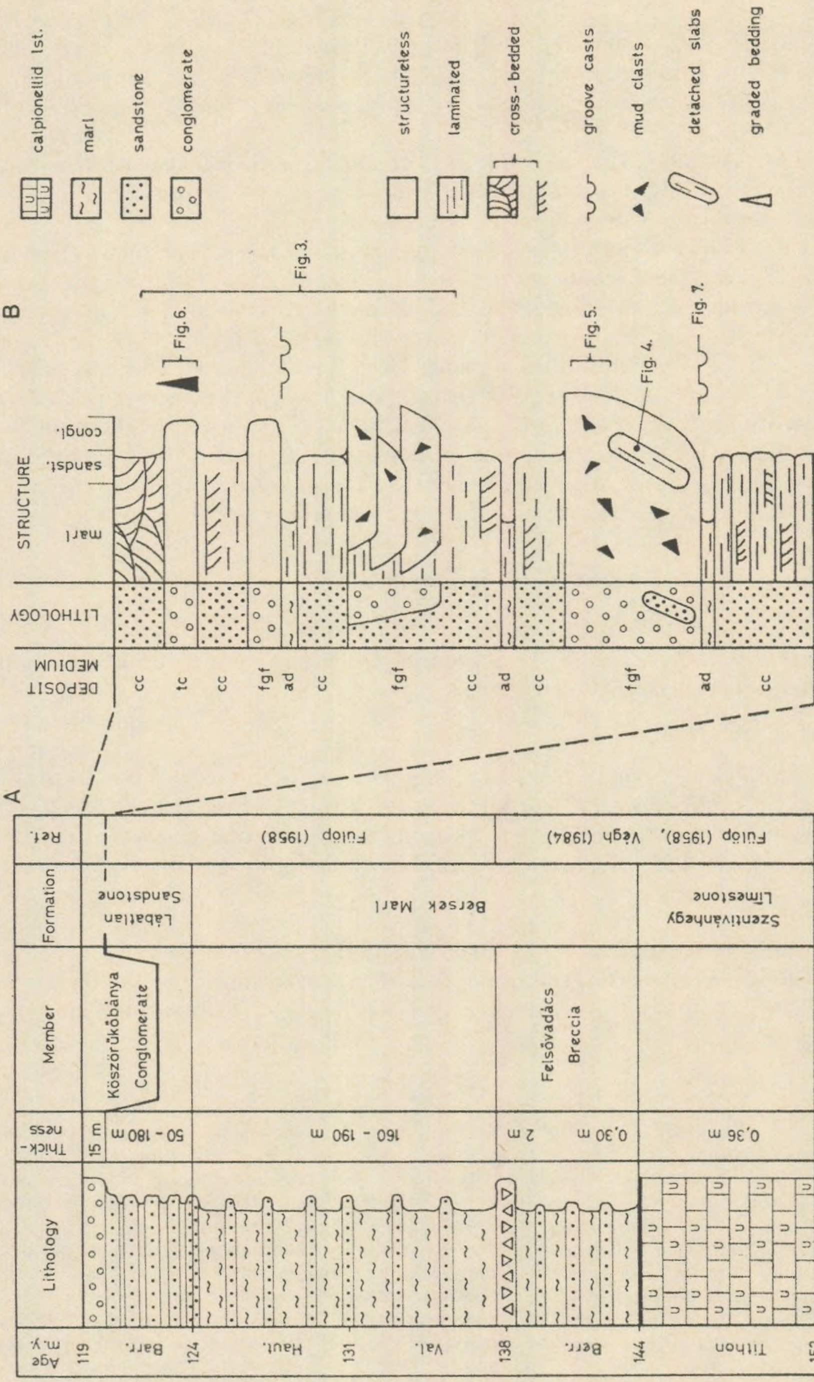


Fig. 1. Location of Lower Cretaceous clastic sediments in the Gerecse Mts. of Hungary (dotted line). Tectonic units after KÁZMÉR (1986). L = Lábatlan. Inset: location of Köszörűkőbánya quarry (K) at Lábatlan.

– well-sorted sandstone layers between the conglomerate beds are the products of the winnowing effect of wave action.

FÜLÖP in his treatise on the Bakony Lower Cretaceous (1964) figured this region as a bay surrounded by land to the W, S and E. Papers of the next decade (SZENTES, 1968; FÜLÖP, 1968, 1969, 1976; HORVÁTH, 1978) repeated the statements in FÜLÖP'S (1958) volume. A probably new interpretation showed up in a palaeontransport map series of the Carpathian region based mostly on flysch sediments (ŚLA,CZKA, 1976), indicating west to east transport direction for the Bersek Marl. Other tentative remarks appeared in the paper of CSÁSZÁR and HAAS (1979), stating that the Lábatlan Sandstone displays many features typical of flysch sediments (graded bedding, flute casts, trace fossils, etc). The Barremian chert breccia and conglomerate was again considered as the final member of the Early Cretaceous sedimentary cycle. This thesis was supported by the occurrence of "biogenic limestone lenses"; this autochthonous interpretation is a retrograde step compared to FÜLÖP'S results (1958). In a synoptic lithostratigrap-



B
calpionellid lst.
marl
sandstone
conglomerate
structureless
laminated
cross-bedded
groove casts
mud clasts
detached slabs
graded bedding
Fig. 3.
Fig. 6.
Fig. 5.
Fig. 4.
Fig. 7.
STRUCTURE
marl
sandst.
congl.
LITHOLOGY
DEPOSIT MEDIUM
cc
tc
cc
fgf
ad
cc
fgf
cc
ad
cc
fgf
ad
cc
A
Age m.y.
Lithology
Thick-ness
Member
Formation
Ref.
119
Barr.
124
Haut.
131
Val.
138
Berr.
144
Tithon
152
15 m
50 - 180 m
160 - 190 m
2 m
0,30 m
0,36 m
Köszörükőbánya Conglomerate
Felsővadács Breccia
Lábatlan Sandstone
Bersek Marl
Szentivánhegy Limestone
Fülöp (1958)
Fülöp (1958), Végh (1984)

hic chart (CSÁSZÁR and HAAS, 1983) the Bersek Marl is drawn in the colours of pelagic sediments, the Lábatlan Sandstone is flysch, but its upper part (Köszörűkőbánya Conglomerate ?) is marked as "Shallow marine detrital formation".

CSÁSZÁR and HAAS (1984) repeat the interpretations of their (1979) paper with a slight modification: the biogenic limestone boulders in the Köszörűkőbánya Conglomerate are referred to as olistolites.

CSÁSZÁR (1984a) extends the appearance of the flysch characters to the Bersek Marl, stresses the exclusiveness of nektonic and planktonic elements in the fauna and considers the Lábatlan Sandstone as a bathyal deposit. CSÁSZÁR (1984b) more or less repeats the description on Köszörűkőbánya quarry of FÜLÖP (1958) and reprints his Fig. 32 in part. Császár correlates the Köszörűkőbánya profile with a gravel bed at the top of the Lábatlan Sandstone, but does not put it down if he accepts its bathyal origin. In the present paper I try to give some evidences in support of the bathyal origin of the Köszörűkőbánya Conglomerate. These results are preliminary and may change in several details during further investigations.

Sedimentology

The composite lithological column of the Köszörűkőbánya quarry at Lábatlan village (Fig. 2) summarizes the most conspicuous sedimentary features observed in the field.

Marl

Thin (10 – 20 cm) marl layers separate some conglomerate and sand beds. In some places these contain gypsum (FÜLÖP, 1958) formed from pyrite in the weathering crust. Marl clasts of irregular shape (referred to as mud clasts in Fig. 2B) are embedded in the conglomerate (Fig. 5).

Sandstone

Parallel laminated and cross-stratified sandstone beds form the majority of rocks exposed in the quarry. Beds are frequently truncated by channel-filling conglomerate lenses. Cross-bedding is visible on weathered joint

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Fig. 2. Stratigraphy and lithology of the Lower Cretaceous formations in Gerecse Mts. Fig. 2A: Upward shoaling flysch sequence. Tithonian calpionellid limestone (covered by hardground) in overlain by condensed Berriasian marl beds. Lowermost Valanginian limestone olistostrome is covered by thick marly flysch. Sandy flysch deposited in Barremian time, topped by proximal fan conglomerates.

Fig. 2B: Composite lithological column of Köszörűkőbánya quarry at Lábatlan (not to scale). Profile of a proximal fan sequence. Channel-filling conglomerate bodies with marl clasts and sandstone slabs are embedded in sandstone deposited possibly by contour currents. Most conglomerates show no internal structures except the topmost one with graded bedding. Total thickness about 15 m. Geochronology after PALMER (1983). Abbreviations: cc = contour current or truncated turbidity current; tc = turbidity curent; fgf = fluidized grain flow; ad = autochthonous deposition.

surfaces of the sandstone; the determination of the true dip of foresets was not carried out due to their poor preservation; more patient studies may improve this situation. These beds might represent truncated Bouma (1962) sequences: T_b or T_d for parallel laminated beds and T_c for cross-bedded layers; however, these also might be contourites (BOUMA, 1973). Further studies are needed to resolve this question. The sandstones contain the foraminifer *Orbitolina birmanica*, indicating Barremian ege for this sequence (FÜLÖP, 1958).

Conglomerate

Thick, lense or wedge-shaped conglomerate bodies made mostly of chert pebbles are the most striking features of the Köszörűkőbánya quarry. These were deposited in distributary channels, sometimes cross-cutting each other (Fig. 3). These lag deposits does not bear any internal structure. Large sandstone slabs of 0.5 – 1.5 m in diameter are embedded in the conglomerate: these are fragments from the undercut wall of a submarine canyon (Fig. 4). Normally lying, vertically oriented and overturned slabs occur; overturning was determined from the shape of cross-bedding within the slabs.

Several channel-infilling conglomerate bodies contain angular mud clasts (Fig. 5), probably reworked from non-lithified banks of the channel.

A conglomerate bed with sharp, parallel lower and upper boundaries shows graded bedding (Fig. 6), indicating deposition from a turbidity current. Its composition is somewhat different from that of the channel fills, containing more limestone than chert clasts and pebbles. The largest boulder is about 15 cm in diameter (not figured in the picture).

Olistoliths

CSÁSZÁR (1984b) mentioned the presence of olistoliths in Köszörűkőbánya quarry: he affixed this term to the bioclastic limestone boulders in the channel-filling conglomerate. I think, that all pebbles and other clasts (rounded or not rounded) must be ranged within this group.

Direction of transport

An average S to N (or N to S) direction of transport (with SW to NE and SE to NW components) was determined from sole marks, orientation of slabs and dip of slide(?) surface (Fig. 8). Dip azimuths of foresets in cross-bedded sandstones were not measured. The graded conglomerate bed did not yield sole mark data.

Groove casts or channel casts

The lowermost, lense-shaped conlomerate body bears 15 – 20 cm wide, 5 cm deep straight casts of former grooves on its underside (Fig. 7). The grooves were made on the surface of a marl bed (now removed by erosion) and were contemporaneously filled with coarse clastics.

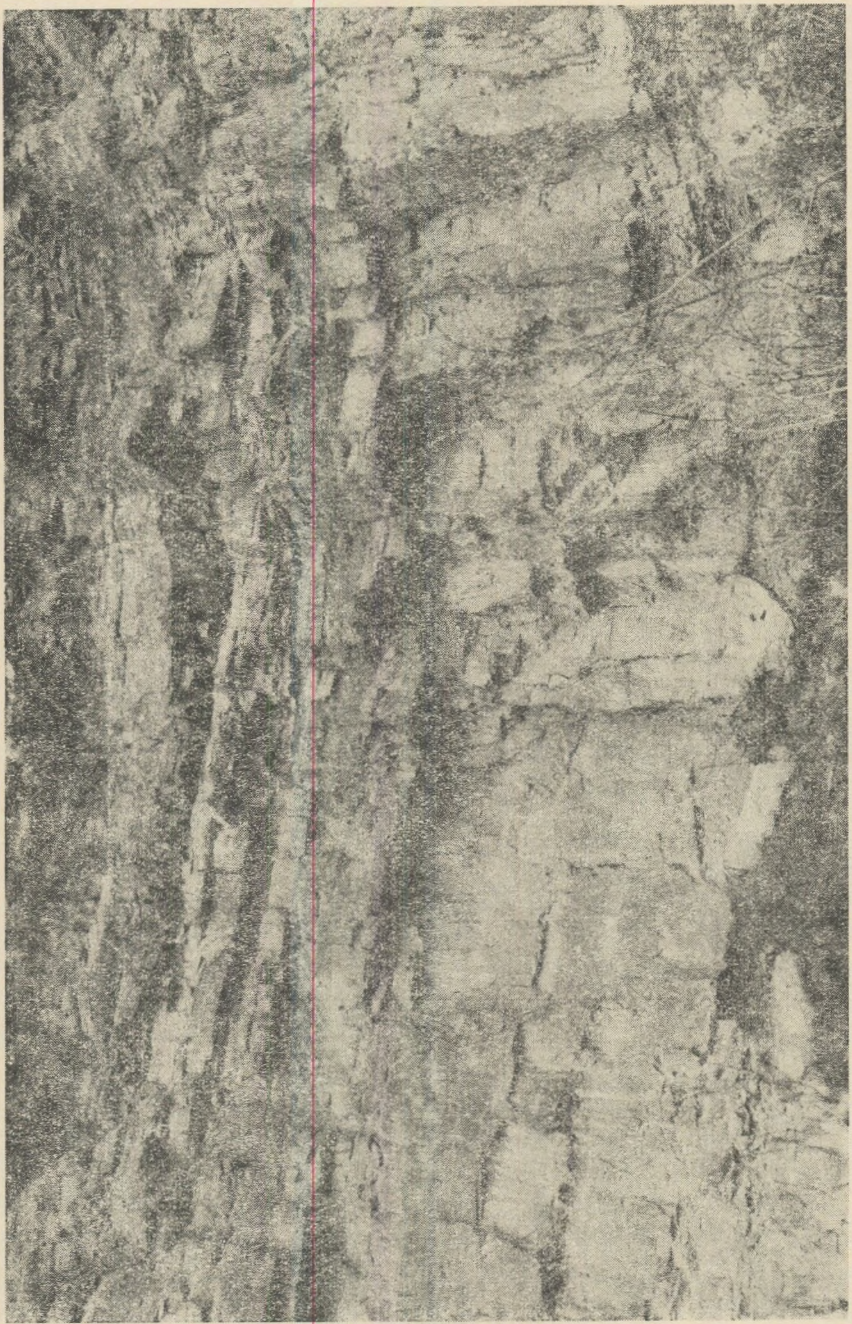
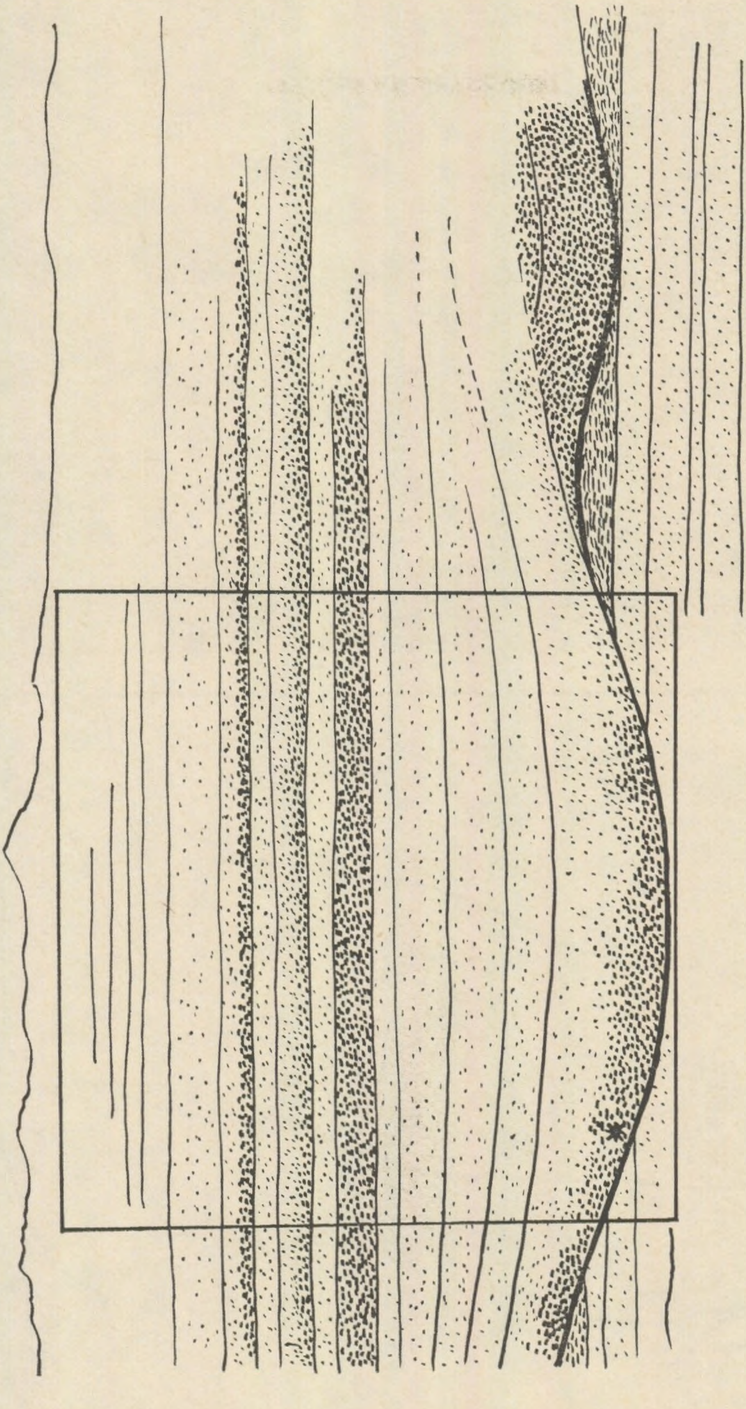
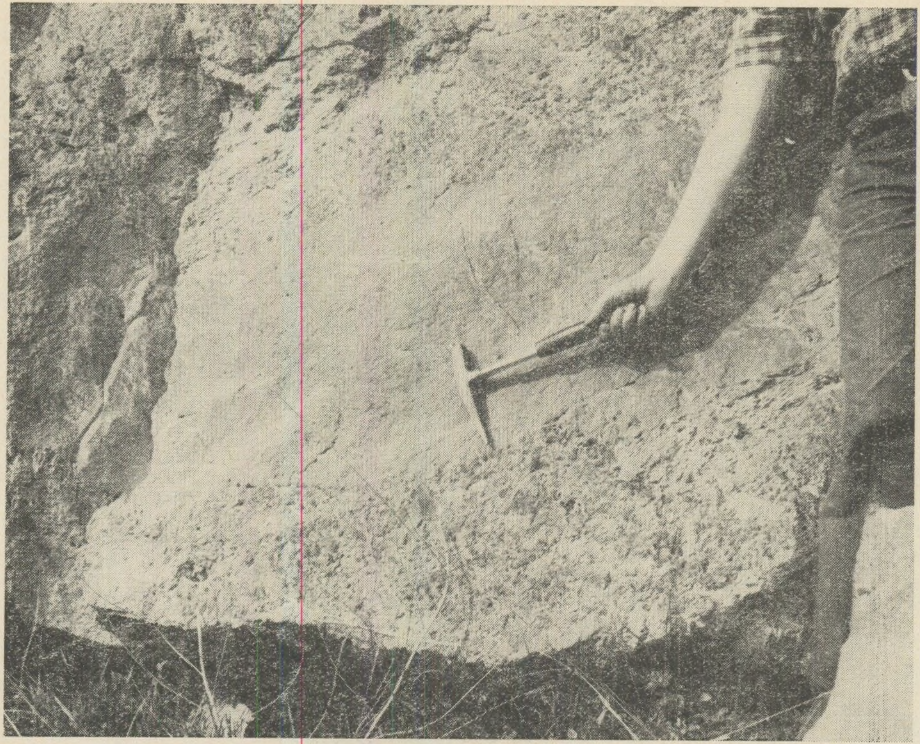


Fig. 3. Channel-filling conglomerate cut into underlying marl and sandstone. Graded beds on the top. (Photographed by I. Főzy, drawn Gy. b Tari.) Asterisk on the drawing marks the location of the large sandstone slab figured on Fig. 4.





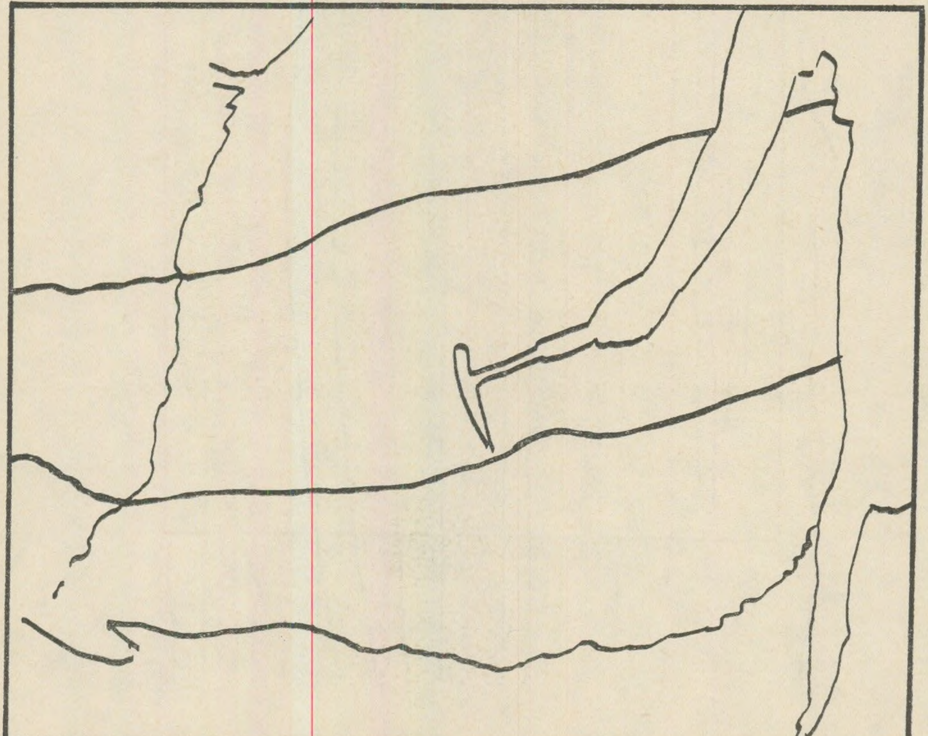


Fig. 5. Holes show the places of angular mud clasts embedded in channel-filling conglomerate (photo by I. Főzy).

Fig. 4. Sandstone slab detached from an undercut submarine canyon wall, embedded in channel-filling conglomerate (location is marked by an asterisk on Fig, 3B). (Photographed by I. Főzy, drawn by G. Tari.)

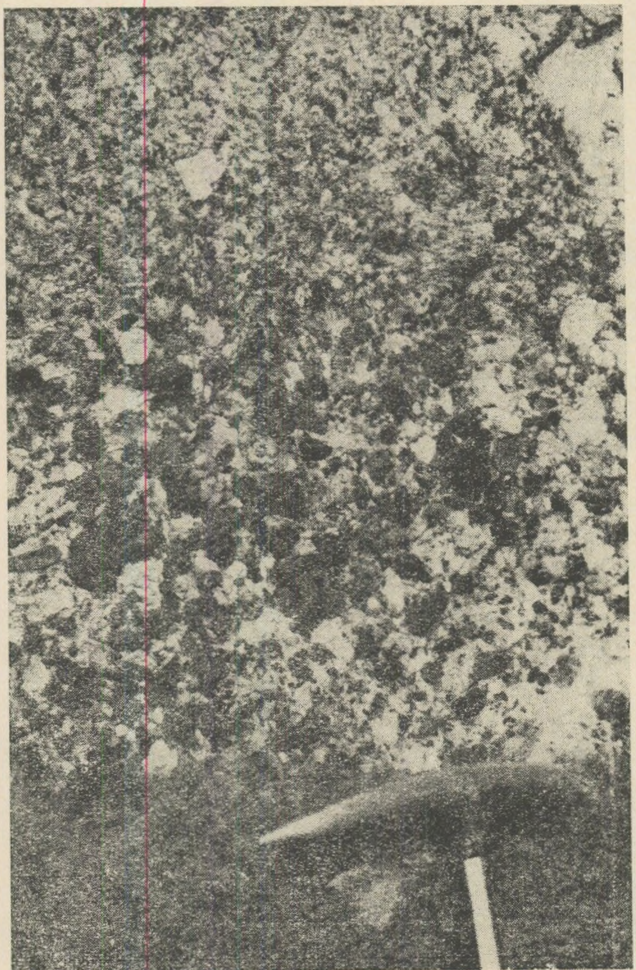


Fig. 6. Graded conglomerate bed on top of the profile (Photo by I. FŐZY).

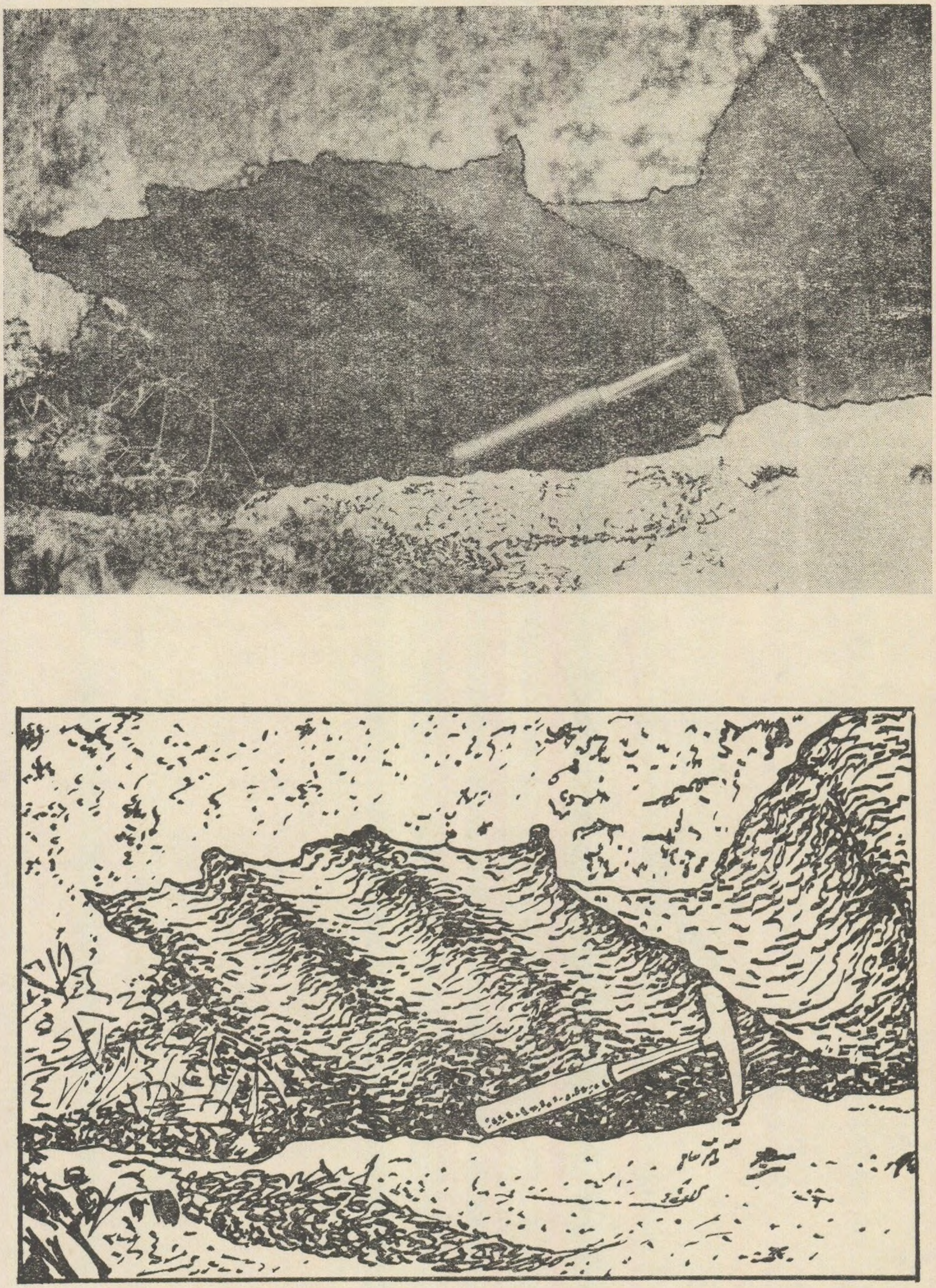


Fig. 7. N – S directed groove casts on the underside of the lowermost channel-filling conglomerate body, Underlying marl was removed by erosion. (Photo by I. FŐZY, drawn by G. TARI).

Dip of large sandstone slabs

Some conglomerate lenses contain large-size sandstone slabs 0.5 – 1.5 m in diameter and 0.2 – 0.5 m in thickness (Fig. 4). These slabs probably were detached from the undercut banks of a submarine canyon, overturned sometimes and after transport embedded in the coarse lag deposit of the channel. Their upcurrent dip is a reliable indicator of ancient flow direction (POTTER and PETTIJOHN, 1977). The dip direction was easily measured on weathered bedding planes of the parallel-bedded or cross-bedded sandstone slabs.

Slide surfaces

Some sandstone beds are cut by listric surfaces, being nearly perpendicular to the top and make small angle with the bottom of the respective bed. The surfaces are covered by a few millimetres thick marl layer. These are considered as traces of penecontemporaneous sliding, their dip azimuth indicating downslope direction.

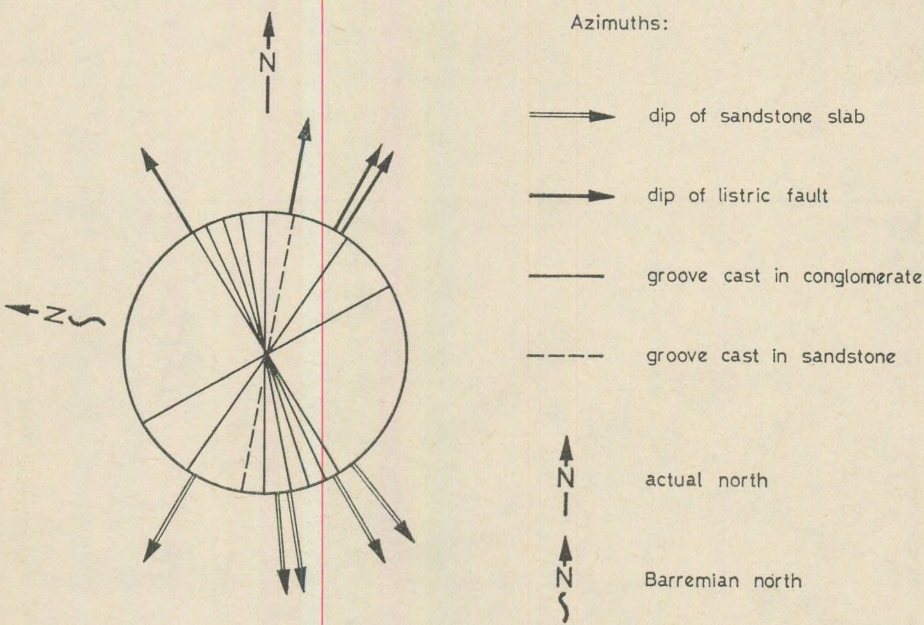


Fig. 8. Paleotransport directions at Köszörűkőbánya quarry at Lábatlan. We measured dip directions of large (up to 1.5 m) sandstone slabs in the channel-filling conglomerate, dip directions of listric faults – probably of syndepositional slide origin – within sandstone beds, and groove casts on the underside of channel-filling conglomerate beds, and a sandstone bed. While azimuths are scattered, a definite N – S (or S – N) transport direction is shown. The apparent opposing transport directions may be due to the small number of measurements and/or uncertain interpretation of sedimentary structures. However, considering the rotation of the Transdanubian Midmountains (= Bakony unit) since Barremian time (MÁRTON and MÁRTON, 1985), there was a W to E (or E to W) transport of clastics at that time.

Fig. 8 shows paleotransport directions in the actual tectonic position of the Gerecse Mts. However, MÁRTON E. and MÁRTON P. (1985) proved by palaeomagnetic studies that during Early Cretaceous time the long axis of the Transdanubian Midmountains (including the Gerecse) occupied a position almost perpendicular to the present-day one (their Fig. 5). The correction of our measurements with the MÁRTONS' rotation data indicates a Barremian transport from W to E or from E to W.

The approximately W to E (actual) transport direction of the Bersek Marl in the Hauterivian (ŚLĄCZKA, 1976) seems to be in contrast with the above data. Since documentation of the measurements was not published, we cannot estimate their reliability. As opposite transport directions can be often observed in flysch sequences (POTTER and PETTIJOHN, 1977), a thorough investigation is badly needed.

Transport mechanisms

Products of several ways of redeposition were briefly described above. The graded conglomerate bed of Fig. 6 have been deposited by a high density turbidity current able to keep clasts up to 15 cm in motion.

Parallel and cross-laminated sandstone beds (truncated Bouma sequences ?) might have been deposited by either turbidity currents or by contour currents. Further sedimentological and petrological studies (sand grain orientation, sorting, etc.) may give answer to this question.

The thick conglomerate lenses without any internal structure are lag deposits of fluidized grain flows which cut their transport channels into sand (or sandstone) beds or into older gravel-filled channels. These grain flows undercut the walls of the submarine canyon near the point of their origin or the banks of their channel and transported large, detached sandstone slabs and mud clasts far away from their original position.

Basin evolution

FÜLÖP (1958) has recognized that the Lower Cretaceous sequence in the Gerecse Mts. shows an upward increase of coarse clastic components. From short remarks of CSÁSZÁR and HAAS (1979, 1984) and CSÁSZÁR (1984a, b) we know that the marl (Bersek Formation) and sandstone (Lábatlan Formation) complex shows flysch characters and was deposited in the bathyal region. The following basin history is based on the re-interpreted excellent description of FÜLÖP (1958) and on the personal observations of the author at the Köszörűkőbánya quarry.

Approximately at the Tithonian – Berriasian boundary the sedimentation of the condensed calpionellid limestone ceased and by an abrupt change alternating marl and sandstone beds were deposited (VÍGH, 1984). This sudden change from carbonate to clastic deposition occurred in these times at various localities of the African-Apulian margin: in the middle sector of the Northern Calcareous Alps (SCHLAGER and SCHÖLLNBERGER, 1974; FAUPL and TOLLMANN, 1979) and at the Moroccan margin of the

Central Atlantic ocean (VON RAD and SARTI, 1986). The common cause was the interaction of block faulting and a global regression providing extensive subaerial regions for increased clastic supply (VON RAD and SARTI, 1986). The local block faulting in the Gerecse Mts. is indicated by an olistostrome possibly originated from a fault scarp.

The basin subsided to the zone below aragonite, but above calcite compensation depth, as shown by plenty of aptychi without much ammonites (the latter are molds only). The thin, graded sandstone beds indicate distal turbidity current activity, during the Berriasian – Hauterivian interval with occasional olistostrome deposition. During Barremian time the Lábatlan Sandstone was deposited, with more and thicker sandstone beds indicating an approaching submarine fan. The Köszörűkőbánya section topping the sequence shows proximal turbidite sedimentation, interlayered with even more proximal channel-filling fluidized grain flow deposits. The whole Lower Cretaceous clastic sequence is evidence for a bathyal basin visited by distal turbidity currents, showing upward shoaling as a result of the prograding of a submarine fan during Barremian time.

Palaeogeography

The relationships between the Gerecse Lower Cretaceous and the Rossfeld Beds of the same age in the Northern Calcareous Alps were recognized by HANTKEN more than a century ago (fide FÜLÖP, 1958). Considering the palaeogeographic model of KÁZMÉR and KOVÁCS (1985), both formations have been deposited in the Lower Cretaceous Belluno trough, east (or southeast) of the submerged Trento plateau. (Their present-day position is the result of a Palaeogene continental escape of the Bakony unit.) If – following further palaectransport studies – the S to N transport will be proved correct, it will be in favor of the hypothesis of FAUPL and TOLLMANN (1979) on a Lower Cretaceous ridge in the middle of the East Alpine region shedding detritus towards N and S. If the N to S transport will prevail, a Dinaride origin of the detritus must be suggested.

However, new, but still insufficient palaeomagnetic data on the Mesozoic rotation history of the Northern Calcareous Alps (BECKE and MAURITSCH, 1985) may invite efforts to develop considerably renewed palaeogeographic reconstructions.

Conclusions

The Lower Cretaceous clastic formations of the Gerecse Mts. form an upward shoaling turbiditic sequence. At the Tithonian – Berriasian boundary – contemporaneously with other Tethyan and Atlantic localities – carbonate deposition ceased, due to block faulting and worldwide regression. A bathyal basin was formed with distal turbidite sedimentation. During Barremian time increasing clastic influx indicated the prograding of a submarine fan. The most proximal deposits of the fan (investigated at the Köszörűkőbánya quarry at Lábatlan, Gerecse Mts.) include channel-filling conglomerates, transported by fluidized grain flow, proximal turbidity currents and contour currents. Preliminary investigations of directional structures provided contrasting evidences on the transport of coarse clastics. Since the investigated region was to the south of the Northern Calcareous Alps during Early Cretaceous time (KÁZMÉR and KOVÁCS, 1985) the mafic components of the Neocomian beds in the Alps and Gerecse must have been transported either from an Intra-Alpine ridge (FAUPL and TOLLMANN, 1979) or from the Dinarids.

Acknowledgements

The author is grateful to L. FÉLEGYHÁZY, L. FODOR, I. FŐZY, S. KOVÁCS, T. KOZMA, G. TARI and Cs. TRENGER for assistance in the field and for inspiring discussions. I. FŐZY made the photographs and G. TARI draw the figures of the outcrops. Their help is acknowledged herein.

REFERENCES

BECKE, M., MAURITSCH, H. J. (1985): Die Entwicklung der Nördlichen Kalkalpen aus paläomagnetischer Sicht. – Archiv für Lagerstättenforschung der Geologischen Bundesanstalt 6, 113–16, Wien

BOUMA, A. H. (1962): Sedimentology of Some Flysch Deposits – A Graphic Approach to Facies Interpretation. Elsevier, Amsterdam, 168 p.

BOUMA, A. H. (1973): Contourites in Niesenflysch, Switzerland. – Eclogae geologicae Helvetiae 66/2, 315–323, Basle

CSÁSZÁR G. (1984a): Lábatlan, Bersekhegy: Valanginian–Barremian Bersek Marl Formation and Lábatlan Sandstone Formation. – In: Császár G., Haas J. et al.: Hungary. 27th Int. Geol. Congr., Excursion 104: Mesozoic Formations in Hungary, pp. 82–84, Budapest

CSÁSZÁR G. (1984b): Lábatlan, Köszörűkőbánya: Barremian – Köszörűkőbánya Conglomerate Member. – In: Császár G., Haas J. et al.: Hungary. 27th Int. Geol. Congr. Excursion 104: Mesozoic Formations in Hungary, pp. 84–85, Budapest

CSÁSZÁR, G., HAAS J. (1979): Review of facies and paleogeography of the Cretaceous in Hungary. – In: Wiedmann, J. (ed.): Aspekte der Kreide Europas, IUGS Ser. A, No. 6, 413–424, Schweizerbart, Stuttgart

CSÁSZÁR G., HAAS J. (eds.) (1983): Magyarország litosztratigráfiai formációi. (Lithostratigraphic formations of Hungary). Hung. Geol. Inst., Budapest, 1 p. (poster)

CSÁSZÁR G., HAAS J. (1984): The Cretaceous in Hungary: A review. – Acta Geologica Hungarica 27/3–4, 417–428, Budapest

FAUPL, P. (1979): Turbiditserien in der Kreideablagerungen des Ostalpins und ihre paläogeographische Bedeutung. – In: Wiedmann, J. (ed.): Aspekte der Kreide Europas, IUGG Ser A, No. 6, 403–411, Schweizerbart, Stuttgart

FAUPL, P,. TOLLMANN, A. (1979): Die Rossfeldschichten: Ein Beispiel für Sedimentation im Bereich einer tektonisch Aktiven Tiefseerinne aus der kalkalpinen Unterkreide. – Geologische Rundschau 68/1, 93–120, Stuttgart

FÜLÖP J. (1958): Die kretazeischen Bildingen des Gerecse-Gebirges. – Geologica Hungarica, series Geologica 11, 124 p., Budapest

FÜLÖP, J. (1964): Unterkreide-Bildungen (Berrias–Apt) des Bakonygebirges. – Geologica Hungarica, series Geologica 13, 194 p., Budapest

FÜLÖP, J. (1968): Geology of the Transdanubian Central Mountains. – 23th Int. Geol Congress, Prague, Guide to Excursion 39C, 50 p., Hungarian Academy of Sciences, Budapest

FÜLÖP, J. (1969): Földtani kirándulás a Dunántúli-középhegységbe. (Geological Excursion to the Transdanubian Central Mountains). 9th Congress of the Carpatho-Balkan Geological Association, Hungarian Geological Institute, Budapest, 60 p. (in Hungarian)

FÜLÖP, J. (1976): The Mesozoic basement horst blocks of Tata. – Geologica Hungarica, series Geologica 16, 229 p., Budapest

HORVÁTH, A. (1978): Conglomerat de Köszörűkőbánya. – In: Fülöp, J. (éd.): Lexique Stratigraphique International, vol. I, fasc. 9, Hongrie, pp. 285–286, CNRS, Paris

KÁZMÉR, M. (1986): Tectonic units of Hungary: Their boundaries and stratigraphy (A bibliographical guide). – Annales Univ. Sci. Budapest., Sectio Geologica 26, 45–120, Budapest

KÁZMÉR, M., KOVÁCS, S. (1985): Permian–Palaeogene palaeogeography along the eastern part of the Periadriatic Lineament: Evidence for continental escape of the Bakony–Drauzug unit. – Acta Geologica Hungarica 28/1–2, 69–82, Budapest

MÁRTON, E., MÁRTON, P. (1985): Tectonic and palaeoclimatic aspects of palaeomagnetism studies in the Transdanubian Central Mountains. – Acta Geologica Hungarica 28/1–2, 59–70, Budapest

PALMER, A. R. (1983): The Decade of North American Geology 1983 Geologic Time Scale. – Geology 11/9, 503–504, Boulder

POTTER, P. E., PETTIJOHN, F. J. (1977): Paleocurrents and Basin Analysis. Second, corrected and updated edition., Springer-Verlag, Berlin, 425 p.

SCHLAGER, W., SCHÖLLNBERGER, W. (1974): Das Prinzip stratrigraphischer Wenden in der Schichtfolge der Nördlichen Kalkalpen. – Mitteilungen der Geologischen Gesellschaft in Wien 66–67 (1973–74), 165–193, Wien

SLACZKA, A. (ed.) (1976): Atlas of Palaeotransport of Detrital Sediments in the Carpathian-Balkan Mountain System, 1:2 000 000, Part I: Tithonian–Lower Cretaceous. CBGA Sedimentological Commission, Instytut Geologiczny, Warszawa

SZENTES F. (1968): Magyarázó Magyarország 200 000-es földtani térképsorozatához (Explanations to the 1:200 000 geological map series of Hungary). L–34–I, Tatabánya. Hungarian Geological Institute, Budapest, 158 p. (in Hungarian)

VÍGH, G. (1984): Die biostratigraphische Auswertung einiger Ammoniten-Faunen aus dem Tithon des Bakonygebirges sowie aus dem Tithon-Berrias des Gerecsegebirges. – Annales Inst. Geol. Publ. Hung. 67, 210 p., Budapest

VON RAD, U., SARTI, M. (1986): Early Cretaceous "events" in the evolution of the eastern and western North Atlantic continental margins. – Geologische Rundschau 75/1, 139–158, Stuttgart

A PALAEONTOLOGICAL DATA BASE AND ITS PROCESSING SYSTEM ON PERSONAL COMPUTER: A METHODOLOGICAL EXPERIMENT

by

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Abstract

The system we have developed may be used for storing and subsequently processing data relating to the taxa (specific marks, biometric values, references) offering the user an adaptable and constantly improvable method.

This system meets the following requirements:

– it enables the taxa's representing various taxonomic levels to be described;
– the references relating to the taxon may be stored;
– the taxa may be separated on the basis of the given taxonomic marks., with the references in the literature also accessible;
– it may be used together with cluster and with certain statistical programmes.

As a matter of course, the success of the work rests on the expertise of the palaeontologist, since the software may alter only the time factor and the number of the simultaneously accessible data.

An enormous amount of information is routinely collected by the palaeontologist on the investigated taxa. This data base is stored usually on different kind of cards, developed by the researcher himself. The determination of the taxa is based on this data base and on comparisons with published results. Studying the investigation process and the structure of information on taxa we have realized the necessity to develop a computerized data base operation system to help the palaeontologists in their work.

Our requirements relating this system are the following:

– it should make possible the discription of a given taxon on different – mostly generic and species – taxonomic levels;
– it should make available the references on publications necessary for the determination of the taxon;
– answers should be obtainable based on the systematic descriptions;
– statistical, cluster, etc. processing should be easily connected to the system.

The task is solved by two units, operating independently:

– a palaeontological system and
– a bibliographical system.

Input data of the palaeontological data base are the following:

– name of the taxon,

– synonym list of the taxon,
– morphological and biometrical features of the taxon, using a predetermined mask,
– description of the taxon in words in free format.

Concerning the above mentioned data types, the success of the data base depends mostly on the mask. Mask means a chart (data sheet, certificate), with references on the features of the taxon to be described. Special caution and care is needed to develop this description chart fulfilling all needs. Manipulation of a mask containing features of any taxon of a higher taxonomic category (class, family) is complicated and may put up debatable questions. According to our experiences the greatest problem of similar systems is the rigid chart (filling out mask) or the fixed code system. The taxon description contains subjective elements.

Keeping in mind these problems we decided to develop a versatile system, which can be further developed by the user, according to his needs and experiences. The user palaeontologist can make several mask types of generic, subgeneric or species group level, which can be expanded at any time.

Direct application of the data base is the multiple access to the data:
– direct access by taxon name;
– search based on given features by any types of mask (selection of all taxa sytisfying the given criteria);
– search based on key words and word groups in the description of the taxa;
– access to the references in the synonym list.

Input data of the bibliographical data base are the following:
– author;
– title;
– journal title or publisher of book
– key words (listing of all taxa discussed in the text; at palaeontological applications of the systems only)
– area for free use (for notes).

Access to and search for the stored information can be made according to the input types. The types (title, author, key words) are considered as free format texts, and can be searched for any word or group of words contained in them.

The most important character of the bibliographic system is the possibility of search according to key words, making available the literature references of a given topic (taxon). In the case of consequent, regular input, the programme provides standardized reference lists.

One of the most frequent tasks of a palaeontologist is to determine a taxon. In this case a search of the palaeontological system according to the mask types (based on observed characters of the fossil) provides the list of taxa fulfilling the desired criteria. Then a search of the bibliographical system according to key words provides the list of literature references of the taxon.

Taxonomic characters of a taxon	INPUT

PALAEONTOLOGICAL SYSTEM

List of taxa	OUTPUT INPUT

BIBLIOGRAPHICAL SYSTEM

List of references	OUTPUT

A data base filled with the necessary amount of data provides the possibilities for comparative taxonomic studies and/or statistical evaluations, which would last for an extremely long time by manual methods.

Naturally, the success depends on the expert palaeontologist, since the software can modify the time factor and the amount of operable data only.

Communication with the computer is as simple as possible and is highly flexible. The information can be given as free format text, and can be corrected or modified. The commands are given by pushbuttons.

Filling of the systems by data and testing is in progress. Our experiences with the programme will be published later.

Source programme:	OS/L BASIC
Hardware:	TPA/L – 32 CM 5400 disk printer.

REFERENCES

BRUNTON, C. H. C. (1979): The development of a computer based curatorial system for paleontology at the British Museum (Natural History). – Spec. Pap. Paleont., 22, 159 – 174, London

JONES, B. (1979): Data storage and retrieval for the paleontological collections, University of Alberta. – Spec. Pap. Paleont. 22, 175 – 188, London

SMITH, P. L. (1984): The implications of data base management systems to paleontology: a, discussion of Jurassic ammonoid data. (in press), Vancouver

WILEY, E. O. (1981): Phylogenetics: the theory and practice of phylogenetic studies. – Wiley Interscience Publications, New York.

FE-P BEARING CALCAREOUS CONCRETIONS FROM ZIRC „MARBLE QUARRY" (TRANSDANUBIAN CENTRAL RANGE, HUNGARY)

by

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Abstract

Pelagic Tithonian limestone of 2 m thickness is paraconformably overlain by 0,5 m Barremian shallow marine limestone in the "Marble quarry" of Zirc. This single 2 – 3 m^2 Barremian limestone spot contains a rich, condensed Mediterranean ammonite fauna. Globular or half-cut concretions occur frequently on partly dissolved ammonite specimens, within the ammonite shells, and in the matrix. Two types were distinguished: the first is half-cut, cloudy, cauliflower-like one enclosed in the matrix, of 1 – 30 mm in diameter. The other type is globular or oval, of 10 – 20 mm in diameter. The structure is laminated, made of thin lamellae. The lamellae wedge out; frequent constrictions occur. Cores are built of tiny limestone fragments. Ca – P element composition was proved for the nodules by electron microprobe, surrounded by a Fe-rich crust. The latter contain clay minerals. Small amounts of adsorbed Mn and Ni occur on the surface of probably FeO(OH). X-ray investigations proved the Ca – P as apatite. The detailed textural, mineralogical and geochemical investigation of the nodules yielded more precise data on the ancient sedimentation environment. Probably the globular stromatolites, oncoids were formed above wave base, in a nearshore environment less than 50 m deep, where the formation of a continuous algal mat was not possible.

Introduction

The "Marble quarry" of Zirc is famous for its rich ammonite fauna, found by WEIN (1934), and investigated by NOSZKY (1934) and FÜLÖP (1964). NOSZKY determined the age of the fauna as Hauterivian, while he considered the Barremian age as an interval of bauxite formation. FÜLÖP (1964) has determined the megafauna more precisely and put the limestone of the "Marble quarry" into the Lower Barremian. Thus he denied the hypothesis of the Barremian continent, which lasted during the whole age.

This ammonitic limestone frequently contains layered concretions of brownish black colour. NOSZKY (1934) and FÜLÖP (1964) mentioned these as limonitic, clayey, manganese nodules.

Besides the determination and stratigraphic evaluation of the ammonite fauna we have to reconstruct the original environment of deposition. We have investigated the texture, mineralogy and geochemistry of the concretions from the "Marble quarry" to provide further data to the knowledge of this problem.

Most of the exposure in the "Marble quarry" of Zirc is made of a thick-bedded, light grey Tithonian limestone, paraconformably overlain by a

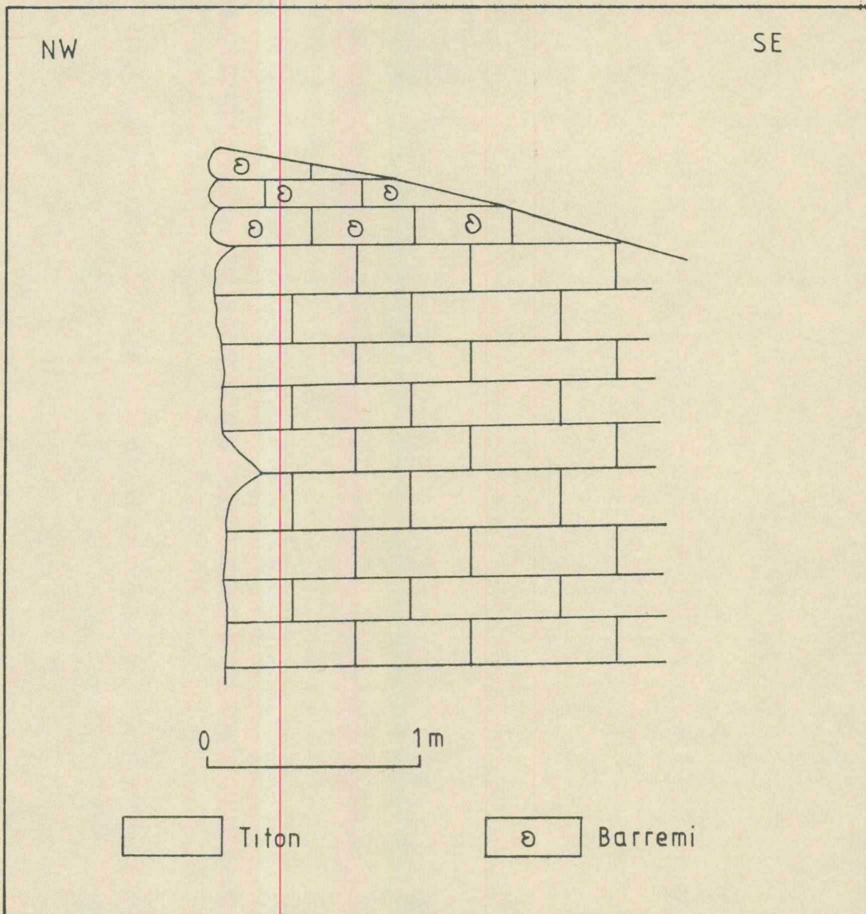


Fig. 1. The profile of „Marble quarry".

50 cm thick, compact, red to beige Barremian limestone bed. *(Fig. 1–2)*.

The samples containing the concretions are from museum collections collected during 1940's and 50's by J. Fülöp.

Besides megascopic and microscopic textural and mineralogical investigations we have carried out X-ray and electron microprobe analyses. The latter were made by M. Polgári and J. Fórizs at the Geochemical Reserach Laboratory of the Hungarian Academy of Sciences on a Jeol/Superprobe 733.

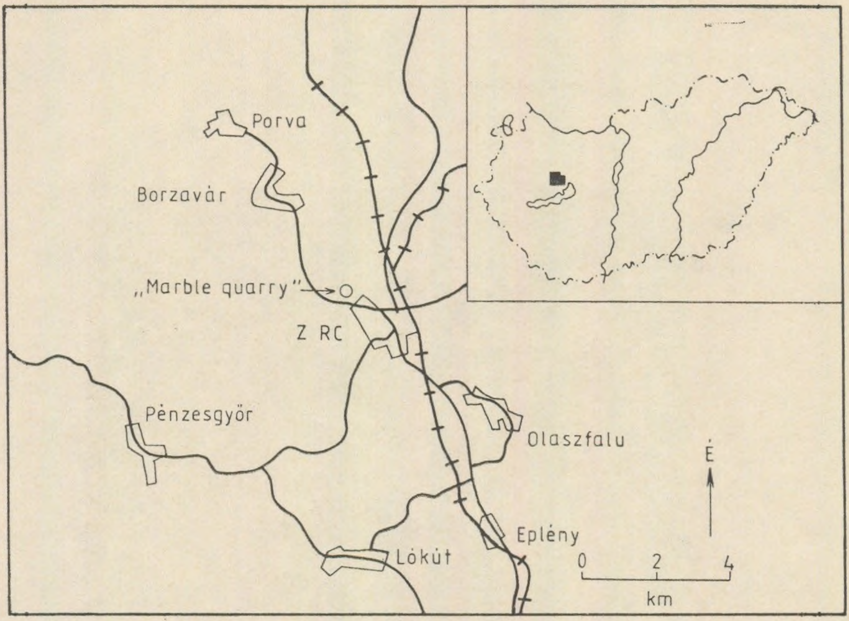


Fig. 2. Location chart of „Marble quarry".

Results

There are frequent cloudy, cauliflower-like and platy concretions on the resorbed surfaces of ammonites and in the limestone matrix. Their dimensions range from 1 – 2 mm to 2 – 3 cm. (Plate I). These are light brown coloured. Another group of the concretions are globular or oval with a diameter of 1 – 2 cm. Their colour is dark brown.

The structure of the concretions is laminated, formed of thin lamellae, looking like concentric at the first glance. Thin section investigations showed wedging out of lamellae and constrictions (Plate II, fig. 1 – 2).

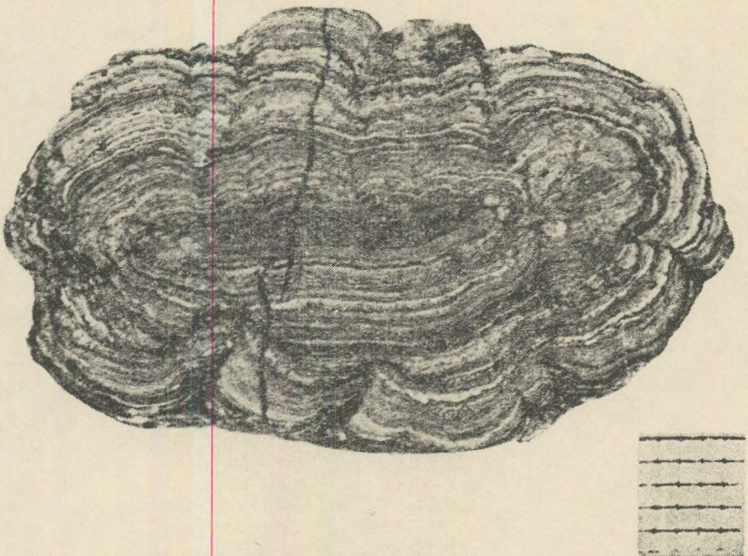
Cores of the concretions are formed of clastic grains, mostly of carbonate composition. The concretions frequently contain clastic mineral grains: quartz, rutile, ilmenite, magnetite, potash feldspar (plagioclase), mica (muscovite) and chlorite. The coloured components are mostly weathered, chloritised.

X-ray diffraction showed the concretions to be built of calcite (60 – 80%). Amount of quartz ranges from 5 to 10% and of apatite (phosphorite) from 0 to 20%.

Electron microprobe investigations were carried out on 9 concretions, covered by ca. 20 nm carbon film in a vacuum vaporizer to enhance electric conductivity. The results were surprising. The limonite-clay-manganese nodules described in the literature contain manganese in traces only. Consequently these cannot be considered as Mn-nodules. The dark laminae

PLATE I.

Concretions in limestone.



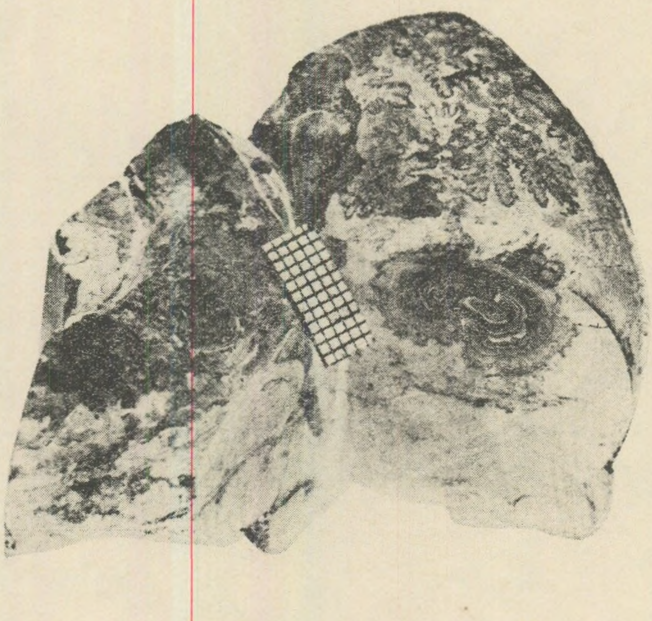


PLATE II.

Fig. 1. Macrooncoid with a limestone nucleus.
Fig. 2. Macrooncoid in an ammonite chamber.

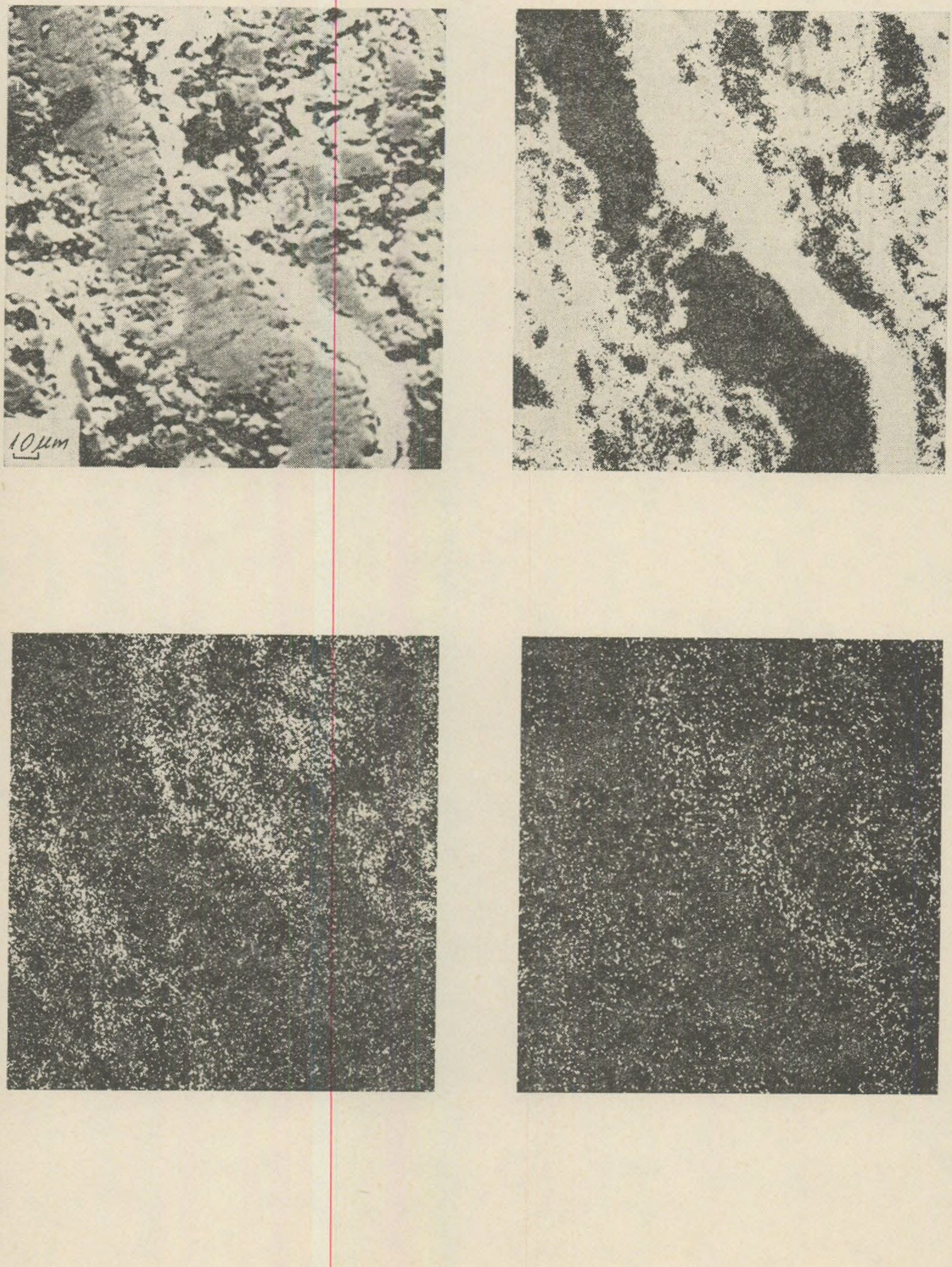

10 μm

PLATE III.

Fig. 1. Backscattered electron picture.
(The light parts are rich in Fe and contain small amount of Mn, Ni and clay, the grey phase is calcite.)

Fig. 2. X-ray area scan for Fe.

Fig. 3. X-ray area scan for Mn.

Fig. 4. X-ray area scan for Ni.

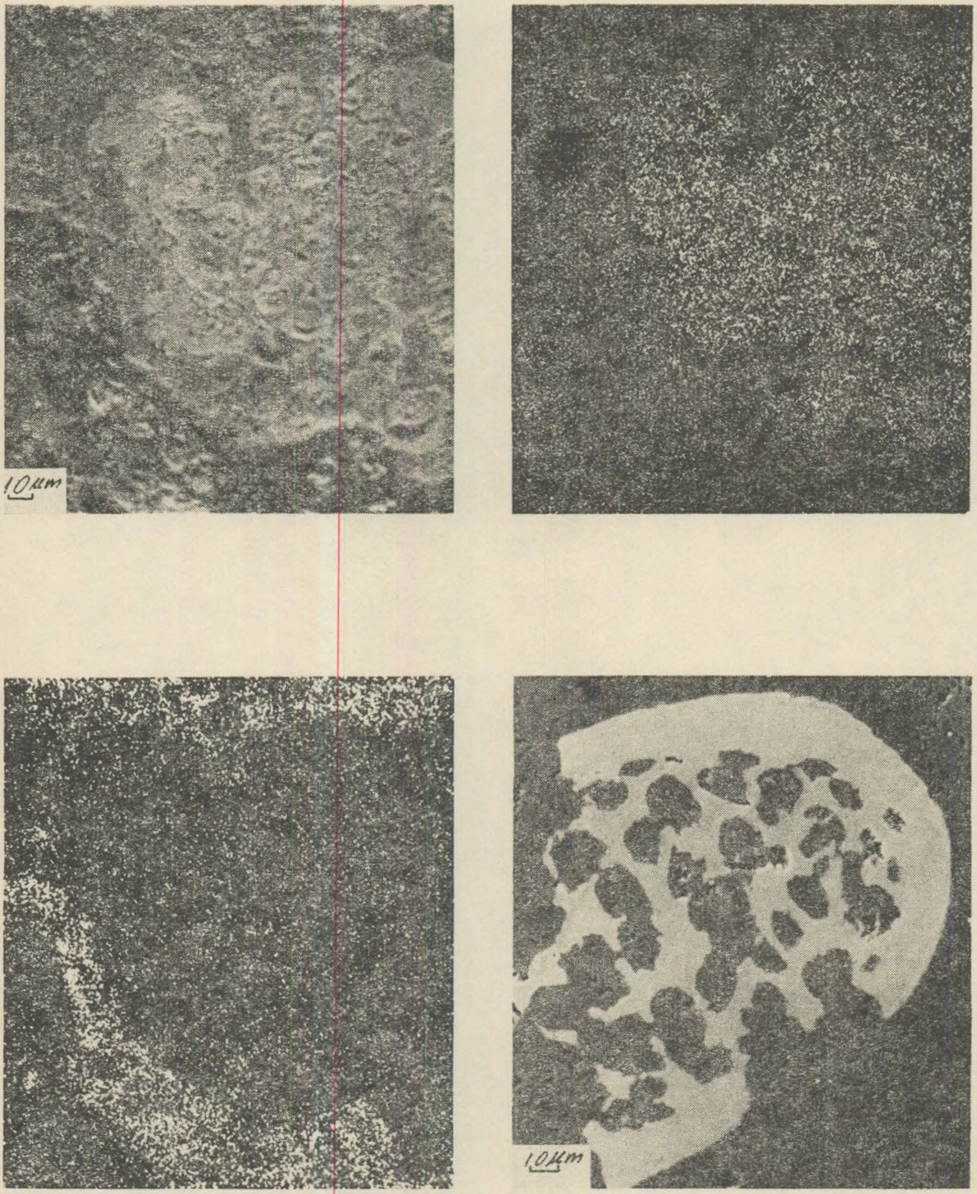

10µm
10µm

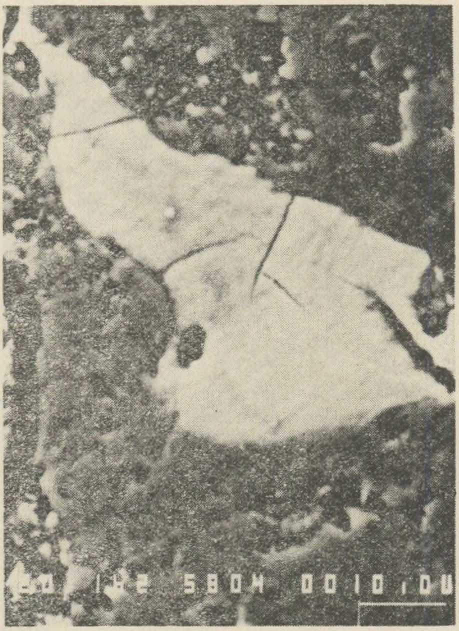
PLATE IV.

Fig. 1. Backscattered electron picture.
(The light-grey phase is/Ca, P), the dark-grey part is calcite, and the black crust around the phosphorite contains Fe- (Mn, Ti, Ni)-bearing clay.)

Fig. 2. X-ray area scan for P.

Fig. 3. X-ray area scan for Fe.

Fig. 4. Backscattered electron picture.
(The light phase is (Ca, P), the dark part is calcite).



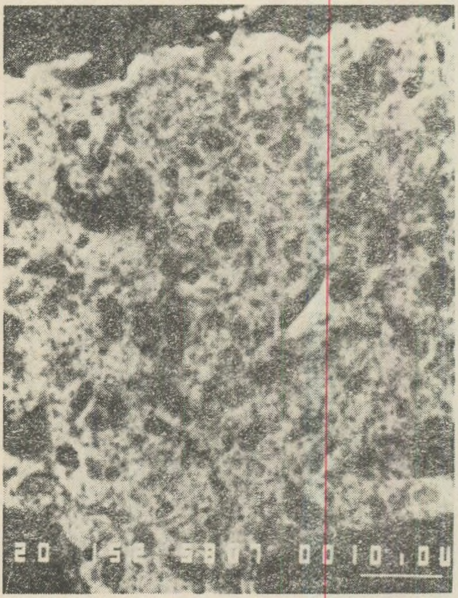


PLATE V.

Fig. 1. Backscattered electron picture.
(The light phase is (Ca, P)-concretion in limestone).

Fig. 2. Backscattered electron picture.
(The (Ca, P)-bearing phase (light phase) has sharp boundaries, and it has no any internal structure).

Fig. 3. Backscattered electron picture.
(The grain contains calcite (dark phase), and (Ca, P)-bearing phase (light part) in chaotic form).

Fig. 4. Backscattered electron picture.
(The limestone (dark parts) contains (Ca, P)-bearing phases of diffuse appereance.)

observed by the naked eye are rich in iron and show higher clay content. The Fe-rich phase locally contains trace amounts of Mn and Ni(Plate III). We could not decide, if the Fe-rich phase (goethite) or the clay adsorbed the Mn and Ni. Electron microprobe investigations did not allow more exact determination of the clay phase.

Both the concretions and the limestone matrix frequently contain Ca and P containing phases (phosphorite, apatite) of very variable appearance.

The limestone contains grains of Ca and P composition of probably biogenic origin (Plate IV), but also occur phases with sharp boundaries without any internal structure and phases of diffuse appearance. We have observed grains, which contain calcium carbonate and calcium phosphate in chaotic form (Plate V).

In the concretions there are Ca, P containing phases within the ferrous laminae, most probably of biogenic origin.

Phosphorite is frequent in the samples, reaching considerable amounts.

Discussion

It is very hard to differentiate between concretions and oncoids of algal origin and Fe-Mn nodules of chemical (bacterial) origin. Some types of the two nodules occur in similar sedimentary environments; their structure, size and element composition might be very similar. Their formation is the result of several factors (water depth, light, oxygen, Eh, pH, bacterial effects, currents, etc.).

The ferrous-carbonate concretions investigated by us barely contain manganese, consequently these cannot be considered as Mn-nodules. But ferrous concretions can be formed by purely chemical processes. The considerable Ca and P phase content of the carbonatic, ferrous concretions from the "Marble quarry" of Zirc, the structure of the phosphatic phase, the texture with laminae, wedging out of layers, and with constrictions (Wendt, 1970) provide evidence for the organic origin of the concretions.

Conclusions

If the algal origin of the Zirc concretions is true, it makes possible precise determination of the sedimentary environment (depth, currents, etc.), since algal activity can be observed in the upper 30 – 50 m depth of the sea. We think, that the ammonitic limestone of Zirc was deposited in a shallow marine environment of ca. 50 m depth. The algal nodules – concretions do not form a continuous algal mat; probably the environment was not suitable for the formation of it, due to the great depth or due to the effects of currents.

REFERENCES

Wein, Gy. (1934): Tithonschichten der Umgebung von Zirc. – Földtani Közlöny 64, 81 – 99.

Noszky, J. (1934): Beiträge zur Kenntnis der Kretazischen Bildungen des Nördlichen Bakony. – Földtani Közlöny 64, 99 – 136.

Fülöp, J. (1964): Unterkreide-Bildungen (Berrias-Apt) des Bakony Gebirges. – Geologica Hungarica, series Geologica 13, 1 – 192.

Wendt, J. (1970): Stratigraphische Kondensation in triadischen und jurassischen Cephalopoden – Kalken der Tethys. – N. Jb. Geol. Palaont, Mh. 1. 433 – 449.

Krajewski, P. (1983): Albian pelagic phosphate-rich macrooncoids from the Tatra Mts (Poland). – In: Peryt, T.M. (ed.): Coated Grains. Springer, Berlin, 345 – 357.

OSTRACOD FAUNA AND PALAEOECOLOGY OF THE LUTETIAN (EOCENE) MOLLUSC SAND AT DUDAR, HUNGARY

by

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Abstract

The ostracod fauna of the Lutetian (Middle Eocene) "Mollusc Sand" of Dudar consists of the following species with detailed descriptions: Cytherella (Cytherelloidea) gantensis Monostori; Platella gyrosa (Roemer); Bairdia (Bairdoppilata) gliberti Keij; Cnestocythere hungarica Monostori; Schizocythere hungarica n.sp.; Schizocythere depressa Méhes; Schizocythere ex gr. tessellata (Bosquet); Clithrocytheridea faboides gantensis Monostori; Neocyprideis williamsoniana (Bosquet); Monsmirabilia triebeli Keij; Krithe bartonensis (Jones); Phalcocythere horrescens (Bosquet); Pterygocythere jonesi (Méhes); "Echinocythereis" dadayana (Méhes); Leguminocythereis dudarensis n.sp.; Leguminocythereis aff. erasa Ducasse; Pokornyella ex gr. limbata (Bosquet): Pokornyella aff. ventricosa (Bosquet); Grinioneis haidingeri paijenborchiana Keij; "Hermanites" acuticosta gantensis Monostori; "Bradleya?" validornata hungarica Monostori; Quadracythere angusticostata (Bosquet); Quadracythere vahrenkampi Moos; Caudites monsmirabiliensis Apostolescu; Cytheretta cf. bambruggensis Keij; Paracytheridea cf. gradata (Bosquet); Semicytherura aff. alata (Lienenklaus); Eucytherura cf. keiji Pietrzeniuk; Xestoleberis gantensis Monostori; Uroleberis parnensis (Apostolescu); Paracypris contracta (Jones); Novocypris gantensis Monostori: The ostracod associations washed from several genera of gastropods indicate a depositiona environment in the nearshore region of a shallow sea, characterized by weak, probably seaso nal oscillation of salinity. The region might have been occupied by a lagoon, its parts dominated by different kinds of gastropods. The ostracod associations enclosed in the shells provide evidences on the environmental factors of each part. We could distinguish parts with strong open marine connections, and parts with the characters of a nearshore, inner lagoon, with weak salinity changes.

Introduction

An extremely rich mollusc fauna occurs in the Eocene coal measures of Dudar. The systematic description of the gastropods has been published by STRAUSZ (1966). The rock is mostly coarse sand with more or less clay and calcareous matrix. It rarely contains well preserved microfauna. However, the infill of the gastropod shells yielded plenty of microfossils, including ostracods. Their preservation is similar to that of Recent forms. Similar differences in preservation have been observed between the microfauna of the Mollusc Marl at Gánt and the infill of its gastropod fauna. (MONOSTORI, 1972a, 1972b, 1973, 1977). While publishing the results of the investigation of the Gánt fauna, I reported on the Dudar one in a preliminary form only. Due to priority problems, the Dudar fauna can be published only now, after the the extremely delayed publication of the monograph on the Eocene ostracods of the Dorog basin (it was in press for 7 years).

Material

The Dudar beds have yielded ostracods from the infills of several gastropod genera. We have attempted to draw conclusions on the ecological needs of some ostracod species, based on their occurrences in certain gastropods, as we have made on the Gánt material (MONOSTORI, 1972a, 1977). Capital letters under "Material" in the systematic part indicate the type of gastropods.

A: *Cerithium subcorvinum* OPPH. specimens from museum material;
B: *Cerithium subcorvinum* specimens and different Naticidae specimens from the same block;
C: specimens of *Velates schmidelianus* CHEMNITZ;
D: Naticidae specimens found together with *Velates*;
E: *Cerithium (Campanile) parisiense urkutense* MUNIER CHALMAS specimens from museum material;
F: gastropods of a sand with coal fragments, containing abundant Naticidae.

Systematic part

Subclass Ostracoda LATREILLE, 1806
Order Podocopida G. W. MÜLLER, 1894
Suborder Platycopa SARS, 1866
Family Cytherellidae SARS, 1866
Genus *Cytherella* JONES, 1849

Cytherella (Cytherelloidea) gantensis MONOSTORI, 1977
Pl. I, fig. 1–3.

1977. *Cytherella (Cytherelloidea) gantensis* n. sp. – MONOSTORI, pp. 76–77, pl. I, fig. 1.

1985. *Cytherella (Cytherelloidea) gantensis* MONOSTORI, forma A – MONOSTORI, pp. 27–29, pl. I, fig. 1–3, 13.

Remarks: Maximal carapace width of juvenile specimens lies much farther from the posterior end, than that of adult ones.

Dimensions

Adult left valve L = 0.68–0.72 mm
H = 0.35–0.38 mm L/H = 1.91–1.93
Adult right valve: L = 0.71–0.73 mm
H = 0.34–0.38 mm L/H = 1.94–2.07

Material

A: 13 isolated valves, 9 juvenile isolated valves, 14 fragments
B: 2 isolated valves, 6 juvenile isolated valves, 4 fragments
C: 1 isolated valve
D: 1 isolated valve
E: 1 fragment
F: 1 isolated valve, 1 juvenile isolated valve, 6 fragments

Cytherella (Cytherelloidea) sp.

Remarks

Fragmented specimen, indeterminable to the species level.

Material

D: 1 fragment

Genus *Platella* CORYELL et FIELDS, 1937

Platella gyrosa (ROEMER, 1938)
Pl. I. fig. 4.

1838. *Cytherina gyrosa* n. sp. – ROEMER, p. 517, T. VI, fig. 22.
1955. *Platella gyrosa* (ROEMER) – APOSTOLESCU, p. 244, t. I, fig. 6.
1957. *Platella gyrosa* (ROEMER) – KEIJ, p. 49, pl. I. fig. 1.
1961. *Cytherella gyrosa* (ROEMER) – DELTEL, p. 15, pl. I, fig. 17.
1962. *Platella ? gyrosa* (ROEMER) – HINTE, p. 168, T. II, fig. 2.
1965. *Platella gyrosa* (ROEMER) – EAGAR, p. 28,
1968. *Platella gyrosa* (ROEMER) – HASKINS, pp. 255–256, pl. 2, fig. 27–30,
1969. *Cytherella gyrosa* (ROEMER) – DUCASSE, pp. 8–9, pl. I. fig. 6.
1969. *Platella gyrosa* (ROEMER) – SCHEREMETA, p. 52, Pl. II, fig. 1–3.

Remarks

The fine, more or less concentric ribbing and the Cytherellidae muscle scar characterizing this species together, can be easily recognized even on the fragmentary specimens.

Geographical and stratigraphical distribution

England: Lutetian–Ledian; The Netherlands: Bartonian; Belgium: Ypresian–Bartonian; France: Lutetian–Ledian; Austria: Ypresian; Soviet Union: Bartonian.

Material

C: 1 fragment
D: 1 fragment

Suborder Podocopa SARS, 1866
Superfamily Bairdiacea SARS, 1866
Family Bairdiidae SARS, 1888
Genus *Bairdia* McCOY, 1844

Bairdia (Bairdoppilata) gliberti KEIJ, 1957
Pl. I, fig. 5–7.

1957. *Bairdoppilata gliberti* n. sp. – KEIJ, p. 53, pl. I, fig. 18–21.
1958. *Bairdoppilata gliberti* KEIJ – MARLIERE, p. 18, pl. II, fig. 5–6.
1959. *Bairdoppilata gliberti* KEIJ – DUCASSE, pp. 13–14, pl. I, fig. 4, pl. X, fig. 2a–b.
1968. *Bairdoppilata gliberti* KEIJ – HASKINS, p. 3, pl. 2, fig. 29–30.
1969. *Bairdoppilata gliberti* KEIJ – DUCASSE, p. 24, pl. II, fig. 29.
1969. *Bairdia gliberti* (KEIJ) – PIETRZENIUK, p. 15, T, 2, fig. 9–10, T. XVI, fig. 1–2.
1969. *Bairdoppilata gliberti* KEIJ – SCHEREMETA, pp. 57–58, pl. II, fig. 15–16.
1971. *Bairdoppilata gliberti* KEIJ – BLONDEAU, p. 25, pl. II, fig. 3–4.
1973. *Bairdoppilata gliberti* KEIJ – OLTEANU, POPESCU, p. III, fig. 28.
1973. *Bairdoppilata gliberti* KEIJ – SÖNMEZ-GÖKÇEN, pp. 38–39, pl. IV, fig. 12–14.
1975. *Bairdoppilata gliberti* KEIJ – CARBONNEL, p. 47, pl. 1, fig. 3–4.
1977. *Bairdoppilata gliberti* KEIJ – SZCZECHURA, pp. 63–64, pl. 17, fig. 1–4.
1978. *Bairdoppilata gliberti* KEIJ – KEEN, pl. 1, fig. 11, 14.
1985. *Bairdia (Bairdoppilata) gliberti* KEIJ – DUCASSE et al., pl. 72, fig. 7–8.
1985. *Bairdoppilata* cf. *gliberti* KEIJ – MONOSTORI, pp. 33–35, pl. II, fig. 1–9.

Remarks

The outer morphology is the same as of the forms described from the Dorog basin (MONOSTORI, 1985). In the Dudar material the inner features can be examined also, making possible the exact identification of the species. In the hinge of the Dudar specimens there is no similar strong furrow as can be observed on the type figure, i.e. the valve surface bends more inward around the largest height.

Dimensions

Adult left vale L = 0.91–0.98 mm
H = 0.53–0.57 mm L/H = 1.71–1.73
Adult right valve L = 0.93–1.18 mm
H = 0.47–0.70 mm L/H = 1.69–1.98

Stratigraphical and geographical distribution:

England: Lutetian–Bartonian; Belgium; Palaeocene–Eocene; France: Upper Palaeocene–Upper Oligocene; Germany: Upper Eocene–Lower Oligocene; Poland: Upper Eocene; Rumania: Eocene; Soviet Union: Palaeocene–Eocene; Turkey: Eocene–Oligocene.

Material

A: 7 isolated valves, 2 juvenile isolated valves, 7 fragments;
B: 3 fragments;
C: 3 juvenile isolated valves, 9 fragments;
D: 3 isolated valves, 12 fragments;
E: 1 isolated valve, 2 fragments;
F: 2 juvenile isolated valves, 4 fragments.

Bairdia (Bairdoppilata) aff. *gliberti* Keij
Pl. 2, fig. 1–2.

Remarks

There are some Bairdia at Dudar, which show an almost total resemblance to the type figure of Keij (1957), but do not show the terminal denticulation of the dorsal margin. The inner lamella of these – like a juvenile character – is less well developed than that of the usual adult specimens. However, the dimensions (H = 0.93 – 1.04 mm) are those of the adult specimens.

Material

A: 10 isolated valves, 4 fragments;
D: 3 isolated valves.

Bairdia sp. 1.
Pl. 1, fig. 8–9.

Description

The anterior outline of the left valve shows small radius and is asymmetric. The dorsal outline shows large radius, and is almost symmetrical (the radius of its posterior half decreases). The posterior end is tapering below the one-third of maximal height. The upper branch of the posterior outline is concave, the lower branch is convex with large radius. The ventral outline is more or less straight or slightly concave. The lower branches of the anterior and the posterior outlines are slightly denticulated.

The anterior outline of the right valve is strongly asymmetrical. The dorsal outline shows a trapezoidal form, the breaks of the outline lie at one-third and three-quarter of the length. The posterior outline is more tapering, while the ventral outline shows a strong, asymmetrical sinuosity. The ventral halves of the anterior and posterior outlines are strongly denticulated.

The fine dotting of the surface can be observed especially on the right valve.

The internal characters are those of the genus *Bairdia*.

Dimensions

Adult left valve L = 0.61 – 0.64 mm
H = 0.33 – 0.34 mm L/H = 1.86
Adult right valve L = 0.59 – 0.63 mm
H = 0.30 – 0.31 mm L/H = 1.92 – 2.12

Remarks

This form is related to the species "*Bairdia*" complanata of DUCASSE (1967), described from the Middle Eocene of France. The specimens from Dudar shows more arcuate dorsal outline. The adult specimens are characteristically small compared to the usual dimensions of the genus.

Material

A: 7 isolated valves;
F: 1 isolated valve.

Superfamily Cytheracea BAIRD, 1850
Family Cytheridae BAIRD, 1850
Subfamily Cytherinae BAIRD, 1850
Genus *Cnestocythere* TRIEBEL, 1950

Cnestocythere hungarica MONOSTORI, 1985
Pl. 2, fig. 3 – 8.

1985. *Cnestocythere hungarica* n. sp. – MONOSTORI, pp. 40 – 43, pl. III, fig. 9 – 22, pl. IV. fig. 1 – 2 (partim).

Remarks

We could examine the hinge of a few specimens only from the Dorog area; these had a hinge of *Cnestocythere*-type. The excellently preserved material from Dudar revealed, that part of the specimens has *Cnestocythere* hinge, another part has *Schizocythere* hinge. All their other characters (shape, ornamentation) are uniform.

The two homoeomorphic species occurs together in the same samples, i.e. in the same environments. Their only distinctive features are the hinges only. Consequently, the *Cnestocythere hungarica* n. sp. described in the Dorog volume (MONOSTORI, 1985) includes the specimens of the *Schizocythere* species as well.

The following data on dimensions and material are of the *Cnestocythere*, which could be exactly separated.

Dimensions

Adult left valve L = 0.50 – 0.52 mm
H = 0.31 – 0.33 mm L/H = 1.56 – 1.65
Adult right valve L = 0.48 – 0.53 mm
H = 0.38 – 0.34 mm L/H = 1.55 – 1.71

Material

B: 1 isolated valve;
C: 11 isolated valves;
D: 3 isolated valves;
E: 7 isolated valves;
F: 20 isolated valves.

Genus *Schizocythere* TRIEBEL, 1950

Schizocythere hungarica n. sp.
Pl. 2, fig. 9 – 14, pl. 3, fig. 1 – 2.

1985. *Cnestocythere hungarica* n. sp. – MONOSTORI, pp. 40 – 43, pl. III, fig. 9 – 22; pl. IV, fig. 1 – 2 (partim).

Derivatio nominis:

After its occurrence in Hungary.
Holotype: left valve.
Stratum typicum: Lutetian marl with Cerithium subcorvinum.

Diagnosis

Form and ornamentation are the same as of the species *Cnestocythere hungarica* MONOSTORI, 1985, but the hinge is a characteristic *Schizocythere* one.

Remarks

Individual variation of shape and ornamentation of *Cnestocythere hungarica* MONOSTORI, 1985 and *Schizocythere hungarica* n. sp. is much larger within each species than the differences between the two species. The two species can be distinguished on the basis of the hinge only. Adult specimens of the two species range into the same size magnitude, so it is not probable that we have the adult specimens and specimens of the last larval stage of the same species. The inner lamella is equally developed on the specimens of equal size. Average strength of ornamentation on the *Schizocythere* species is somewhat greater.

Possibly the *Cnestocythere* genus was separated from the *Schizocythere* genus by neotenic evolution during the Eocene; the Hungarian fauna shows this separation.

Dimensions

Adult left valve L = 0.51 mm
H = 0.32 mm L/H = 1.59
Adult right valve L = 0.48 – 0.52 mm
H = 0.31 – 0.33 mm L/H = 1.50 – 1.69

Material

A: 38 isolated valves;
B: 16 isolated valves;
C: 11 isolated valves;
D: 4 isolated valves;
E: 1 isolated valve;
F: 4 isolated valves.

Schizocythere depressa (MÉHES, 1936)
Pl. 3. fig. 3 – 4.

1936. *Eucytherura depressa* n. sp. – MÉHES, pp. 25 – 26, pl. III. fig. 5 – 8.
1977. *Schizocythere depressa* (MÉHES) – MONOSTORI, pp. 98 100, pl. III, fig. 1 – 4.
1985. *Schizocythere depressa* (MÉHES) – MONOSTORI, pp. 44 – 46, pl. IV, fig. 3 – 16.

Remark

Our adult specimens of poor preservation represent the smallest size range observed at Dorog.

Dimensions

Adult left valve L = 0.39 – 0.40 mm
H = 0.26 – 0.27 mm L/H = 1.43 – 1.55

Material

B: 2 isolated valves, 1 carapace;
D: 1 isolated valve.

Schizocythere ex gr. *tessellata* (BOSQUET, 1852)
Pl. 3, fig. 5 – 6.

Remarks

Similar to the most stubby forms described in the literature.

Dimensions

Adult left valve L = 0.38 mm
H = 0.27 mm L/H = 1.39

Material

F: 2 isolated valves

Schizocytherini juv.

Due to the homoeomorphy described above the larval shells of *Cnestocythere* and *Schizocythere* species are evaluated together.

Material

A: 6 juvenile isolated valves;
B: 3 juvenile isolated valves;
C: 17 juvenile isolated valves;
D: 9 juvenile isolated valves;
E: 13 juvenile isolated valves;
F: 33 juvenile isolated valves.

Family Cythereideidae SARS, 1925
Subfamily Cythereideinae SARS, 1925
Genus *Clithrocytheridea* STEPHENSON, 1936

Clithrocytheridea faboides gantensis, MONOSTORI, 1977
Pl. 3. fig. 7–8.

1977. *Clithrocytheridea faboides gantensis* n. ssp. MONOSTORI, pp. 83–85, pl. II, fig. 2–4.
1985. *Clithrocytheridea faboides gantensis*, MONOSTORI, – MONOSTORI, pp. 49–52, pl. IV, fig. 19–26; pl. V, fig. 1–5.

Remarks

All Hungarian materials show individual variation in outline and ornamentation. The meeting point of the anterior and dorsal outlines can be shifted backwards, thus making the straight dorsal outline much shorter. The ornamentation may be reduced to a nearly smooth surface; in this case only the anterior wrinkles appear very slightly. The Dudar material show a much greater variability than to that of other Hungarian localities, despite the small number of fossils.

Dimensions

Adult right valve L = 0.38–0.45 mm
H = 0.20–0.21 mm L/H = 1.78–2.23
Adult left valve L = 0.40–0.44 mm
H = 0.21–0.24 mm L/H = 1.75–1.89

Material

D: 1 isolated valve;
F: 14 isolated valves, 4 isolated juvenile valves.

Genus *Neocyprideis* APOSTOLESCU, 1956

Neocyprideis williamsoniana (BOSQUET, 1852)
Pl. 3. fig. 9.

1852. *Cytheridea williamsoniana* n. sp. – BOSQUET, pp. 43–44, pl. II, fig. 6.
1985. *Neocyprideis williamsoniana* (BOSQUET) – MONOSTORI, pp. 52–53, pl. V, fig. 6–7. (cum syn.).

Remarks

The Dudar specimens are unornamented, like a part of the Gánt ones (Monostori, 1977). The species *Neocyprideis apostolescui* (Keij, 1957) may be ranged into this species as an ecological variety.

Dimensions

Adult right valve L = 0.71 – 0.72 mm
H = 0.40 – 0.44 mm L/H = 1.65 – 1.76

Material

A: 3 isolated valves, 1 juvenile isolated valve.

Subfamily Cuneocytherinae Mandelstam, 1959
Genus *Monsmirabilia* Apostolescu, 1955

Monsmirabilia triebeli Keij, 1957
Pl. 3, fig. 10 – 11.

1957. *Cuneocythere (Monsmirabilia) triebeli* n. sp. – Keij, p. 79, t. IX, fig. 1 – 4.
1985. *Monsmirabilia triebeli* Keij – Monostori, pp. 60 – 64, t. VI, fig. 15 – 27; t. VII, fig. 1 – 8, (cum syn.).

Remarks

Variation of the outline is significant like of the specimens from Gánt and Dorog basin. The description of the ornamentation must be completed: a short posteromarginal margin can be observed besides the anteromarginal margin in the whole material from Hungary. This – like the anteromarginal margin – is strong on the right valve and barely perceptible on the left one. This character was described from the type material, too (Keij, 1957).

Dimensions

Adult right valve = 0.47 – 0,52 mm
H = 0.25 – 0.27 mm L/H = 1.82 – 2.00
Adult left valve L = 0.50 – 0.61 mm
H = 0.32 – 0.40 mm L/H = 1.53 – 1.59

Material

A: 7 isolated valves;
B: 8 isolated valves;
C: 1 isolated valve;
F: 20 isolated valves.

Genus *Krithe* BRADY, CROSSKEY et ROBERTSON, 1874

Krithe bartonensis (JONES, 1857)
Pl. 3, fig. 12–13.

1857. *Cytherideis bartonensis* n. sp. – JONES, p. 50, t. V, fig. 2a, b, 3a, b.
1985. *Krithe bartonensis* (JONES) = MONOSTORI, pp. 64–66, t. VII, fig. 9–21. (cum syn.).

Remarks

KHOSLA and HASKINS (1980) ranged this species to the genus *Dentokrithe*, based on the posterior tooth in the left valve and its socket in the right valve. Posterior part of the cylinder bordering the furrow from below in the left valve may be thickened at several *Krithe* species; these make their counterpart depression on the edge of the right valve. This hinge occurs on many forms of *Krithe bartonensis* at Gánt, Dorog and Dudar. (The break of the edge of the right valve lies at 0.4 length, instead of 0.6 length, as the descriptions indicate it! (MONOSTORI, 1977, 1985). (All hungarian localities yield some specimens, which bear a tooth-like thickening on the left valve and a socket-like depression on the right one. These specimens are generally more stubby; these can be found together with those ones, which bear this character very indistinctively. It is questionable, if it is correct to establish a new genus based on this character. Examining the Hungarian material, we can conclude, that this case is only the morphological variation of the same species.

Dimensions

Adult left valve L = 0.66 – 0.68 mm
H = 0.32 – 0.34 mm L/H = 2.00 – 2.07
Adult right valve L = 0.61 – 0.68 mm
H = 0.27 – 0.30 mm L/H = 2.24 – 2.32

Material

A: 11 isolated valves, 3 juvenile isolated valves;
B: 6 isolated valves;
C: 1 fragment;
D: 3 fragments;
F: 13 isolated valves, 2 juvenile isolated valves.

Family Trachyleberididae SYLVESTER – BRADLEY, 1948
Subfamily Trachyleberidinae SYLVESTER – BRADLEY, 1948

Genus *Phalcocythere* SIDDIQUI, 1971
Phalcocythere horrescens (BOSQUET, 1852)
Pl. 3, fig. 14 – 16.

1852. *Cythere horrescens* n. sp. – BOSQUET, pp. 119, pl. VI, fig. 5.
1955. *Trachyleberis horrescens* (BOSQUET) – APOSTOLESCU, p. 272, pl. VIII, fig. 125 – 126.

1957. *Hirsutocythere horrescens* (BOSQUET) – KEIJ, p. 101, pl. XV, fig. 4; t. XVII, fig. 6–7.
1959. *Hirsutocythere horrescens* (BOSQUET) – DUCASSE, pp. 61–64, pl. IV, fig. 3; pl. XXIII, fig. 2.
1961. *Hirsutocythere horrescens* (BOSQUET) – DELTEL, pp. 169–170, pl. 16, fig. 281.
1966. *Hirsutocythere horrescens* (BOSQUET) – MOUSSOU, pp. 100–102, pl. 30, fig. 127a–b, 128.
1969. *Trachyleberis horrescens* (BOSQUET) – DUCASSE, pp. 148–149, pl. X, fig. 208.
1969. *Hirsutocythere horrescens* (BOSQUET) – SCHEREMETA, p. 202, pl. XIV, fig. 11–12.
1971. *Trachyberis horrescens* (BOSQUET) – BLONDEAU, pp. 54–55, pl. VI, fig. 1–5.
1971. *Phalcocythere horrescens* (BOSQUET) – SIDDIQUI, pp. 57–58, pl. 29, fig. 5; pl. 30, fig. 1–6; pl. 33, fig. 12–13.
1973. *Hirsutocythere horrescens* (BOSQUET) – SÖNMEZ–GÖKÇEN, pp. 85–86, pl. XI. fig. 16–17.
1985. *Phalcocythere horrescens* (BOSQUET) – DUCASSE etal., pl. 78, fig. 15–17.

Description

1. In outer lateral view the anterior outline of the left valve is asymmetrically rounded; radius of the upper half is much larger than that of the lower half. The anterior outline makes a 120° angle with the dorsal outline. The cardinal angle strongly protrudes, forming a flat spine bending towards posterior direction. The dorsal outline is straight, but some spines of the lateral surface reach beyond it. The dorsal outline turns into the posterior outline by a 120° angle at 0.8 length. Upper part of the posterior outline is slightly concave, the lower part is convex in a small radius arc. The ventral outline diverges from the dorsal outline in anterior direction. Its posterior part beyound 0.7 length is concave. Between 0.3 and 0.7 length the ventral outline is barely convex (an ornamentation feature, the ventral keel forms this slightly convex section). At 0.3 length – where the ventral and anterior outlines meet – the outline is slightly depressed.

The anterior outline of the right valve is less asymmetric and the cardinal angle does not protrude. The caudal termination is more tapering, due to the stronger concavity of the upper part of the posterior outline. Anterior parts of both valves is densely denticulated; on the posterior part 6–7 larger spines protrude from the outline.

In dorsal view of the left valve the the rise of the outline is insignificant until 0.2 length, then it rises to neat half-length by 30°, then it rises in a somewhat smaller angle until 0.8 length. Behind the outline slopes towards the plane separating the valves along ca. one-third of the local width perpendicularly; then it slopes by 45° almost until the end of the valve. At the end of the valve the outline is almost parallel with the plane separating the valves along a small section.

In dorsal view of the right valve the outline shows similar characters.

2. Ornamentation. There is a strong ventral keel on the left valve from 0.2 to 0.8 length. This keel starts slightly above the ventral outline then extends below the ventral outline on its posterior part. The keel is plate-like and bears a spine-like tapering on its posterior part. The lateral surface is covered by dense spines. There is an especially strong spine near the dorsal outline before the posterior hinge element. The subcentral nodule bears conspicuously stronger spines. There is a strong row of spines along the anterior outline. The protruding cardinal part of the left valve is formed by a plate-like valve-extension, bending like a spine in posterior direction. The posterodorsal spine on the right valve is somewhat weaker.

3. Dimensions

Adult left valve L = 0.54 – 0.57 mm
H = 0.32 – 0.38 mm L/H = 1.47 – 1.70
Adult right valve L = 0.54 – 0.58 mm
H = 0.28 – 0.31 mm L/H = 1.85 – 1.92

4 – 8. The inner characters cannot be studied.

9. There is a strong eye-nodule at the cardinal angle.

Remarks

Even the details of the ornamentation can be easily compared to the type material of BOSQUET (1852) revised by KEIJ (1957). Protruding character of the caudal angle of the left valve can be observed on the figures of DUCASSE et al. (1985) like on the Dudar specimens. Individual variation is low, displaying itself in the variability of spinosity.

Geographical and stratigraphical distribution:

France: Ypresian – Ledian; Belgium: Lutetian – Ledian; Soviet Union: Lutetian – Bartonian; Turkey: Bartonian.

Material

A: 17 isolated valves, 2 juvenile isolated valves, 7 fragments.

Genus *Pterygocythere* HILL, 1954

Pterygocythere jonesi (MÉHES, 1936)
Pl. 4, fig. 1 – 2.

1936. *Cytheropteron jonesi* n. sp. – MÉHES, pp. 22 – 25, t. III, fig. 1 – 4.
1977. *Pterygocythere jonesi* (MÉHES) – MONOSTORI, pp. 81 – 83, Pl. I, fig. 10 – 12.
1985. *Pterygocythere jonesi* (MÉHES) – MONOSTORI, pp. 73 – 75, Pl. VIII, fig. 7 – 9.

Remarks

The two intact left valves are elongated; the local height less decreases towards posterior direction than on the majority of the Gánt and Dorog specimens (MONOSTORI, 1977, 1985). The dorsal outline is nearly straight. The discrepance may be due to sexual dimorphism (male specimens). Teeth of the anterior and posterior margins are long. The wing-like widening terminates in a long spine, observable due to the extremely good preservation.

Dimensions

Adult left valve L = 0.89 0.92 mm
H = 0.45 – 0.53 mm L/H = 1.73 – 1.97

Material

A: 3 fragments;
F: 2 isolated valves, 3 fragments.

Genus *Echinocythereis* PURI, 1954

"*Echinocythereis*" *dadayana* (MÉHES, 1941)
Pl. 4, fig. 3 – 6.

1936. *Cythereis dadayi* n. sp. – MÉHES, pp. 40 – 42, t. IV, fig. 12 – 13.
1985. *Echinocythereis dadayana* (MÉHES) – MONOSTORI, pp. 75 – 79, Pl. VIII, fig. 10 – 15, Pl. IX. fig. 1 – 11. (cum syn.).

Remarks

The Dudar specimens are less ornamented, like those of the original description (MÉHES 1936). The Gánt fauna also contains similar forms (MONOSTORI, 1977). The posterodorsal keel mostly can be easily recognized on the Dudar specimens; it lies between 0.6 – 0.8 length like an upward bending plate. Many juvenile specimens occur in some samples. Their surface is almost smooth. The ventral keel is indicated by a strong break in the lateral surface and a tiny spine of the termination of the keel. There is a short, barely perceptible rib or ribs on the ventral part near the outer margin. The posterior teeth can be easily recognized, there are no anterior teeth. The marginal zone is extremely narrow, the hinge is weak. The dorsal and ventral outlines show more convergence in posterior direction than on the adult specimens.

Dimensions

Adult right valve L = 0.74 – 0.80 mm
H = 0.41 – 0.45 mm L/H = 1.78 – 1.83
Adult left valve L = 0.73 – 0.76 mm
H = 0.44 – 0.45 mm L/H = 1.63 – 1.70
Juvenile right valve L = 0.31 – 0.60 mm
H = 0.18 – 0.35 mm L/H = 1.70 – 1.73
Juvenile left valve L = 0.47 – 0.55 mm
H = 0.30 – 0.35 mm L/H = 1.57 – 1.60

Material

A: 239 isolated valves, 1 carapax, 66 juvenile isolated valves;
B: 38 isolated valves, 3 carapaces, 8 juvenile isolated valves;
C: 3 isolated valves;
D: 1 isolated valve;
F: 12 isolated valves.

Subfamily Campilocytherinae PURI, 1960
Genus *Leguminocythereis* HOWE et LAW, 1936

Leguminocythereis dudarensis n. sp.
Pl. 4, fig. 7–8.

Derivatio nominis: named after the type locality.
Holotype: left valve.
Locus typicus: Dudar, Hungary.
Stratum typicum: Lutetian molluscan marl.
Diagnosis

The dominant longitudinal ornamentation elements on the valve weaken from the muscle scar area towards anterior direction; these are anterodorsally fading. The ventral outline is barely convex. There is a definite spine posteroventrally.

Description

1. In outer lateral view the anterior outline of the left valve is strongly asymmetrically rounded; radius of the upper two-thirds is much larger than that of the lower part. The anterior outline bends into the nearly straight dorsal outline at 0.4 length. The latter turns into the posterior outline before 0.9 length in ca. 140° angle. The upper part of the posterior outline is barely concave; the lower branch is rounded by a small radius arc after a 120° break. The ventral outline is nearly straight, being slightly convex between 0.4 and 0.7 length. Height lies at 0.4 length. In outer lateral view of the right valve the height is moved towards the valve surface. The ventral outline is less convex. In inner lateral view there is an asymmetric sinus on the outer margin of the left valve between 0.3 and 0.6 length.

2. Ornamentation. There are two strong, parallel ribs along the anterior outline of the left valve, beginning from the anterior hinge element; the inner one is thinning and fades into the surface at three-quarters of the length. The outer rib slightly moves away from the posterior outline and runs towards the posterior hinge element. The lateral surface bears 10 to 12 uneven, more or less parallel ribs, which partly wedge out towards posterior direction. This longitudinal ribbing is weak on the anterodorsal and ventral parts of the valves from the muscle scar area backwards; the surface is almost smooth here. There is a strong posteroventral spine on the outer concentric rib. There are 3 tiny spines near the lower branch of the posteroventral outline. The ornamentation of the right valve is similar.

3. Dimensions
Adult left valve L = 0.83 mm
H = 0.46 mm L/H = 1.79
Adult right valve L = 0.94 mm
H = 0.50 mm L/H = 1.88
Embryonic right valve L = 0.50 mm
H = 0.27 mm L/H = 1.85

4. The inner lamella is wide anteriorly and posteroventrally. There is no vestibulum. The selvage runs near the outer margin.

5. The marginal pore canals are relatively dense, straight and simple at the anterior and posteroventral parts.

6. The hinge contains a strong anterior socket in the left valve, a strong anteromedian tooth bending downwards and in anterior direction, a reticulated posteromedian cylinder and an elongated posterior socket.

7. The normal pores are disseminated and arranged in the spaces between the longitudinal ribs.

8. The muscle scar area cannot be studied.

9. There is no eye nodule.

10. The left valve slightly overlaps the right valve dorsally and ventrally.

12. The juvenile forms bear a longer straight part of the dorsal outline.

Comparisons

The species is most near to the group of *L. oertlii* KEIJ, but differs by the shape of the outline and by the mostly longitudinal ornamentation. Consequently, it is a separate species.

Material

F: 2 isolated valves, 5 juvenile isolated valves, 14 fragments.

Leguminocythereis aff. *erasa* DUCASSE, 1967
Pl. 4, fig. 9.

Remarks

A single right valve, bearing a nearly symmetrically, in a small radius arc rounded anterior outline, and a nearly symmetrically, in a large radius arc rounded dorsal outline. The meeting point of the dorsal and the anterior outlines is slightly depressive, while the meeting point of the dorsal and posterior outlines is strongly depressed. The posterior outline is rounded in a very small radius arc. The ventral outline is strongly convex; it is formed by a strongly bulging lateral surface between 0.2 and 0.8 length. Ornamentation is that of described by DUCASSE (1967); weak traces of ribbing can be observed on the upper, mostly smooth part of the valve. The strongly bulged ventral part is shifted forward, compared to the type specimen, together with the locations of greatest height and width. In dorsal view the posterior slope of the outline is steeper than on the type, the section of the outline which is parallel with the plane separating the valves is longer.

This single specimen cannot give possibility to determine if these differences are individual variations only, or van be evaluated taxonomically.

Material

C: 1 isolated valve.

Leguminocythereis sp.

Remarks

Fragments indeterminable to the species level.

Material

E: 2 fragments.

Family Hemicytheridae PURI, 1953

Subfamily Hemicytherinae PURI, 1953

Genus *Pokornyella* OERTLI, 1956

Pokornyella ex gr. *limbata* (BOSQUET, 1852)
Pl. 5, fig. 1, 3.

Description

1. In outer lateral view of the left valve the anterior outline is very asymmetrically rounded, bending into the slightly concave dorsal outline at 0.5 length by a 130 – 140° break. At the transition towards the posterior outline there is a 90° break at 0.9 length. The upper part of the posterior outline is strongly concave, while the lower part forms a strong caudal process. The transition of the posterior and ventral outlines is concave around 0.8 length. The ventral outline is asymmetrically convex until 0.8 length. Meeting of the ventral and anterior outlines is concave again around 0.3 length. Height lies at 0.5 length.

Anterior outline of the right valve turns into the dorsal outline at 0.4 length by ca. 150° angle. The latter is straight until 0.6 length, then convexly bends towards the ventral outline until 0.9 length. The upper branch of the posterior outline is strongly concave, while the lower branch is strongly convex, forming a tapering caudal process at the lower third of the height. The posterior outline gradually turns into the weakly and slightly asymmetrically convex ventral outline. Height lies in the middle.

In inner lateral view the outer margin of the left valve definitely deviates from the outline dorsally and ventrally as well. In dorsal view the outline rises in 45° angle until 0.4 length. Then the rise decreases, becoming zero behind 0.5 length. Then the outline slopes in posterior direction. The slope increases from 0° to 60° until a little before 0.9 length. Then the outline is parallel with the plane separating the valves until the termination of the valve at one-fourth level of maximal width.

2. Ornamentation. Valve surface is pitted, being frequently fading, especially on the most convex part of the valve. The large, angular spaces

bordering the anterior outline can be well observed on some specimens. There is a definite ventral keel in the immediate neighbourhood of the ventral outline. There is a protruding ornamentation terminated by a pointless spine on the upper part of the lateral surface before the meeting of the dorsal and posterior outlines. There are longitudinal wrinkles on the caudal process.

3. Dimensions
Adult left valve L = 0.61 – 0.72 mm
H = 0.41 mm L/H = 1.54 – 1.74
Adult right valve L = 0.66 – 0.67 mm
H = 0.38 – 0.40 mm L/H = 1.68 – 1.75

4. The inner lamella is moderately wide. There is no vestibulum. The selvage runs near the outer margin.

5. There is a moderate number of marginal pore canals; these are simple and straight.

6. The anterior hinge element of the left valve is a large socket. The anteromedian element is a strong, button-like tooth, located towards the inner part of the valve compared to the anteromedian element. The posteromedian element is a strong, lath-like cylinder, bordered by a dorsal, strong furrow. The posterior element is a strong socket.

7. There are many large normal pores.

8. The central muscle scars cannot be studied.

9. There is a small, but definite eye-nodule at the cardinal angle.

10. The left valve definitely overlaps the right valve dorsally and ventrally.

11. Part of the forms are more elongated: these might be the male specimens.

Remarks

Compared to the type of BOSQUET revised by KEIJ (1957) the left valves bears somewhat weaker ornamentation, the anterior asymmetry is more definite and the dorsal outline is more straight. The pertinent literature contains more significant differences than these in the large numbers of occurrences ranged into this species. It is questionable if these are subspecies or – rather – the species shows very high individual variation.

Material

B: 2 isolated valves;
E: 2 isolated valves, 1 fragment;
F: 1 fragment.

Pokornyella aff. *ventricosa* (BOSQUET) juv.
Pl. 4, fig. 10.

Remarks

This juvenile form can be identified by its outline and ornamentation with the forms of the Paris basin ranged to this species.

Material

F: 1 juvenile isolated valve.

Subfamily Thaerocytherinae HAZEL, 1967
Genus *Grinioneis* LIEBAU, 1975

Grinioneis haidingeri paijenborchiana KEIJ, 1957
Pl. 5, fig. 2.

1957. *Hermanites paijenborchiana* n. sp. – KEIJ, p. 110, t. XVII, fig. 11–14, t. XXI, fig. 10–11.
1985. *Hermanites haidingeri paijenborchiana* KEIJ – MONOSTORI, pp. 83–87, Pl. X, fig. 7–16, Pl. XI, fig. 1–7 (cum syn.).

Remarks

Part of the specimens bear a less well developed dorsal keel. On these specimens the lateral surface steeply slopes from the strongly protruding ventral keel towards the dorsal keel. Here the subcentral nodule is less protruding.

Dimensions

Adult right valve L = 0.67 mm
H = 0.37 mm L/H = 1.84
Adult left valve L = 0.68 mm
H = 0.37 mm L/H = 1.87
Adult carapace L = 0.68 mm
H = 0.37 mm W = 0.30 mm L/H = 1.87
Adult carapace (variation mentioned in Remarks)
L = 0.76 mm H = 0.41 mm
L/H = 1.83 W = 0.42 mm

Material

B: 1 carapace;
C: 1 isolated valve, 3 carapaces;
D: 2 isolated valves, 1 carapax, 2 isolated juvenile valves;
F: 2 isolated valves.

Genus *Hermanites* PURI, 1955

"*Hermanites*" *acuticosta gantensis* MONOSTORI, 1977
Pl. 5, fig. 6.

1977. *Hermanites acuticosta gantensis* n. ssp. – MONOSTORI, pp. 104–107. Pl. IV, fig. 3–6.

Remarks

The plate of the dorsal keel is not divided into two parts on the Dudar specimens. Generally the ornamentation is less well developed.

Dimensions

Adult left valve L = 0.57 – 0.61 mm
H = 0.33 – 0.35 mm L/H = 1.69 – 1.79
Adult right valve L = 0.58 – 0.60 mm
H = 0.31 – 0.32 mm L/H = 1,85 – 1.89

Material

A: 28 isolated valves;
B: 2 isolated valves.

Genus *Bradleya* HORNIBROOK, 1952

Bradleya? validornata hungarica MONOSTORI, 1977
Pl. 5, fig, 4 – 5, 7.

1977. *Bradleya validornata hungarica* n. ssp. – MONOSTORI, pp. 100 – 102, t. III, fig. 5 – 8.
1985. *Bradleya validornata hungarica* MONOSTORI – MONOSTORI, pp. 90 – 94, Pl. XI, fig. 21 – 22, Pl. XII, fig. 1 – 6.

Dimensions

Adult left valve L = 0.85 – 0.87 mm
H = 0.53 mm L/H = 1,60 – 1,64
Adult right valve L = 0,86 mm
H = 0.50 mm L/H = 1.74

Material

C: 2 isolated valves;
D: 4 isolated valves.

Genus *Quadracythere* HORNIBROOK, 1952

Quadracythere angusticostata (BOSQUET, 1852)
Pl. 5, fig. 8.

1852. *Cythere angusticostata* n. sp. – BOSQUET, pp. 91 – 92, Pl. IV, fig. 12.
1985. *Quadracythere angusticostata* (BOSQUET, 1852) – MONOSTORI, pp. 94 – 97, Pl. XII, fig. 7 – 15, Pl. XIII, fig. 1 – 3. (cum syn.).

Dimensions

Adult left valve L = 0.77 – 0.79 mm
H = 0.44 – 0.45 mm L/H = 1.76

Material

C: 1 isolated valve;
D: 2 isolated valves.

Quadracythere vahrenkampi Moos, 1965
Pl. 6, fig. 2 – 10.

1965. *Quadracythere (Hornibrookella) vahrenkampi* n. sp. – Moos, pp. 599 – 602, t. 34, fig. 6 – 8.
1985. *Quadracythere vahrenkampi* Moos, 1965 – Monostori, pp. 98 – 100, Pl. XIII, fig. 4 – 12 (cum syn.).

Remarks

On part of the specimens the ornamentation elements merge into each other of fade; these show an unreticulated subcentral node. Ornamentation displays high individual variation. We have found the possibly juvenile forms described from the Dorog basin (Monostori, 1985). Shape and ornamentation of adult specimens is similar to the *Quadracythere vermiculata* (Bosquet) specimens figured by Ducasse et al. (1985), but significantly differs from the description and figures of Keij's (1957) revision of the *vermiculata* type material.

Dimensions

Adult left valve L = 0.73 – 0.83 mm
H = 0.41 – 0.47 mm L/H = 1.75 – 1-84
Adult right valve L = 0.77 – 0.83 mm
H = 0.38 – 0.40 mm L/H = 1,97 – 2.09

Material

A: 96 isolted valves, 7 carapaces;

C: 1 juvenile? isolated valve, 1 juvenile? carapax;
D: 2 juvenile? isolated valves; 2 fragments;
E: 1 juvenile? isolated valve;
F: 5 isolated valves, 2 carapaces, 2 juvenile? isolated valves, 3 fragments.

Subfamily Oriononinae Puri, 1973
Genus *Caudites* Coryell et Fields, 1937

Caudites monsmirabiliensis Apostolescu, 1955
Pl. 7, fig. 1 – 3.

1955. *Caudites monsmirabiliensis* n. sp. – Apostolescu, p. 251, t. II, fig. 33 – 34.
1985. *Caudites monsmirabiliensis* Apostolescu – Monostori, pp. 101 – 103, Pl. XIII, fig. 13 – 17 (cum syn.).

Remarks

The Dudar specimens are characterized by the morphological characters of the Dorog material (Monostori, 1985), differing slightly from the type.

Dimensions

Adult left valve L = 0.52 mm
H = 0.27 mm L/H = 1.91
Adult carapax L = 0,50 mm
H = 0,25 mm L/H = 2.00 W = 0.18 mm

Material

A: 1 carapax;
C: 1 isolated valve;
F: 1 isolated valve.

Subfamily Cytherettidae TRIEBEL, 1972
Genus *Cytheretta* G. W. MÜLLER, 1894

Cytheretta cf. *bambruggensis* KEIJ, 1955
Pl. 7. fig. 5–6.

Description

1. In outer lateral view the anterior outline of the left valve is asymmetrically rounded; radius of the lower part is much larger than that of the upper part. The anterior outline turns into the nearly straight dorsal outline by a ca. 150° angle. Between 0.6 and 0.8 length the dorsal outline is formed by a slightly arched section of the strong dorsal rib. The dorsal outline is strongly depressed between 0.8 and 0.9 length, consequently the transition to the posterior outline is protruding. The upper branch of the posterior outline has smaller radius than that of the lower branch. The lower branch continuously bends into the nearly straight ventral outline. The lower part of the anterior outline is denticulated.

In inner lateral view the dorsal margin of the left valve is straight, while the ventral margin is slightly sinuous somewhat before half length.

2. Ornamentation. Surface of the left valve displays strong ribbing. Number of ribs is 9. The arched dorsal rib, which is somewhat stronger than the others starts at 0.4 length somewhat below the dorsal outline; it forms the dorsal outline in a straight line between 0.6 and 0.8 length. Behind it bends downwards in a more and more steep arc and terminates at 0.9 length and at one-third of the local height. The second rib is slightly arched in dorsal direction, starting from the neighbourhood of the anterior outline. Immediately near to it starts the less arched third rib. The 4. and 5. ribs are slightly sinuous. The 5. rib is barely perceptible around 0.5 length along a short section. The 6. rib is especially strong; at the ends it slightly bends upwards. There is a strong intermediate rib between ribs 5. and 6. between 0.4 and 0.8 length. The 7. rib is parallel with the 6. one. The 8. and 9. ribs are parallel with the venteal outline. There is a bifurcating intermediate rib between 7. and 8. ribs on the posteroventral part. All ribs strongly converge at their posterior terminations. The longitudinal ribs are connected by transverse riblets. The valve is smooth above the anterior and

posterior hinge elements. Near the anterior and posterior margins the surface is poorly observable, as well as the spaces formed by the transverse riblets. There are weak anteromarginal and posteromarginal rims.

3. Dimensions
Adult left valve L = 0.77 mm
H = 0.42 mm L/H = 1.83
4–8. The inner characters cannot be studied.
9. There is no eye-node or eye-spot.

Remarks

The longitudinal ornamentation elements can be well compared by the photograph of KEIJ (1972) onthe topotype material. The denticulation of the anterior margin also indicates this species. Certain details of the ornamentation (rise of the dorsal rib above the dorsal margin, characters of the transverse riblets) are similar to the species *Cytheretta haimeana* (BOSQUET, 1852).

Material

B: 2 isolated valves.

Cytheretta sp. 1.

Remarks

This form can be ranged into the group of *C. crassivenia Apostolescu*, 1955.

Material

C: 2 isolated valves.

Cytheretta sp.

Remarks

Fragment indeterminable to the species level.

Material

E: 1 fragment.

Family Paracytheridae PURI, 1957
Genus *Paracytheridea* G. W. MÜLLER, 1894
Paracytheride cf. *gradata* (BOSQUET, 1852)

Remarks

Observable characters of the injured valves indicate this species.

Material

C: 2 isolated valves.

Family Cytheruridae G. W. MÜLLER, 1894
Subfamily Cytherurinae G. W. MÜLLER, 1894
Genus *Semicytherura* WAGNER, 1957
Semicytherura aff. *alata* (LIENENKLAUS, 1894)

Remarks

Outline and ornamentation can be easily identified with published figures. The anterior outline is more asymmetrical, the ventral keel protrudes along a longer section and the dorsal outline is more arcuate than those of the type. It is questionable, if the forms described from various ages under this name indicate wide variability or the authors amalgamated different species. The Dudar material is too poor to answer this question.

Material

A: 1 isolated valve;
F: 2 isolated valves.

Genus *Eucytherura* G. W. MÜLLER, 1894
Eucytherura cf. *keiji* PIETRZENIUK, 1969

Remarks

All observable characters of the single specimen of poor preservation (outline, reticulation, shape of the ventral keel, a short anterior roblet running towards the centre, character of the posterodorsal bulge) indicate this species.

Material

F: 1 isolated valve.

Subfamily Cytheropterinae HANAI, 1957
Genus *Cytheropteron* SARS, 1966
Cytheropteron sp. div.

Remarks

Poorly preserved, scattered specimens belonging to several species.

Material

A: 1 isolated valve;
B: 1 isolated valve;
C: 1 isolated valve;
D: 1 isolated valve;
E: 1 isolated valve;
F: 1 isolated valve.

Family Xestoleberididae SARS, 1928
Genus *Xestoleberis* SARS, 1866
Xestoleberis gantensis MONOSTORI, 1977
Pl. 7, fig. 4, 8–11.

1977. *Xestoleberis gantensis* n. sp. – MONOSTORI, pp. 113–115, t. IV, fig. 14–17.
1985. *Xestoleberis gantensis* MONOSTORI – MONOSTORI, pp. 121–124, Pl. 121–124, Pl. XVI, fig. 1–3.

Remarks

Most specimens are tiny, morphologically variable, thin shelled, probably juvenile forms, like in Gánt and in the Dorog basin. Part of them are extremely elongated; these can be ranged here conditionally only.

Dimensions

Adult right valve L = 0.60–0.66 mm
H = 0.41–0.45 mm L/H = 1.47–1.51
Adult left valve L = 0.61–0.68 mm
H = 0.45–0.48 mm L/H = 1.37–1.41

Material

A: 46 isolated valves, 34 juvenile isolated valves, 34 juvenile isolated valves (elongated forms);
B: 2 isolated valves, 18 juvenile isolated valves;
C: 2 isolated valves, 4 juvenile isolated valves;
D: 3 isolated valves, 9 juvenile isolated valves;
E: 1 isolated valve, 5 juvenile isolated valves;
F: 6 isolated valves, 32 juvenile isolated valves.

Xestoleberis sp. 1.
Pl. 7, fig. 7, 12.

Remarks

Valves with nearly symmetrical dorsal outline, with nearly the same anterior and posterior rounding and with slightly concave symmetrical ventral outline.

Dimensions

Adult left valve L = 0.41–0.50 mm
H = 0.24–0.28 mm L/H = 1.75–1.82

Material

F: 18 isolated valves.

Genus *Uroleberis* TRIEBEL, 1958

Uroleberis parnensis (APOSTOLESCU, 1955)
Pl. 7, fig. 13–15.

1955. *Eocytheropteron parnensis* n. sp. – APOSTOLESCU, p. 259, Pl. IV, fig: 66–67.

1957. *Microxestoleberis parnensis* (APOSTOLESCU) – KEIJ, p. 167, Pl. XV, fig. 9.
1958. *Uroleberis parnensis* (APOSTOLESCU, 1955) – TRIEBEL, pp. 110–112, T. 2, fig. 5–12, T. 3, fig. 13.
1959. *Eocytheropteron parnensis* APOSTOLESCU – DUCASSE, pp. 43–44, Pl. XVIII, fig. 3a, b.
1961. *Uroleberis parnensis* (APOSTOLECU) – DELTEL, p. 35, Pl. 12, fig. 207–208.
1969. *Uroleberis parnensis* (APOSTOLESCU) – SCHEREMETA, pp. 217–218, Pl. XXI, fig. 1–3.
1969. *Uroleberis parnensis* (APOSTOLESCU) – DUCASSE, p. 102, Pl. VII, fig. 146.
1971. *Uroleberis parnensis* (APOSTOLESCU, 1955) – BLONDEAU, p. 97, pl. X, fig. 15.

Description

1. In outer lateral view of the left valve the anterior outline is rounded with a small radius arc. The transition to the dorsal outline is concave at 0.2 length. The dorsal outline is rounded nearly symmetrically in a relatively small radius arc. The upper branch of the posterior outline is concave from 0.9 length, while the lower branch is almost straight. The posterior outline forms a protruding caudal process, having its axis somewhat below one-third height. The ventral outline is formed of the ventral bulge between 0.3 and 0.8 length; it is almost straight. Height lies at 0.5 length.

In outer lateral view of the right valve the dorsal outline forms a slight trapezoidal break; the caudal process is more tapering.

2. Valve surface is smooth with a strong ventral bulge between 0.2 and 0.8 length. The latter steeply terminates posteriorly, while anteriorly slowly rises from the lateral surface.

3. Dimensions.

Left valve L = 0.57 mm, H = 0,37 mm, L/H = 1.54. Right valve L = 0.53 mm, H = 0.31 mm, L/H = 1.73

4. The inner lamella is relatively narrow; there is a definite anterior vestibulum.

5. There are many short, simple, straight marginal pore canals anteriorly.

6. The strong adaptation furrow in the left valve and the elongated, crenulate anterior and posterior teeth in the right valve can be well studied.

7–8. The normal pores and the muscle scars cannot be well studied.

9. There is no eye-spot or eye-node; the characteristic ,,xestoleberis spot'' can be easily recognized.

Remarks

The Dudar form is very similar to the topotype material figured by TRIEBEL (1958).

Geographical and stratigraphical distribution: France: Middle to Upper Eocene; Soviet Union, southern parts: Middle to Upper Eocene.

Material

A: 6 isolated valves, 2 isolated embryonic valves, 2 fragments;
F: 1 isolated valve.

Family Bythocytheridae SARS, 1866
Genus *Monoceratina* ROTH, 1928

Monoceratina sp.

Remarks

Single, fragmented specimen of poor preservation.

Material

E: 1 isolated, fragmented valve.

Superfamily Cypridacea BAIRD, 1845
Family Candonidae KAUFMANN, 1900
Subfamily Paracypridinae SARS, 1923
Genus *Paracypris* SARS, 1866

Paracypris contracta (JONES, 1857)
Pl. 7, fig. 18–19.

1857. *Bairdia contracta* n. sp. – JONES, pp. 53–54, t. V, fig. 1a–c.
1985. *Paracypris contracta* (JONES, 1857) – MONOSTORI, pp. 127–130, Pl. XVI, fig. 8–15, Pl. XVII, fig. 1–6 (cum syn.).

Remarks

Strong individual variation of the outline described by MONOSTORI (1985) from the Dorog basin can be well observed on this material as well.

Dimensions

Adult left valve L = 0.85–0.94 mm
H = 0.38–0.42 mm L/H = 2.11–2.25
Adult right valve L = 0.83–0.94 mm
H = 0.33–0.41 mm L/H = 2.24–2.50

Material

A: 5 isolated valves;
D: 1 isolated valve;
F: 12 isolated valves.

Cypridacea Incertae Familiae
Genus *Novocypris* DUCASSE, 1967

Novocypris gantensis MONOSTORI. 1977
Pl. 7, fig. 16–17.

1977. *Novocypris? gantensis* n. sp. – MONOSTORI, pp. 80–81, t. I, fig. 5–9.
1985. *Novocypris? gantensis* MONOSTORI, 1977 – MONOSTORI, pp. 130–131, Pl. XVII, fig. 7–21.

Dimensions

Adult left valve L = 0.64–0.67 mm
H = 0.32–0.34 mm L/H = 1.97–2.04
Adult right valve L = 0.60–0.65 mm
H = 0.27–0.30 mm L/H = 2.20–2.26

Material

A: 6 isolated valves;
B: 20 isolated valves;
F: 2 isolated valves.

Palaeoecological interpretation

Fundamental principles of the palaeoecological interpretation of ostracod faunas are given by MONOSTORI (1985) on the example of the Eocene ostracods of the Dorog basin. Either the ostracod fauna or the other faunal elements clearly indicate a shallow sublittoral marine environment of deposition.

The following markers have been applied for qualifying the associations on Fig. 1.

I. Forms dominating in the deeper part of the shallow sublittoral region, connected to the open sea. Salinity: normal, Forms:
Krithe bartonensis – Schizocytherini div. sp.

II. Forms dominating in the normal saline shallower part of the shallow sublittoral region:
Quadracythere div. sp. – "*Hermanites*" – Grinioneis – *Phalcocythere horrescens* – *Leguminocythereis* div. sp. – *Bradleya? validornata hungarica*.

III. Forms dominating in the nearshore part of the shallow sublittoral region with slightly oscillating salinity:
"*Echinocythereis*" *dadayana* – *Monsmirabilia triebeli* – *Clithrocytheridea faboides gantensis* – *Pokornyella* div. sp.

IV. Forms dominating in the nearshore part of the shallow sublittoral region with strongly oscillating salinity:
Novocypris gantensis.

V. Forms dominating in different environments:

Cytherella gantensis – *Bairdia (Bairdoppilata) gliberti* – *Xestoleberis gantensis* – *Paracypris contracta*.

Fig. 1. indicates that most of the total fauna (T) is formed by the specimens of group I. This indicates that the formation was deposited in a shallow sublittoral open lagoon with oscillating salinity, at least during some periods of the year.

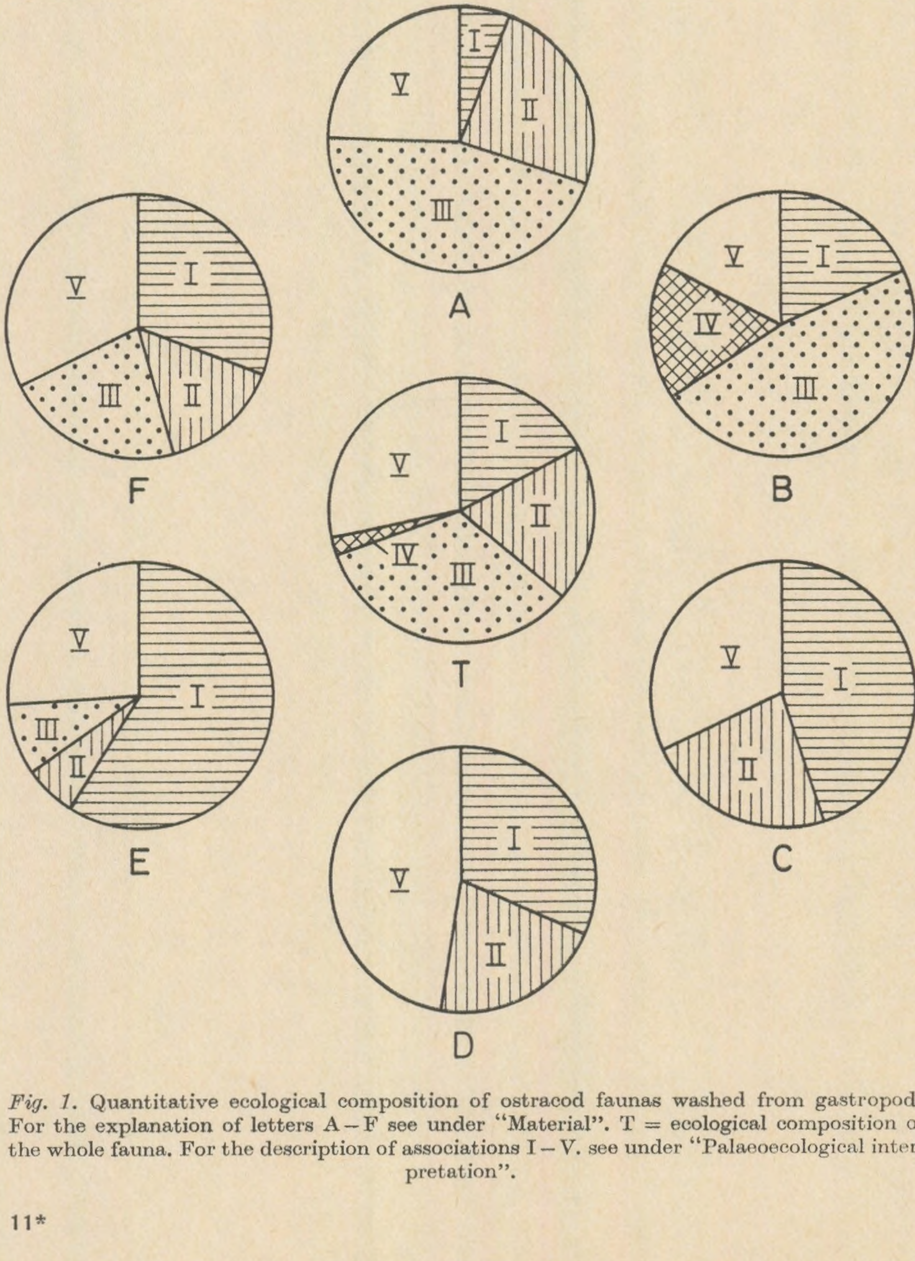

Fig. 1. Quantitative ecological composition of ostracod faunas washed from gastropods For the explanation of letters A – F see under "Material". T = ecological composition of the whole fauna. For the description of associations I – V. see under "Palaeoecological interpretation".

The subordinate significance of group IV. indicates that this effect was not too strong.

The 20% percentage of group I. definitely suggests direct connections with the open sea, at least during some periods of the year.

Washing residues yielded from different gastropod shells show the following differences:

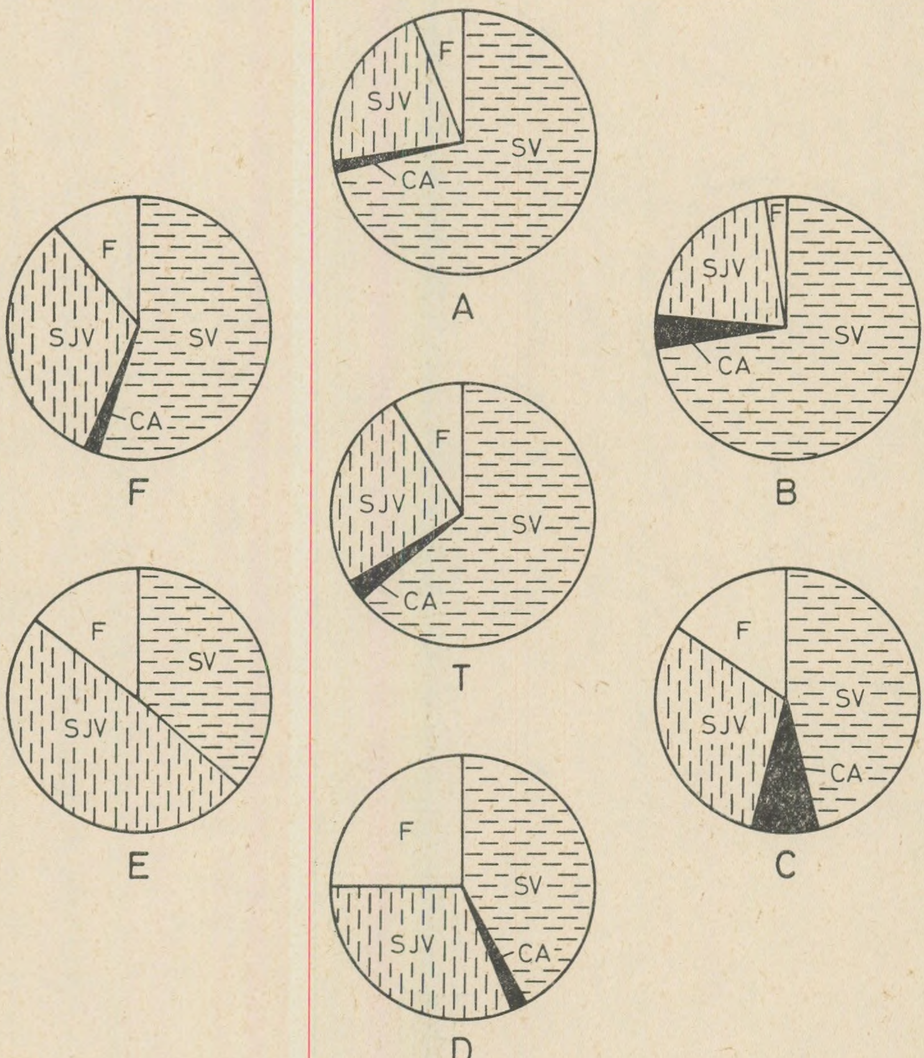

Fig. 2. Quantitative evaluation of preservation of ostracod faunas washed from different gastropods. SV = single valves, CA = carapaces, SJV = single juvenile valves, F = fragments.

A—B: The region characterized by *Cerithium subcorvinum* shows mostly oscillation of salinity: this might have been the innermost and hydrodynamically the most quiet part of the lagoon. Stronger oscillation of salinity (higher frequence of association IV) was characteristic for smaller parts only, and occured rarely.

C—D: The region characterized by *Velates schmidelianus* shows the highest influence of open marine seawater; the continental influence is subordinate. This might have been the outer part of the lagoon and had direct connections with the open sea, with strong hydrodynamic movements.

E: The Campaniles lived in the same region.

F: The coaly sand with Naticidae was deposited under the balanced influence of the lagoon and the open sea.

Fig. 2. presents the distribution of the preservation of fossils. Most of the forms are isolated valves, carapaces are subordinate; there are very many juvenile isolated valves; fragments are relatively rare.

High proportion of isolated valves is generally characteristic for sandy deposits sedimented in highly agitated water. The finer grained sediments are characterized by the dominance of carapaces, except those regions where the deposition was slow. These features provide ready explanation for the dominance of isolated valves in the Dudar fauna.

There are important differences in the percentage of adult and juvenile valves in the washing residues of the different gastropods. This is mostly due to sedimentological causes. For example, the largest proportion of juvenile valves was found in the Campaniles containing much more fine grained infills than other gastropods.

Frequency of embryonic valves is different species by species. The local changes in their abundance might be caused by sedimentological separation as well as different fossilisation potentials and ecological conditions (e.g. unfavorable conditions for certain adult forms).

The multiple causes make the evaluation of juvenile forms percentage difficult. Their frequency indicate good conditions for fossilisation.

Dominance of the species is shown on *Fig. 3.*

The inner part of the ancient lagoon was dominated by "*Echinocythereis*" *dadayana* and highest frequency was reached by *Phalcocythere horrescens*, "*Hermanites*" *acuticosta gantensis*, *Quadracythere vahrenkampi*, *Novocypris gantensis*. Dominance relationships indicate low oscillation of salinity compared to normal conditions; it was normal during most of the year.

The outer part of the lagoon, connected to the open sea was characterized by relatively higher percentage of *Cytherella gantensis*, *Bairdia gliberti*, *Schizocytherini* spp., *Grinioneis haidingeri paijenborchiana*, *Bradleya? validornata hungarica*, *Quadracythere* ex gr. *vermiculata*. The species composition clearly indicates shallow submarine environment.

The index of diversity (calculated by the method of *Williams*, 1964) is much smaller in the inner part with oscillating salinity, than in the outer part connected with the open sea *(Fig. 4.)*. The coaly sand with Naticidae

<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>T</th></tr>
<tr><td>Cytherella (Cytherelloidea) gantensis</td><td>|5</td><td></td><td>/10</td><td></td><td></td><td>3</td><td>4</td></tr>
<tr><td>Bairdia (Bairdoppilata) gliberti</td><td>4</td><td></td><td>|11|</td><td>[25]</td><td>|8</td><td></td><td>|5</td></tr>
<tr><td>Cnestocythere hungarica</td><td></td><td></td><td>|10</td><td>4</td><td>|18|</td><td>|8</td><td>3</td></tr>
<tr><td>Schizocythere hungarica</td><td>|5</td><td>|12|</td><td>|10</td><td>|6</td><td></td><td></td><td>|5</td></tr>
<tr><td>Schizocytherini juv.</td><td></td><td></td><td>|16|</td><td>|13|</td><td>[33]</td><td>|13|</td><td>6</td></tr>
<tr><td>Clithrocytheridea faboides gantensis</td><td></td><td></td><td></td><td></td><td></td><td>|7</td><td>–</td></tr>
<tr><td>Monsmirabilia triebeli</td><td></td><td>|6</td><td></td><td></td><td></td><td>|8</td><td>3</td></tr>
<tr><td>Krithe bartonensis</td><td></td><td>4</td><td></td><td>4</td><td></td><td>|6</td><td>3</td></tr>
<tr><td>Phalcocythere horrescens</td><td>3</td><td></td><td></td><td></td><td></td><td></td><td>–</td></tr>
<tr><td>Echinocythereis dadayana</td><td>[41]</td><td>[35]</td><td></td><td></td><td></td><td>|5</td><td>[27]</td></tr>
<tr><td>Leguminocythereis dudarensis</td><td></td><td></td><td></td><td></td><td></td><td>|8</td><td>–</td></tr>
<tr><td>Leguminocythereis sp.</td><td></td><td></td><td></td><td></td><td>|5</td><td></td><td>–</td></tr>
<tr><td>Pokornyella ex gr. limbata</td><td></td><td></td><td></td><td></td><td>|8</td><td></td><td>–</td></tr>
<tr><td>Hermanites haidingeri paijenborchiana</td><td></td><td></td><td>4</td><td>|7</td><td></td><td></td><td>–</td></tr>
<tr><td>Hermanites acuticosta gantensis</td><td>4</td><td></td><td></td><td></td><td></td><td></td><td>–</td></tr>
<tr><td>Bradeya? validornata hungarica</td><td></td><td></td><td></td><td>|6</td><td></td><td></td><td></td></tr>
<tr><td>Quadracythere vahrenkampi</td><td>|14|</td><td></td><td></td><td>|6</td><td></td><td>|5</td><td>|9</td></tr>
<tr><td>Quadracythere ex gr. vermiculata</td><td></td><td></td><td>|15|</td><td></td><td></td><td></td><td>–</td></tr>
<tr><td>Xestoleberis gantensis</td><td>|15|</td><td>|14|</td><td>|6</td><td>|17|</td><td>|15|</td><td>4</td><td>|15|</td></tr>
<tr><td>Xestoleberis sp.</td><td></td><td></td><td></td><td></td><td></td><td>|7</td><td>–</td></tr>
<tr><td>Paracypris contracta</td><td></td><td></td><td></td><td></td><td></td><td>|5</td><td>–</td></tr>
<tr><td>Novocypris gantensis</td><td></td><td>|14|</td><td></td><td></td><td></td><td></td><td>–</td></tr>
</table>

Symbols:

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5–10%:	|6
11–20%:	|14|
21–30%:	[26]
30<%:	[33]

Fig. 3. Dominance relationships of species in the washing residues from different gastropod species. The different framing of percentage values serves to accentuate certain percentage intervals.

occupied an intermediate position and had a diversity similar to the outer regions. The sample washed from the Campaniles from the outer region showed lesser diversity. It is due to the small amount of the investigated material and due to the fine grained infill of these gastropods compared to the matrix.

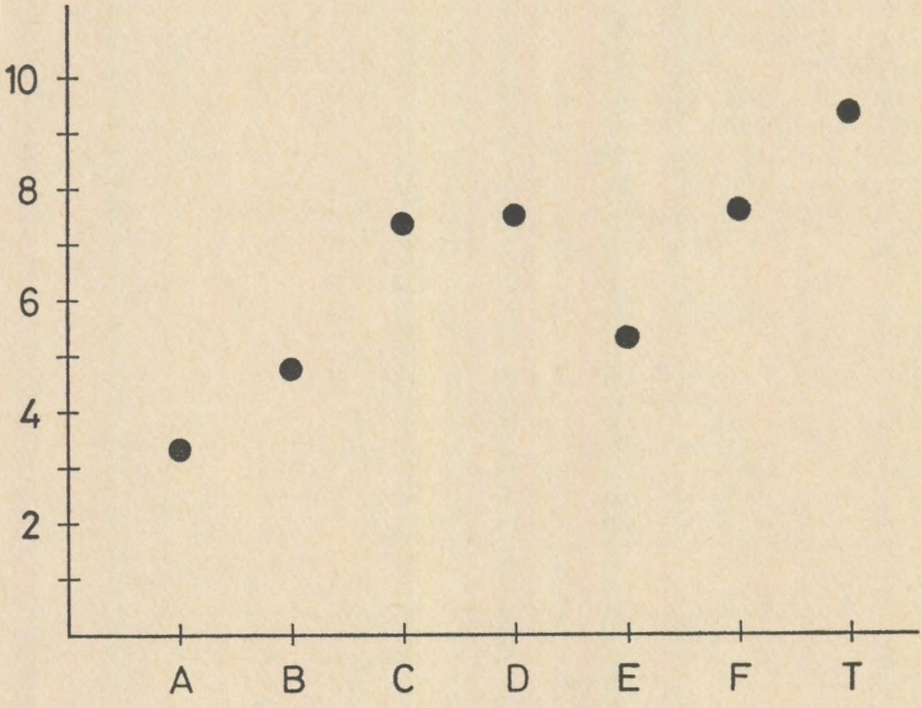

Fig. 4. Diversity indices (after Williams, 1964) of ostracod faunas washed from different gastropod species.

The diversity of the whole fauna is much higher than that any of the faunas washed from the gastropods: it indicates the diversity of the whole lagoon. The diversity of the faunas in the gastropods indicates that of the immediate environment. The diversity of the washing residue of the rock matrix itself might be neareer to the diversity of a larger environmental unit. Our material did not allow us to prove this, since we could not evaluate the ostracod fauna of the coarse-grained matrix.

Summary

The fauna from the washing residue, the rock matrix and the accompanying fauna indicate that the Dudar mollusc sand was deposited in a more or less restricted lagoon. Fossilisation probability was poor for the ostra-

cods living on sandy substratum, but those embedded within gastropods have been preserved in extremely good condition. (MONOSTORI, 1973). Examination of ostracod associations yielded from different gastropod species made possible the differentiation of the lagoon into regions connected to the open sea and into nearshore zones.

The associations clearly indicate that the mollusc sand was deposited in the shallow sublittoral zone, mostly in normal saline sea, where the salinity periodically (probably seasonally) oscillated. Similar conclusions have been drawn by STRAUSZ (1966) based on the examination of the gastropod fauna. The oscillation of the salinity decreased from the inner regions toward the open sea.

Comparing the Dudar locality with the Gánt region (MONOSTORI, 1977) the instability of the environmental conditions was much less; it is indicated by differences in the composition of the ostracod faunas, of the mollusc faunas and by the local massive occurrence of *Nummulites*.

REFERENCES

APOSTOLESCU, V. (1955): Description de quelques ostradoces du Lutetien du Bassin de Paris. Cahiers Géol., 28 – 29, pp. 241 – 279, Pls. 1.8.

BLONDEAU, J. G. (1971): Contribution à l'étude des ostracodes eocènes de Bassins de Campbon et de Saffre (Loire-Atlantique). These de l'Univ. Nantes, pp. 1 – 157, Pls. 1 – 17.

BOSQUET, J. (1852): Déscription des Entomostraces fossiles des terraines de la Francect de la Belgique. Mém. Sav. étrang., Acad. Roy. Sci. Belgique, 24, pp. 10 – 142, Pls. 1 – 6.

CARBONNEL, G. (1975): Les ostracodes de l'Ilerdien (Eocène inférieur) du bassin de Tremp (Espagne): stratotype et coupes avoisinantes. Rev. esp. micropaleontol., 7, 1, pp. 37 – 50, Pls. 1 – 3.

DELTEL, B. (1961): Les ostracodes fu Paléogène moyen et supérieur d'Aquitaine méridionale. Thèse Troisième Cycle, Univ. de Bordeaux, N° 95. pp. 1 – 125, Pls. 1 – 19.

DUCASSE, O. (1959): Les ostracodes de l'Eocène du soussol bordelais: répartition, intérèt stratigraphique et paléogeographique. These Troisième Cycle, Univ. de Bordeaux, No 40, pp. 1 – 132, Pls. 1 – 28.

DUCASSE, O. (1967): Nouxeaux ostracodes de l'Eocène Nord-Aquitaine. Proc. Verb. Soc. Sci. Phys. Nat. Bordeaux, pp. 1 – 89, Pls. 1 – 5.

DUCASSE, O. (1969): Étude micropaléontologique (Ostracodes) de l'Éocène Nord-Aquitain. Thèse Univ. Bordeaux, pp. 1 – 381, Pls. 1 – 20.

DUCASSE, O., GUERNET, Cl., TAMBAREAU, Y. (1985): Paléogène. Atlas des ostracodes de France. Mémoires Elf-Aquitaine, 9, pp. 257 – 311, Pls. 71 – 89.

EAGAR, S. H. (1965): Ostracoda of the London Clay (Ypresian) in the London basin: 1., Reading district. Rev. Micropaléontol., 8, 1, pp. 15 – 32, Pls. 1 – 2.

HASKINS, C. W. (1968): Tertiary Ostracoda from the Isle of Wight and Barton Hampshire, England. Part I – II. Rev. micropaléontol. 10,4, pp. 250 – 260, Pls, 1 – 2. 11., 1., pp 3 – 12, Pls. 1 – 2.

HINTE, J. E. (1962): Ostracoden aus dem Alttertiär des Sonnenberges, Kärnten, Österreichs. Proc. Kon Nederl. Akad. Wetensch., B, 65, pp. 166 – 188, Taf. 1 – 3.

JONES, T. R. (1857): A monograph of the Tertiary Entomostraca of England. Paleontogr. Soc. London, pp. 1 – 168, Pls. 1 – 5.

KEEN, M. C. (1972): Mid-Tertiary Cytherettinae of northwest Europe. Bull. British Mus. (Nat. Hist.), Geol., 21, 6, pp. 263 – 349, Pls. 1 – 23.

KEEN, M. C. (1978): The Tertiary-Palegene In "A Stratigraphical Index of British Ostracoda". Seel House Press, Liverpool, pp. 385 – 450, Pls. 1 – 12.

KEIJ, A. S. (1957): Eocene and Oligocene Ostracoda of Belgium. Inst. Roy. Sci. Nat. Belgique, Mém. 136, pp. 1 – 210, Pls. 1 – 26.

KHOSLA, S. C., HASKINS, C. W. (1980): Dentokrithe, a new genus of Ostracoda. Micropaleontology, 26, 2, pp. 211–215, Pl. 1.

KOLLMANN, K. (1962): Ostracoden aus dem mitteleozänen Flysch des Beckens von Pazin, Jugoslawien. Verh. geol. Bundesanst., pp. 187–227, Taf. 1–6.

LIENENKLAUS, E. (1894): Monographie der Ostracoden des nordwestdeutschen Tertiärs. Zeitschr. Deutsch. Geol. Ges. 46, pp. 158–268, Taf. 1–6.

MARLIÉRE, R. (1958): Ostracodes du Montien de Mons et résultats de leur étude. Mém. in 8° Soc. Belge Géol., Paléont., Hydrol., 5, pp. 1–53, Pls. 1–6.

MÉHES, GY. (1963): Die eozänen Ostracoden der Umgebung von Budapest. Geol. Hung., Ser. Pal., 12, pp. 1–57, Taf. 1–14, (In Hungarian with German abstract).

MÉHES, GY. (1941): Die Ostracoden des Oberoligozäns der Umgebung von Budapest. Geol. Hung., Ser. Pal., 16, pp. 1–96, Taf. 1–7.

MONOSTORI, M. (1972a): Faciological evaluation of Eocene ostracods from Dudar, Hungary. Ősl. Viták, 20, pp. 47–54, (In Hungarian, with English abstract).

MONOSTORI, M. (1972b): Ecological evaluation of Eocene ostracods from Gánt. Transdanubia, Hungary. Ősl. Viták, 20, pp. 55–61, (In Hungarian, with English Abstract).

MONOSTORI, M. (1973): Beitrag zur Methode des Aufsammlung von Mikrofossilien: Mikrofauna aus Gastropoden. Ann. Univ. Sci. Budapest, Sect. Geol., XVI. pp. 137–142.

MONOSTORI, M. (1977): Ostracode fauna from the Eocene of Gánt. Ann. Univ. Sci. Budapest, Sect. Geol. XIX., pp. 75–129, Pls. 1–3.

MONOSTORI, M. (1985): Eocene Ostracods from the Dorog Basin (Northern Transdanubia, Hungary). Akadémiai Kiadó, Budapest, pp. 1–214, Pls. I–XVII.

MOOS, B. (1965): Die Ostracoden-Fauna des Unteroligozäns von Bünde (Bl. Herford-West, 3817) und einige verwandte jüngere Arten (Ostr., Crustacea). I. Quadracythere (Hornibrookella) n. Sg., Pokornyella, Hemicythere, Hermanites. Geol. Jahrb., 87. pp. 1–40. Taf. 1–4.

MOUSSOU, A. (1966): Contribution à l'étude des Ostracodes de l'Oligocène girondin. Thèse Troisème Cycle, Univ. Bordeaux, 374, pp. 1–218, Pls. 1–33.

OLTEANU, R., POPESCU, B. (1973): Paleontological and sedimentological considerations concerning the ostracod evolution in the Eocene deposits west of Cluj. St. cerc. geol., geophys., geogr., Ser. Geol., 18, 1, pp. 245–260, Pl. 1–4.

PIETRZENIUK, E. (1969): Taxonomische und biostratigraphische Untersuchungen an Ostracoden des Eozän 5 im Norden der Deutschen Demokratischen Republik, Paläontol. Abh., Abt. A, IV. 1. pp. 1–162, Taf. 1–28.

ROEMER, F. A. (1838): Die Cytherinen des Molasse-Gebirges. N. Jb. Min. Geogn. Geol. Petref. –Kunde, pp. 514–519. Taf. 6.

SCHEREMETA, V. G. (1969): The Paleogene Ostracods of the Ukraine. Lvov, pp. 1–273, Pls. 1–21, (In Russian with English abstract).

SIDDIQUI, G. A. (1971): Early Tertiary Ostracoda of the family Trachyleberididae from West Pakistan. Bull. British Mus. (Nat. Hist.), Geol., Suppl. 9., pp. 1–182, Pls. 1–42.

SÖNMEZ-GÖKCEN, N. (1973): Étude paléontologique (Ostracodes) et stratigraphique de niveaux du Paléogène du Sud-Est de la Thrace. Publ. Unst. et Rech. Mind. Turquie (MTA), 147, pp. 1–118, Pl. 1–12.

STRAUSZ, L. (1966): Die Eozängastropoden von Dudar in Ungarn. Geol. Hung., Ser. Pal, 33. pp. 1–200, Taf. I–XXIV.

SZCZECHURA, J. (1977): Ostracods from the Upper Eocene of East Poland. Acta Pal. Pol., 22,1, pp. 55–92, Pls. 15–32.

TRIEBEL, E. (1958): Zwei neue Ostracoden-Gattungen aus dem Lutet des Pariser Beckens. Senckenbergiana Lethaea, 39, 1–2, pp. 105–117, Taf. 1–3.

WILLIAMS, C. B. (1964): Patterns in the Balance of Nature. Academic Press, London, pp. 1–324.

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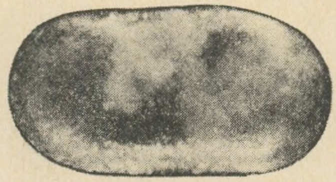

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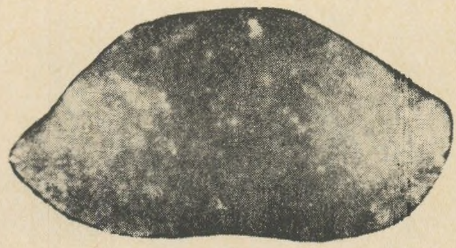

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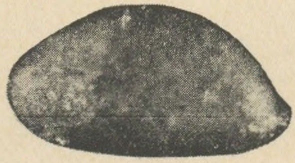

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PLATE 1.

Figs. 1 – 3. *Cytherella (Cytherelloidea) gantensis* MONOSTORI, 1977. Outer view of left valves
Fig. 4. *Platella gyrosa* (ROEMER, 1983), Outer view of a damaged left valve.
Fig. 5 – 7. *Bairdia (Bairdoppilata) gliberti* KEIJ, 1957. Figs. 5, 7: outer view of left valves; fig. 6: outer view of right valve.
Figs. 8 – 9. *Bairdia* sp. 1. Fig. 8: outer view of left valve; Fig. 9.: outer view of right valve.

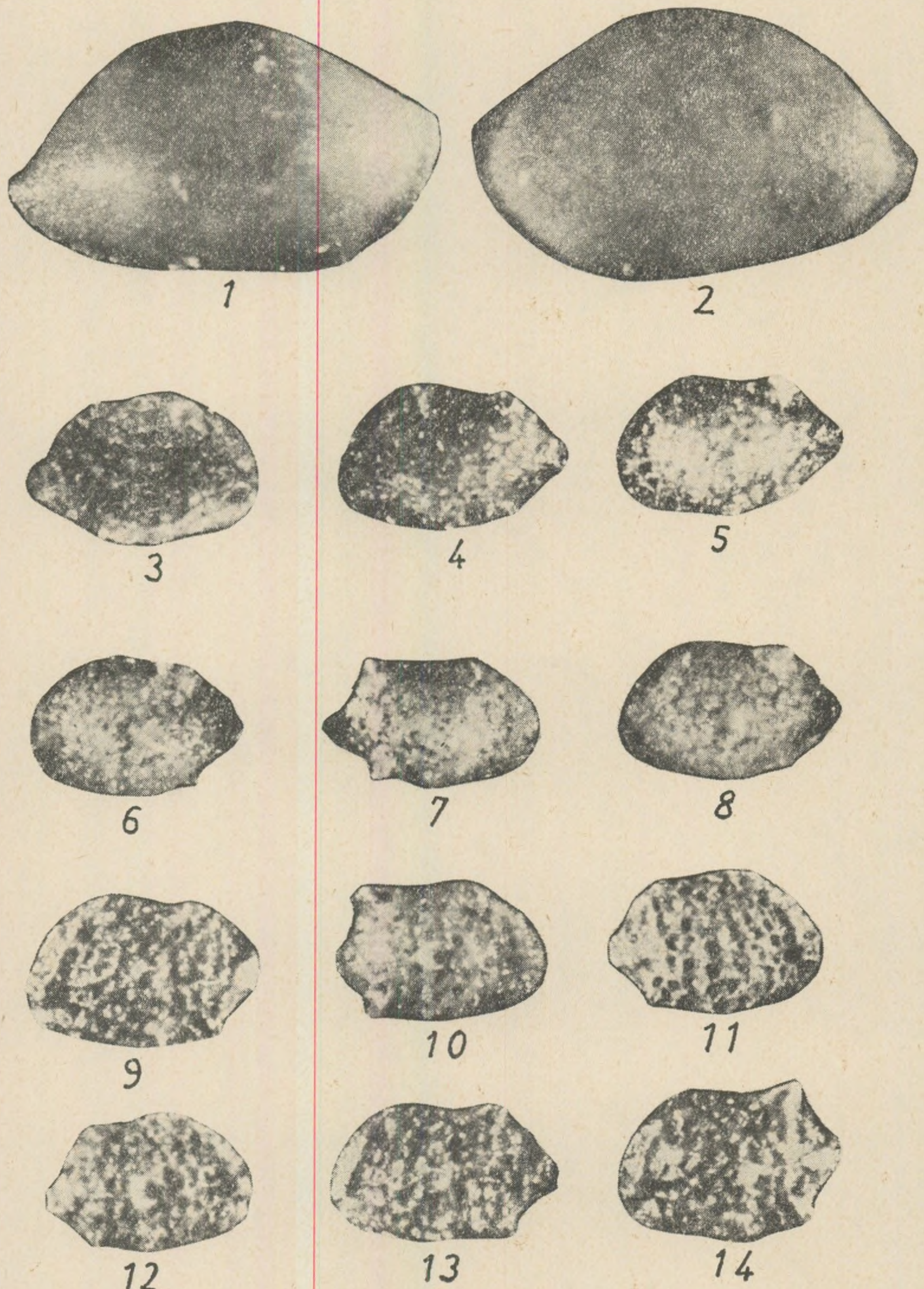
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PLATE 2.

Figs. 1 – 2. Bairdia (Bairdoppilata) aff. *gliberti* KEIJ, 1957. Fig. 1: outer view of right valve; fig. 2: outer view of left valve.

Figs. 3 – 8. Cnestocythere hungarica MONOSTORI, 1985. Figs. 3, 7: Outer view of left valves; figs. 4 – 6, 8: outer view of left valves.

Figs. 9 – 14. Schizocythere hungarica n. sp. Figs. 9, 13 – 14: outer view of left valves; figs 10 – 12: outer view of left valves.

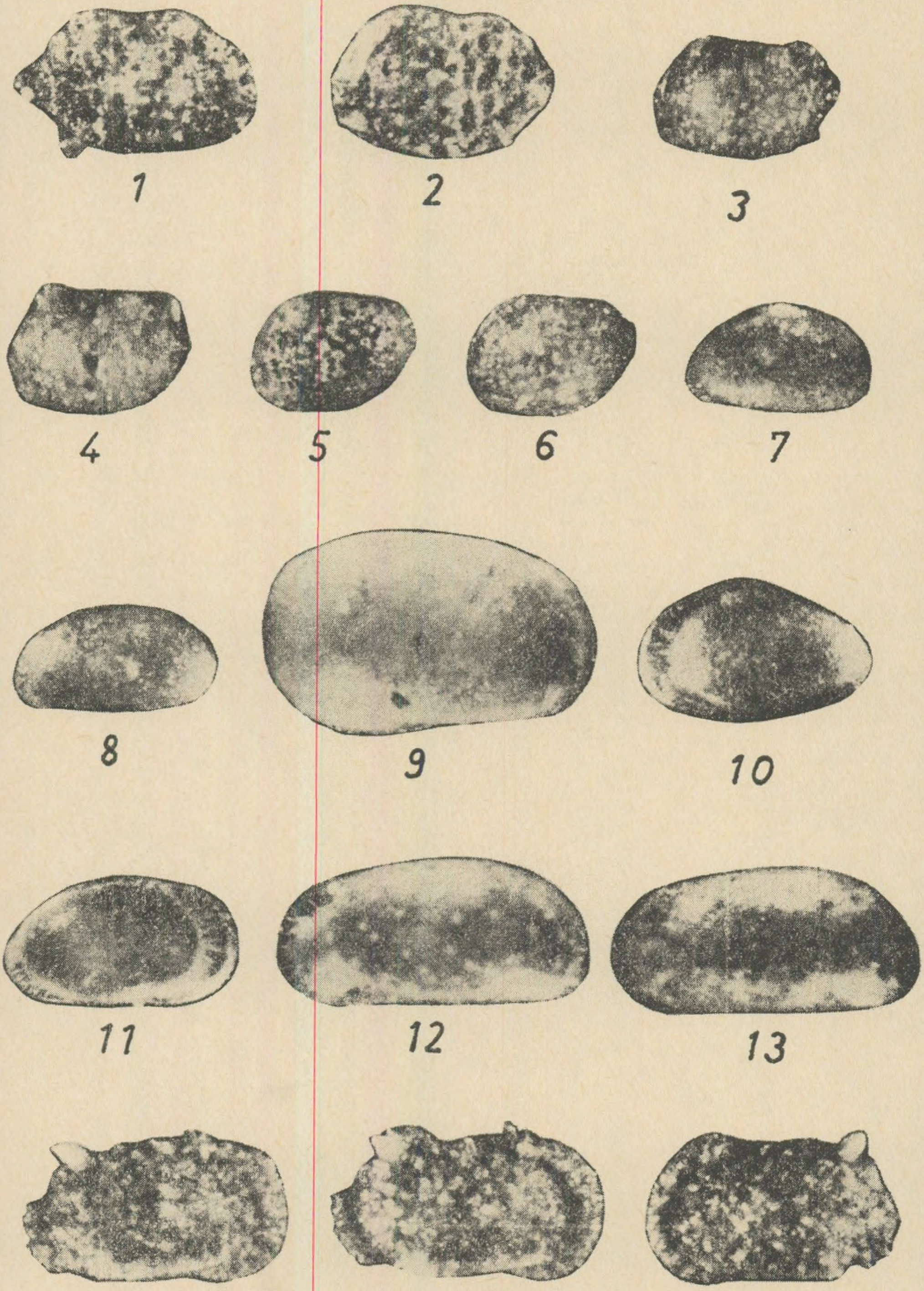
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PLATE 3.

Figs. 1 – 2. Schizocythere hungarica n. sp. Fig. 1: outer view of right valve; fig. 2: outer view of left valve.

Figs. 3 – 4. Schizocythere depressa (MÉHES, 1936). Outer view of left valves.

Figs. 5 – 6. Schizocythere ex gr. *tessellata* (BOSQUET, 1852). Outer view of left valves.

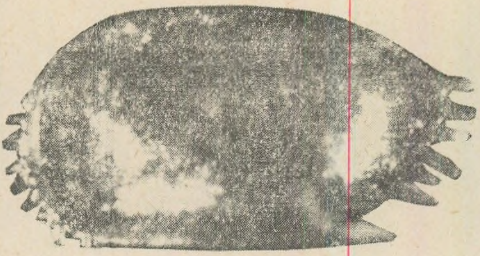
Figs. 7 – 8. Clithrocytheridea faboides gantensis MONOSTORI, 1977. Outer view of left valves.

Fig. 9. Neocyprideis williamsonisna (BOSQUET, 1852). Outer view of right valve.

Figs. 10 – 11. Monsmirabilia triebeli KEIJ, 1957. Fig. 10: outer view of left valve; fig. 11: outer view of right valve.

Figs. 12 – 13. Krithe bartonensis (JONES, 1857). Outer view of left valves.

Figs. 14 – 16. Phalcocythere horrescens (BOSQUET, 1852). Figs. 14 – 15: outer view of right valves; fig. 16: outer view of left valves.



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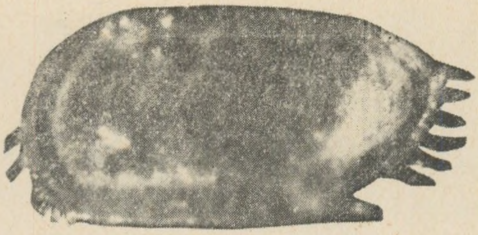

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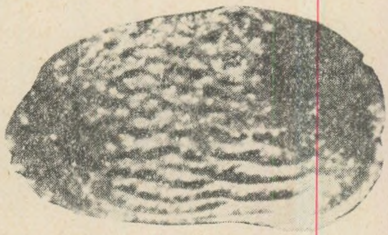

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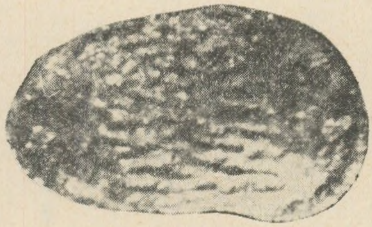

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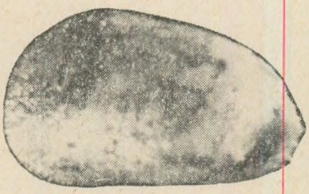

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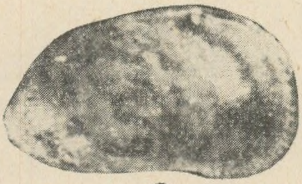

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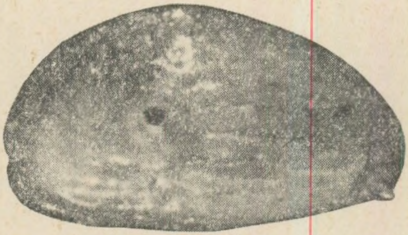

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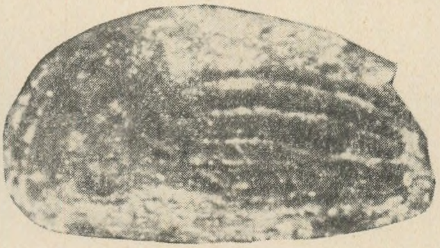

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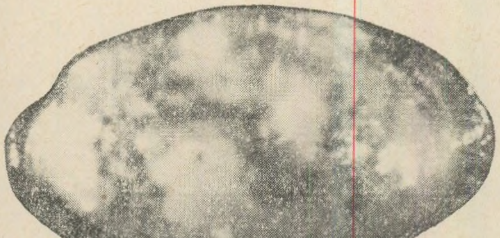

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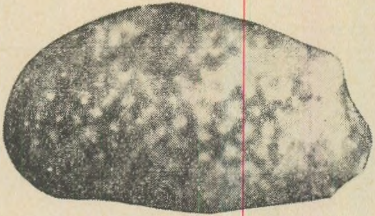
PLATE 4.

Figs. 1 – 2. *Pterygocythere jonesi* (MÉHES, 1936). Outer view of left valves.
Figs. 3 – 6. *Echinocythereis dadayana* (MÉHES, 1941). Figs. 3 – 4: outer view of right valves; fig. 5: outer view of juvenile left valve; fig. 6: outer view of juvenile right valve.
Figs. 7 – 8. *Leguminocythereis dudarensis* n. sp. Outer view of left valves.
Fig. 9. *Leguminocythrereis* aff. *erasa* DUCASSE, 1967. Outer view of right valve.



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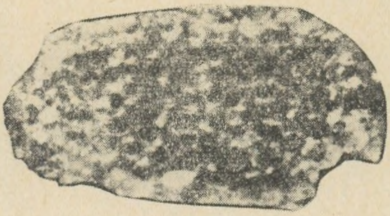

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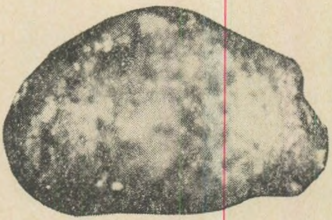

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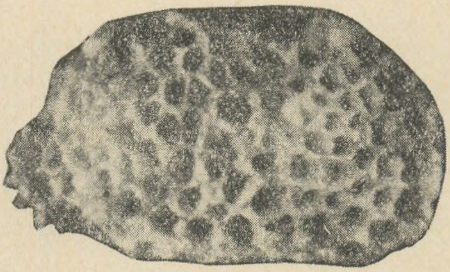

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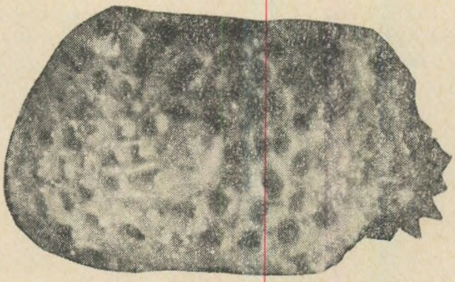

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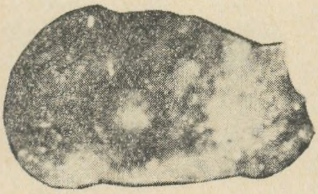

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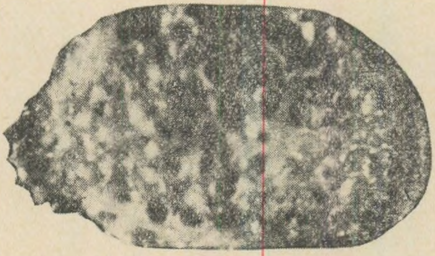

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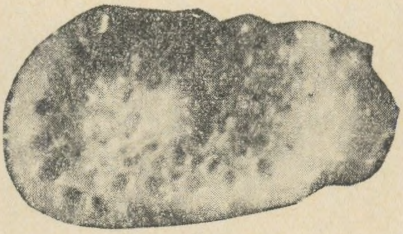

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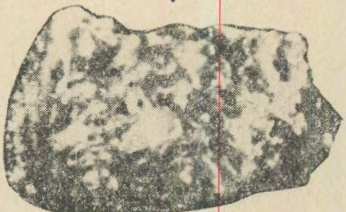

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PLATE 5.

Figs. 1, 3. *Pokornyella* ex gr. *limbata* (BOSQUET, 1852). Outer view of left valves.
Fig. 2. *Grinioneis haidingeri paijenborchiana* KEIJ, 1957. Outer view of right valve.
Figs. 4–5, 7. *Bradleya? validornata hungarica* MONOSTORI, 1977. Figs. 4. 7: outer view of right valves; fig. 5: outer view of left valve.
Fig. 6. „*Hermanites*" *acuticosta gantensis* MONOSTORI, 1977. Outer view of left valve.
Fig. 8. *Quadracythere angusticostata* (BOSQUET, 1852). Outer view of left valve.
Figs. 9–10. *Quadracythere* ex gr. *vermiculata* (BOSQUET, 1852). Outer view of left valve.

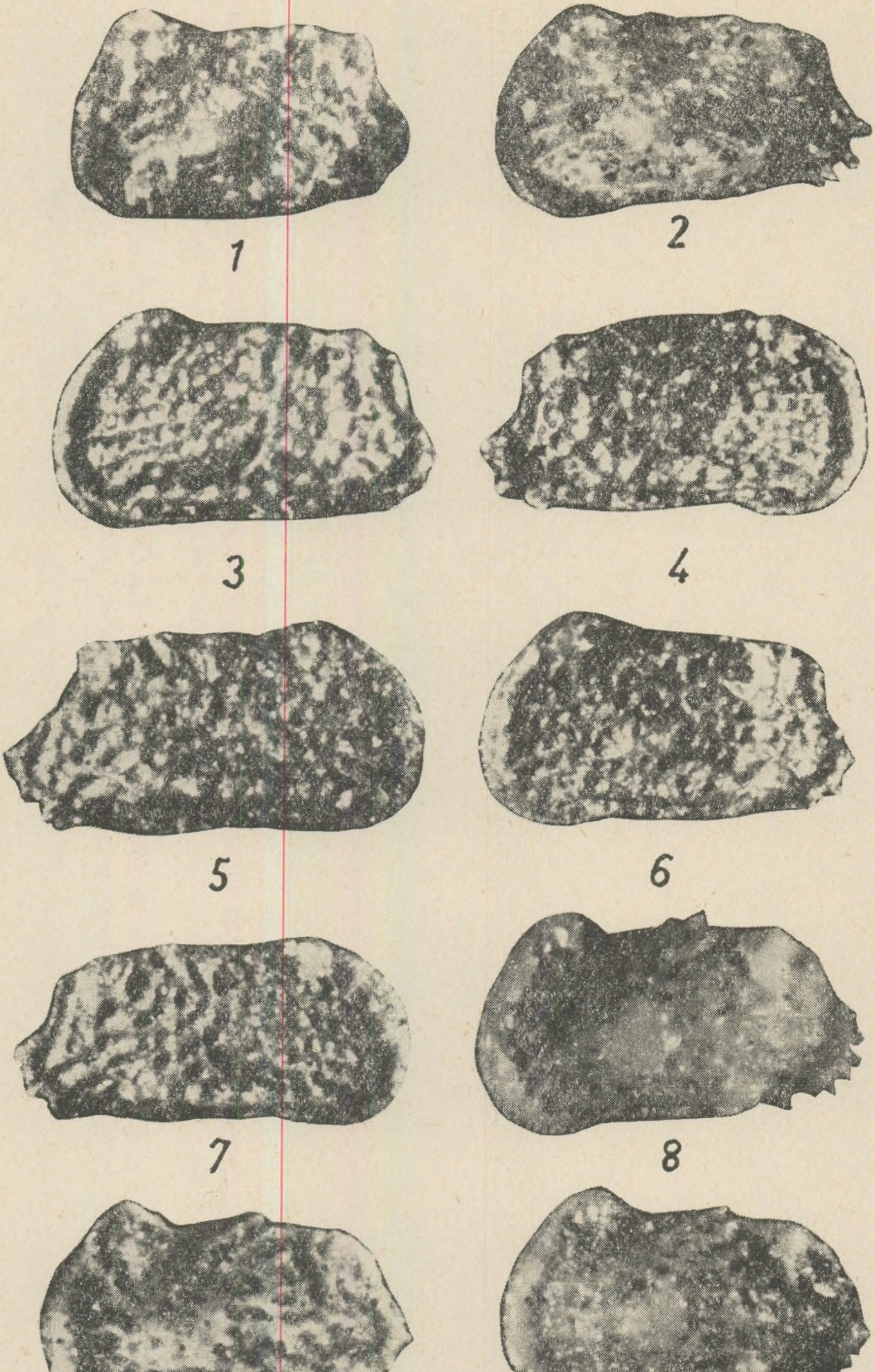
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PLATE 6.

Fig. 1. Quadracythere ex gr. *vermiculata* (BOSQUET, 1852). Outer view of left valve.
Figs. 2 – 10. Quadracythere vahrenkampi MOOS, 1965. Figs. 2 – 3, 6, 8 – 10: outer view of left valves; figs. 4 – 5, 7: outer view of right valves.

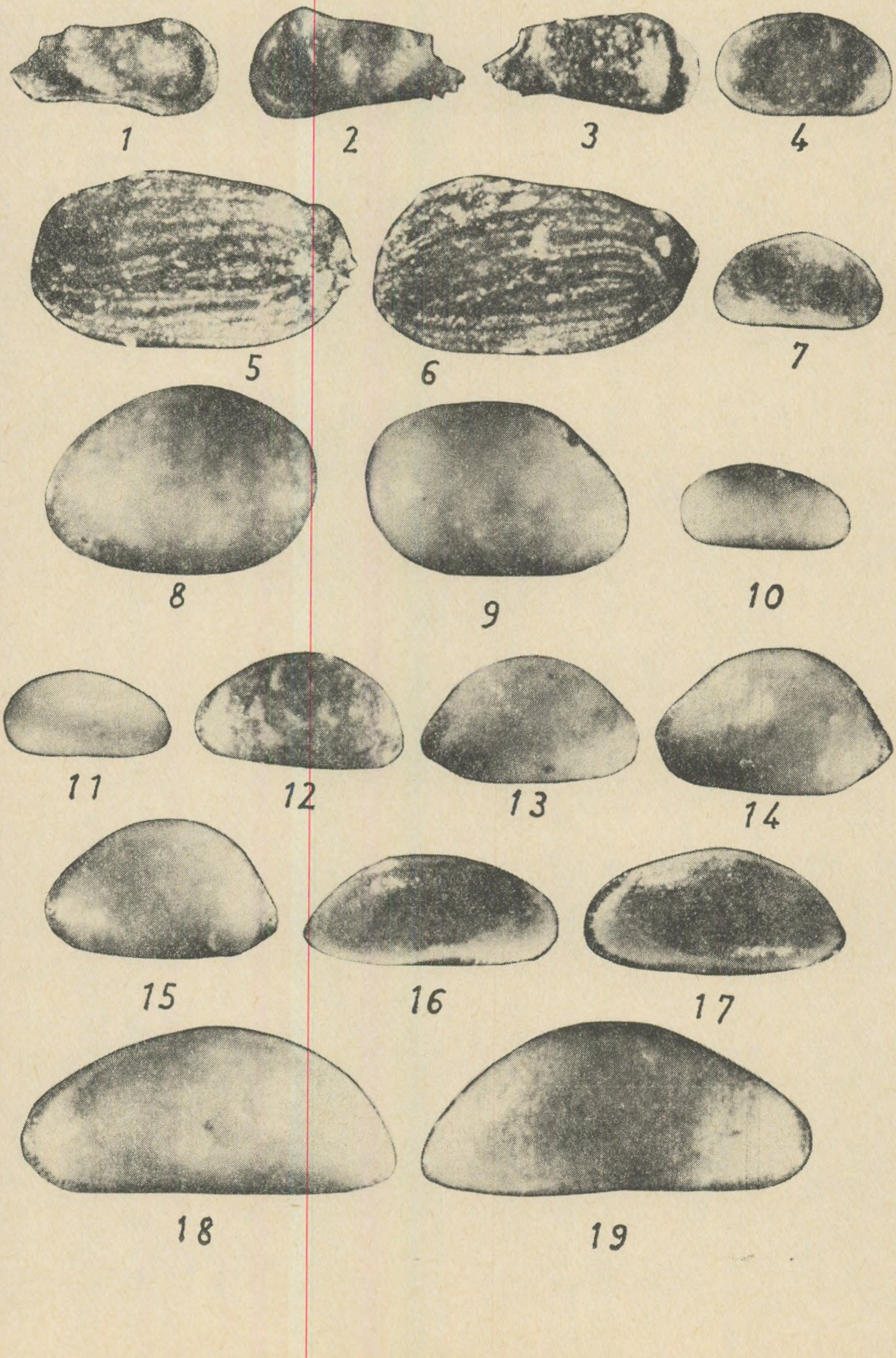
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PLATE 7.

Figs. 1 – 3. Caudites monsmirabiliensis APOSTOLESCU, 1955. Figs. 1, 3: outer view of right valve; fig. 2: outer view of left valve.

Figs. 4, 8 – 11. Xestoleberis gantensis MONOSTORI, 1977. Fig. 4: outer view of juvenile right valve; fig. 8: outer view of left valve; fig. 9: outer view of right valve; figs. 10 – 11: outer view of juvenile right valve (questionably belongs to this species).

Figs. 5 – 6. Cytheretta cf. *bambruggensis* KEIJ, 1957. Outer view of left valves.

Figs. 7, 12. Xestoleberis sp. 1. Fig. 7: outer view of right valve; fig. 12: outer view of left valve.

Figs. 13 – 15. Uroleberis parnensis (APOSTOLESCU, 1955). Fig. 13: outer view of right valve; figs. 14 – 15: outer view of left valves.

Figs. 16 – 17. Novocypris gantensis MONOSTORI, 1977. Fig. 17: outer view of right valve; fig. 17: outer view of left valve.

Figs. 18 – 19. Paracypris contracta (JONES, 1857). Fig. 18: outer view of left valve; fig. 19: outer view of right valve.

STRATIGRAPHY OF A MIDDLE JURASSIC – LOWER CRETACEOUS SEQUENCE N OF ZOBÁKPUSZTA, MECSEK MTS., HUNGARY

by

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Abstract

Results of the mapping in a scale of 1:10 000 of an area lying 4 km east to Komló, in Mecsek Mts., Southern Hungary are presented. The following formations are described: Aalenian-Bajocian grey mottled marl (Fleckenmergel), Bathonian red, nodular calcareous marl, Callovian greenish-grey cherty limestone, Oxfordian light grey cherty limestone, Kimmeridgian red, nodular, cherty limestone, Tithonian white, cherty limestone with intraclasts, Lower Cretaceous alkaline basalt and Recent calcareous tufa. Palaeontological, petrographical, microfacies, sedimentological, heavy mineral, X-ray and DTA investigations indicate open marine sedimentation during Middle and Late Jurassic. The sea deepended from the Aalenian-Bajocian onwards, reaching its maximum depth during Callovian-Oxfordian time. Decrease of depth followed later.

A Lower-Middle Bathonian profile with an abundant ammonite fauna is described for the first time, The substages could be recognized by the presence of *Morphoceras*, *Parkinsonia* and *Bullatimorphites*. *Cererithyris* sp. aff. *intermedia*, a brachiopod previously known to occur from Late Bathonian onwards, is described from Hungary for the first time.

Introduction

We have mapped the area between Hidasi and Takanyó valleys, N of Zobákpuszta, in the Eastern Mecsek Mts. in the scale of 1:10 000 *(Fig. 1)*. This area is very near to the classical Jurassic localities of Síngödör and Márévár valleys, the latter also exposing Lower Cretaceous volcanic rocks. Short notices concerning the mapped area were published by BÖCKH (1880 – 81), listing the fauna collected by HOFMANN in Hidasi valley, and about fifty years later VADÁSZ (1935) mentioned the Hidasi valley and its tributaries as good exposures of the Bathonian stage. KOVÁCS (1953) published a list of fossils collected from the Bathonian rocks near the "Csurgó" calcareous tufa locality. Unfortunately, all of these authors published a mixed list of fossils, indicating that collections were made indifferently from the different beds.

Recent works of BILIK (1966), SIDÓ (1966), NAGY I. (1966, 1967), HETÉNYI (1969), PATAKY et al. (1982) and FŐZY et al. (1985) published data on the lithostratigraphical subdivision, microfacies and foraminifer investigations and on the relationships between sedimentary and volcanic rocks.

The area is characterized by a ca. 20° N or NE dip of strata.

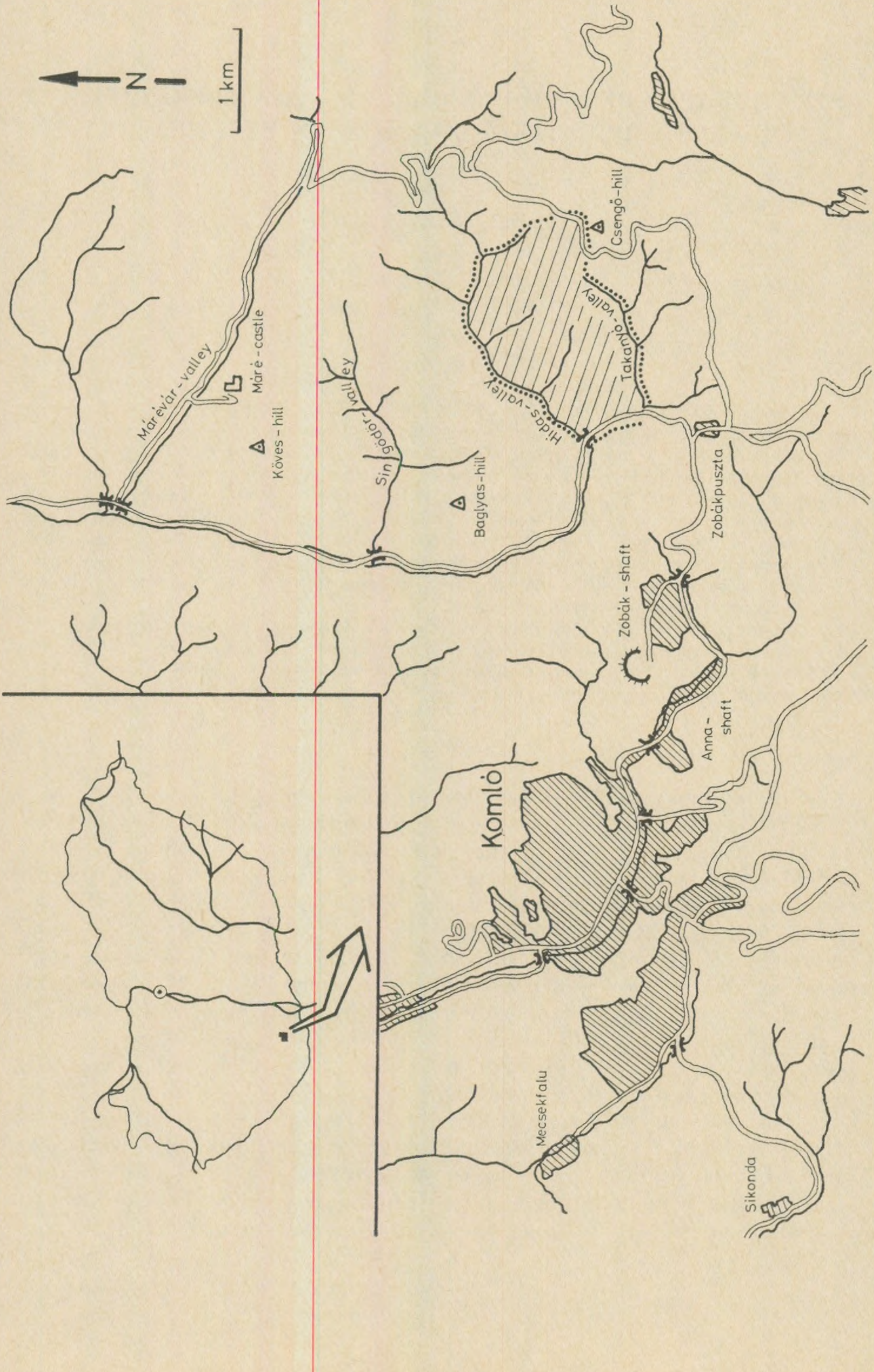


Fig. 1. Location of the investigated area in the eastern Mecsek Mts.

Description of the rocks

The geological map is shown on *Fig. 2*, completed by a stratigraphical column on *Fig. 3*.

Grey mottled marl (Fleckenmergel)

Dark grey rock with light grey spots, rarely with yellow ones. Bituminous. Lower part is silty clayey marl forming 1 – 1.5 cm thick laminae, separated by a slightly undulating clay film. Thin, 15 – 20 cm thick calcareous marl beds are intercalated in the lower part, thickening upwards to 0.5 – 1 m. Their number decreases upwards. The colour is lighter in the upper part and rare chert nodules appear at the top. The fossils are yellowish brown with a limonitic coating. Ammonites, *Bositra*, Belemnites rostra and plant fragments were found.

Thin section features: strongly clayey mudstone-wackestone with radiolarians, *Bositra* and other mollusc fragments and sponge spicules. Rare darker bands are interpreted as traces of bioturbation.

The heavy minerals are much limonite, less garnet, muscovite, pyrite, magnetite and pyroxene. After acid etching some radiolarians were found.

Neither mega-, nor microfossils were suitable for precise age determination. Lithological comparisons indicate Aalenian-Bajocian stages, but its Upper Toarcian age is possible at the SW part of the area (VADÁSZ, 1935; FŐZY et al., 1985).

The rock is part of the Komló Calcareous Marl Formation; its thickness exceeds 200 m.

Red nodular calcareous marl

Red calcareous marl, light yellow green, where weathered; alternating clayey and calcareous strata. The latter contain limestone nodules, 1 to 10 cm in diameter. The nodules are mostly oval; rarely these are ammonites. This marl shows a continuous transition downwards to the clayey gray Fleckenmergel. The red marl has been chosen as a guide bed for the mapping, due to its apparent colour, which made recognition easy.

The rich fossil fauna contains ammonites, Bositra, brachiopods, belemnites and echinozoans. Thin sections revealed a *Bositra*-wackestone microfacies, with plenty of mollusc fragments and some traces of bioturbation.

The 0.1 – 0.2 mm grain size fraction contains heavy minerals: abundant muscovite, limonite, magnetite and pyrite.

This formation belongs to the Bathonian stage, indicated by the ammonites Morphoceras and Bullatimorphites (*Plates* I and II). Its name is Óbánya Limestone Formation. This formation can be observed in a 13 m thick sequence, unique in the Mecsek Mts., which is described at the end of this paper.

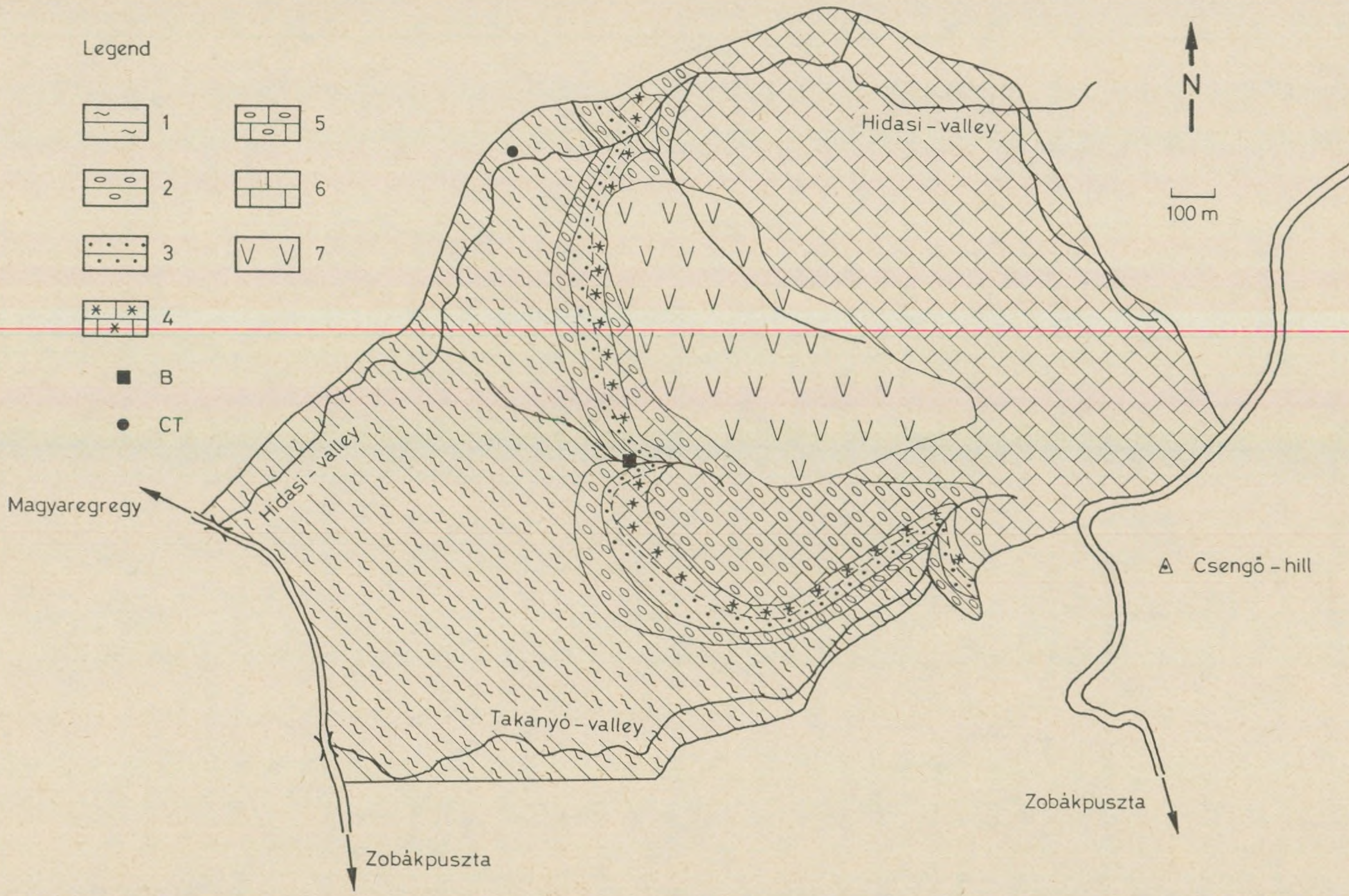


Fig. 2. Geological map. 1: Aalenian-Bajocian grey Fleckenmergel (Komló Calcareous Marl Formation). 2: Bathonian rend, nodular, calcareous marl (Óbánya Limestone Formation. 3: Callovian greenish grey cherty limestone (Dorogó Calcareous Marl Formation). 4: Oxfordian light grey cherty, Mn-dendritic limestone (Fonyászó Limestone Formation). 5: Kimmeridgian red, nodular, cherty limestone (Kisújbánya Limestone Formation). 6: Tithonian white, cherty, intraclastic limestone (Márévár Limestone Formation). 7: Lowe Cretaceous alkaline basalt Mecsekjános (Basalt Formation). B: locality of the Bathonian exposure. CT: locality of the calcareoustufa (Csurgó).

Greenish-grey cherty limestone – light grey cherty limestone with Mn-dendrites

This greenish grey, coarse-grained limestone is characteristically banded at the upper part of the sequence. The bands are red and yellow, with rare ochre intercalations. It is well-bedded, with wavy bedding surfaces. Thicker (50 – 60 cm) and thinner (20 – 30 cm) beds alternate. Thin, cm-sized clay intercalations occur in its lower part, disappearing upwards. The chert forms lenses or bands, displaying mostly brownish grey, rarely yellow and grey colour. There seems to be no continuous transition between the red nodular limestone and the greensih grey, cherty limestone.

The rock contains rare megafossils: a few aptychi have been found.

Thin section investigations revealed the rock to be wackestone-packstone, with abundant radiolarians; besides mollusc fragments and rare echinoderm fragments occur. The banding is visible in thin sections, too. The

thick-ness (m)		Lithology	Lithostratigraphy	Chronostratigraphy
		calcareous basalt		Recent
?		alcalic basalt	Mecsekjános Basalt F.	Lower Cretaceous
80		white, cherty, intraclastic limestone	Márévár Limestone F.	Tithonian
~20		red, nodular cherty limestone	Kisújbánya Limestone F.	Kimmeridgian
~20		light grey, cherty Mn-dendritic limestone	Fonyászó Limestone F.	Oxfordian
~20		greenish - grey cherty limestone	Dorogó Calcareous marl F	Callovian
13		red, nodular calcareous marl	Óbánya Limestone F.	Bathonian
200		grey, spotted marl	Komló Calcareous marl F.	Bajocian Aalenian

Fig. 3. Stratigraphical column. Legend: see at the map, Fig. 2.
(Corr.: calcareous basalt read calcareous tufa)

radiolarians are ordered along limonitic bands. Rare intraclasts occur in the rock.

Heavy mineral examinations revealed some pyrite, limonitized ore minerals and amphiboles.

Neither mega-, nor microfossils allowed precise age determination and biostratigraphical separation of the subsequent cherty limestone with Mn-dendrites.

The former rock gradually changes into light grey, cherty, frequently Mn-dentritic limestone, bearing a greyish weathered surface. This is a finely grained limestone; its bedding surfaces are not nodular. It contains aptychi only.

A considerable enrichment of heavy minerals was shown in this rock: limonite, hematite, apatite, magnetite, tourmaline, muscovite, pyroxene, ilmenite, pyrite, garnet, staurolite and amphibole occur.

The microfacies is wackestone with frequent radiolarians and rare aptychi.

Its separation from the former formation is problematic; the two form the Callovian-Oxfordian stage together. These belong to the Dorogó Calcareous Marl and/or to the Fonyászó Limestone formation. Thickness is 20 – 20 m.

Red nodular cherty limestone

It shows a gradual transition to the underlying light grey, Mn-dendritic, cherty limestone. Texture is compact. In the lower part the red color dominates, turning into mottled upwards, being red, beige and green. Clay content also grows upwards. Megafossils are a few poorly preserved ammonites in the red part and aptychi in the upper part.

Thin section examination reveals a packstone-wackestone texture. The components are mostly echinoderm fragments with syntaxially overgrown calcite. A similar observation has been described by NAGY (1966). Upwards the fossil content changes into radiolarian- and sponge-rich wackestone.

Heavy mineral content mostly resembles to that of the Tithonian limestones: magnetite, limonite, tourmaline, muscovite, apatite and haematite.

The etched samples yielded a large quantity of sponge spicules, displaying tetraxon and Y-forms. Some linear forms also occur, with limonite coating. The amount of radiolarians is insignificant compared to the sponge spicules.

The transition to the overlying white, cherty, intraclastic limestone is not exposed in the mapped area. The age is Kimmeridgian, concluding its stratigraphic position below the Tithonian limestone. Its name is Kisújbánya Limestone Formation. Thickness: 20 m.

White, cherty, intraclastic limestone

White, micritic limestone of conchoidal fracture; it is rarely cherty. Its weathered surface is of yellowish tint, fresh fracture shows beige colour.

Frequently intraclasts occur. Their size ranges from a few millimetres to a few centimetres. The clasts are angular, with sharp edges. Chert occurs in thin, a few mm thick bands or lenses. The light red lower part of the formation, mentioned by VADÁSZ (1935) has not been found; probably the transition section is not exposed. Many small aptychi have been found.

Microfacies examinations: thin sections provided accurate data for the age determination. The rock is a Tithonian mudstone with calpionellids and radiolarians; the latter are nassellarians and spumellarians with easily observable pores. Calcisphaeres also occur, besides mollusc fragments. Narrow calcite veins transect the rock.

Heavy mineral content is relatively high, but similar to that of the underlying formation: limonite, magnetite, hematite, tournaline, muscovite and apatite.

Its name is Márévár Limestone Formation. Its thickness exceeds 80 m.

Alkaline basalt

The second side valley of Hidasi valley to the southeast exposes this formation *(Figs. 1, 2)*. It overlies the underlying formation without any observable contact phenomena. Its weathered surface is greenish brown. The fragmented surface is dark grey, locally black. No minerals could be identified by the naked eye. Rarely the rock shows columnar jointing and a very fresh surface.

Thin section texture is porphyric microholocrystalline. Mineral component are plagioclase, augite, magnetite and other opaque minerals. A conspicuous, red vein was found visible by the naked eye, but which could not be traced in the field. Its thin section characters are markedly different from those of the country rock. It shows equigranular texture with rare crystallites. Mineral components are plagioclase, augite, opaque minerals (more than in the country rock) and chlorite. Grain size is also larger than in the country rock.

Its age is Lower Cretaceous. Concerning its name and age we refer to the papers of BÖCKH (1876), VADÁSZ (1935), BILIK (1966) and NAGY I: (1967). It belongs to the Mecsekjánosi Basalt Formation. Thickness is unknown. Its relationships to other formations are not clear.

Calcareous tufa

Even VADÁSZ (1935) mentioned the "Csurgó" cliff made of calcareous tufa *(Fig. 2.)*. The cliff is about 5 m high and 5 m wide. The rock can be crushed by the fingers. It is travertino of yellowish colour. The process of the encrusting of plants by carbonates can be well observed here. The thin moss sheet growing on the rock surface is covered by a thin calcareous coating. Other calcarous tufa occurrences are in the Takanyó and Hidasi-valleys. These can be recognized easily by the occurrence of flat, slightly emerging terraces.

Lithology and microfacies of the most fossil-rich exposure of the Bathonian red nodular calcareous marl

The location of the exposure is marked by a black square on *Fig. 2.*, *Fig. 4* displays the profile idicating the ammonite and brachiopod content of the strata.

The profile exposes the Bathonian red, nodular, calcareous marl in 13 m thickness. We have made a bed-by-bed collecting. A clayey and the calcareous bed above it have got one number; altogether 55 units have been sampled.

Lithology. the lower 3 metres are characterized by alternating thin (5 cm) calcareous and somewhat thicker (6 – 7 cm) beds. In the following 3 metres the thickness of the calcareous beds attain 8 – 10 cm. In the upper part of the sequence both type of beds strongly thin, while total bed thickness shows considerable variation. In this thinly bedded section the group of beds were distinguished by the occurrence of thicker (8 – 10 cm) calcareous beds *(Fig. 4).*

Microfacies: the whole profile is uniform *Bositra*-wackestone. In the lower part there are some echinoderm fragments together with a few foraminifers. The *Bositra* fragments are smaller that at the top of the profile. The beds are bioturbated; some burrowing traces are concentrically surrounded by *Bositra* shells. The amount of *Bositra* shells grows upwards, while the ratio of other bioclasts decreases. At the upper part of the exposure, where the red nodular calcareous marl turns into greenish grey compact limestone the microfacies characters also change. Plenty of intraclasts contain tiny ammonite shells, radiolarians and mollusc shell fragments. The coarse-grained matrix contains echinoderm fragments and *Bositra* shells.

Fauna and biostratigraphy of the Bathonian red nodular calcareous marl

Faunistic description of the exposure: The study of the collected material made possible to recognize substages in the sequence. Further collections from a larger surface are needed for the recognition of ammonite zones and subzones. The Phylloceratina are dominant element in the fauna (70,62%), while there are relatively few Lytoceratina (13,56%) and Ammonitina (15,82%). The Phylloceratina are represented by the following genera: *Phylloceras*, *Calliphylloceras*, *Holcophylloceras* and *Ptychophylloceras*. The Lytoceratina are represented by *Lytoceras* and *Nannolytoceras*. These genera and *Bositra*, Bivalvia, Spongia and Echinozoa are not figured on *Fig. 4.* A few ammonitines are figured on Pl. II – III.

The lower part of the profile (until bed 111) yielded a large amount of *Nannolytoceras* (partly *N. tripartitum*), which is frequent in the Lower Bathonian. This substage is also characterized by *Morphoceras* (bed 74; Pl. I, Fig. 5.) and *Parkinsonia* (bed 103). The appearance of *Bullatimorphites* in bed 118 indicates a stratigraphic level close to the base of the Middle Bathonian (Pl. II, fig. 1). The boundary of the Lower and Middle Bathonian substages possibly is at beds 119 120. Bed 122 yielded a *Cererithyris* sp.

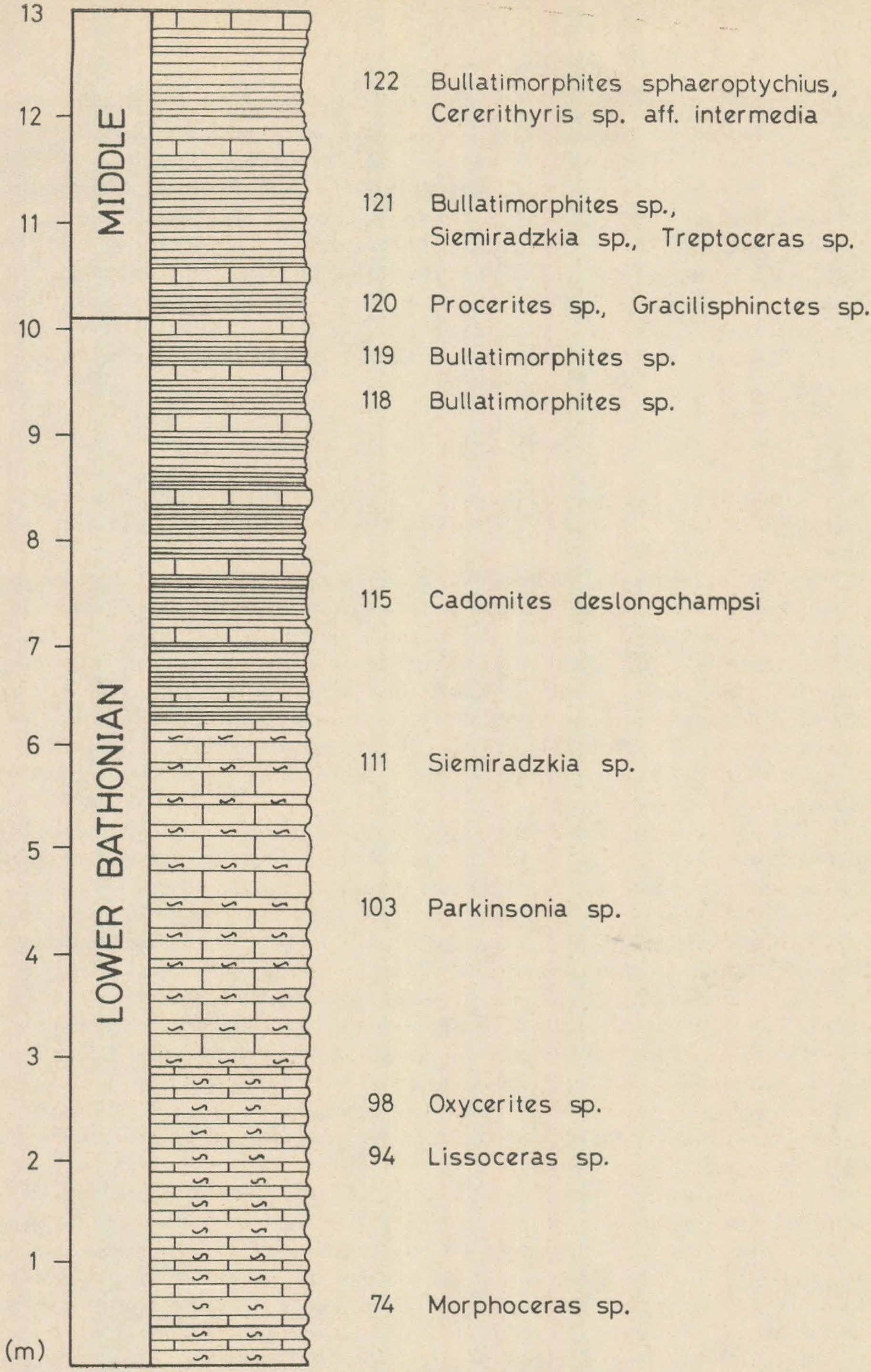


Fig. 4. Measured profile of the Bathonian section. Ammonitina genera and the occurrence of *Cererithyris* sp. aff. intermedia are indicated.

aff. *intermedia* (SOWERBY, 1812), (Pl. II, fig. 2, 3, 4) specimen; further three fragments were collected from the scree. This is the first occurrence of this genus in Hungary. It is characteristic for the NW-European ammonite province and is frequent in the Upper Bathonian substage. This genus appears earlier in the Mecsek Mts. of Submediterranean character, in the Middle Bathonian. The scree yielded also a brachiopod: *Caucasella* ? and the bivalve *Anisocardia* cf. *tenera* (SOWERBY, 1821), Belemnites rostra, echinozoans and most ammonite genera occurring in the profile. We have found plenty of ammonite specimens bearing the traces of worms in the siphonal canal.

Sedimentation environment

X-ray, DTA examinations and sedimentological and palaeontological observations were applied for the reconstruction of the Jurassic sedimentation environments.

The mottled marl (Fleckenmergel) contains relatively high percentage of silica and clay minerals: mostly montmorillonite illite. The red nodular calcareous marl beds contain the highest percentage of clay minerals. Above these beds the illite is dominant with a little associated montmorillonite. The ratio of silica decreases also. In the following greenish grey cherty limestone and light grey cherty limestone the amount of silica reaches its maximum, while the decrease of clay content begins. Its minimum is reached in the Tithonian strata. Towards the Tithonian the amount of silica strongly decreases *(Fig. 5)*.

The appearance of illite instead of montmorillonite indicates a deepening of the sea, supported by the increase of silica content. Palaeontological and sedimentological observations also support this statement.

Either benthonic or planktonic forms occur in the grey Fleckenmergel beds. Bioturbation was not intensive enough to totally mix the sediment. The high amount of terrigenous material indicates a nearshore, but not shallow marine environment. The grey colour indicates a reductive environment. The mottled appearance of the rock may be due to bioturbation.

The Bathonian red nodular calcareous marl is dominated by pelagic fauna: ammonites, *Bositra*, Belemnites and by a few inbenthonic and epibenthonic forms: Echinozoa, Crinoidea, Brachiopoda. Its red colour indicates deposition in an oxydative environment. It is also characterized by a high clay content.

The greenish grey, cherty limestone and the light grey, cherty, Mn-dendritic limestone is dominated by radiolarians, which, however, appear in older rocks also. The lack of ammonites may be due to their easily soluble aragonitic shell. This absence and the increasing percentage of cherts indicates deposition in a growing depth. Percentage of terrigenous material also decreases. Probably this was the maximum depth of the sea.

The red nodular chertly limestone also indicates deep sea, but the appearence of poorly preserved ammonites indicates a slight decrease of water depth. The most frequent fossils of these beds are aptychi.

High carbonate content and terrigenous material percentage of the white cherty intraclastic limestone also indicated deposition in an open marine environment. This is proven by calpionellids, calcisphaeres, radiolarians and aptychi.

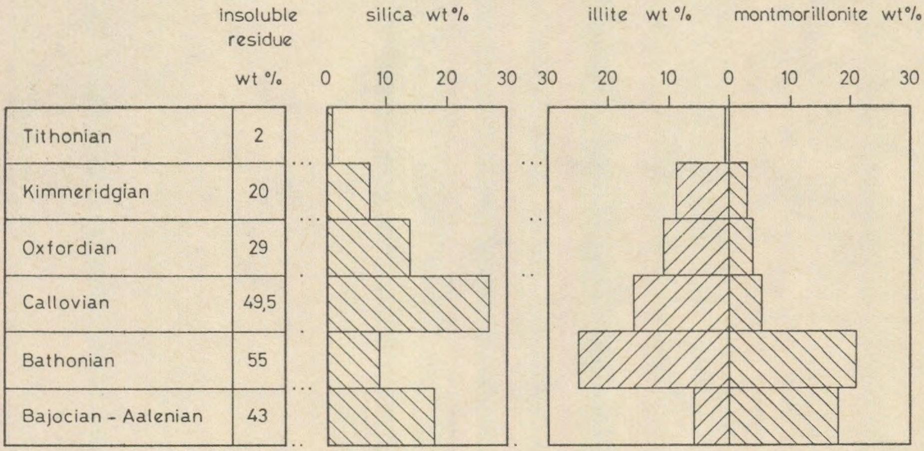


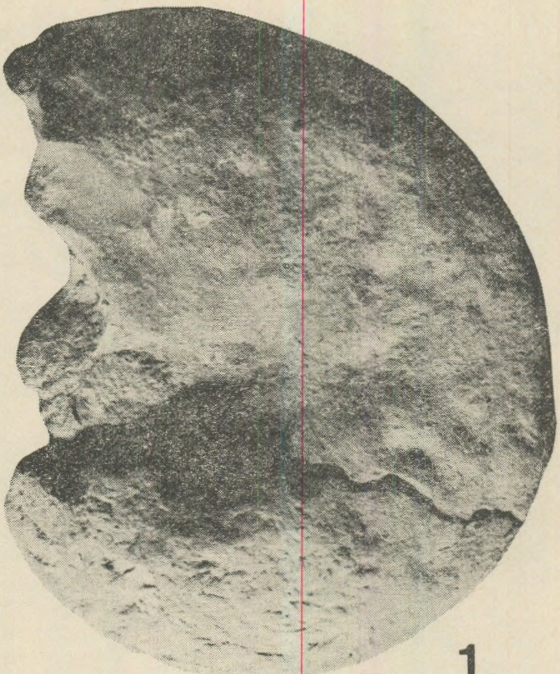
Fig. 5. Insoluble residue, silica and clay mineral (illite, montmorillonite) content in wt%.

Conclusions

A 1:10 000 geological map was made on the investigated area, joining the map of FŐZY et al. (1985). Differentiation of the rocks can be made mostly on lithological grounds. Microfacies studies indicate the Tithonian age of the white intraclastic cherty limestone. Ammonite studies indicate the age of the Bathonian red nodular calcareous marl only.

The investigated profile exposes the thickest Bathonian sequence in the eastern Mecsek Mts. The ammonite fauna (*Morphoceras*, *Bullatimorphites*) indicates the presence of most of the Lower Bathonian and the lower part of the Middle Bathonian. Probably the upper parts of the Bathonian are missing due to subsolution or non-deposition.

Its fauna is dominated by Phylloceratina and Lytoceratina. The relatively high amount of the Ammonitina indicate a transition between the Mediterranean and the NW European ammonite provinces (GÉCZY, 1973, 1984). The brachiopod *Cererithyris* sp. aff. *intermedia* indicates the same position, since this species occurs later, in Late Bathonian time in the NW European province. Further collections may provide more evidences on the Submediterranean character on the Mecsek Jurassic.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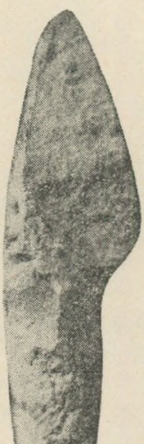
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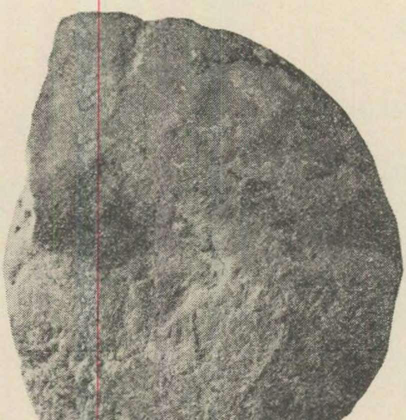
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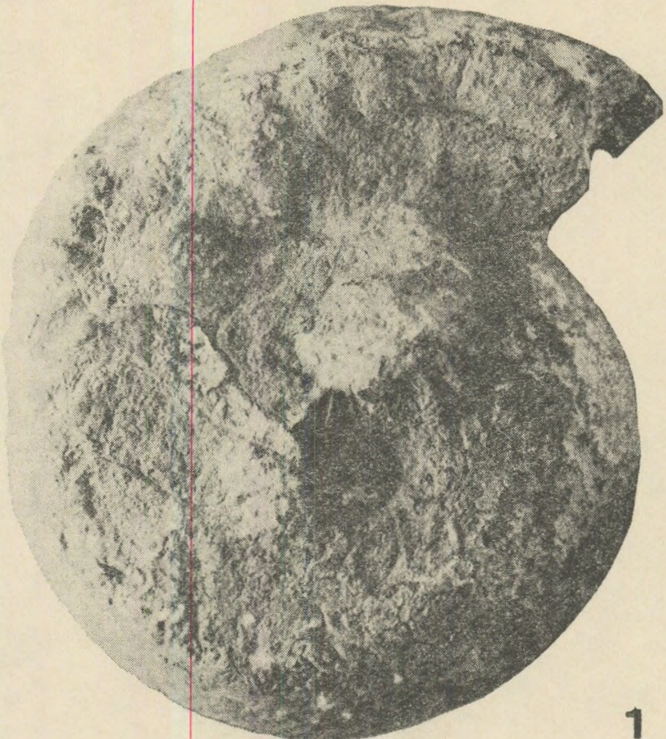
PLATE I.

Fig. 1. Lissoceras sp. (natural size)
Fig. 2. Procerites sp. (natural size)
Fig. 3. Oxycerites sp. (natural size)
Fig. 4. Oxycerites sp. Lateral view of the specimen of Fig. 3.
Fig. 5. Morphoceras sp. (natural size)



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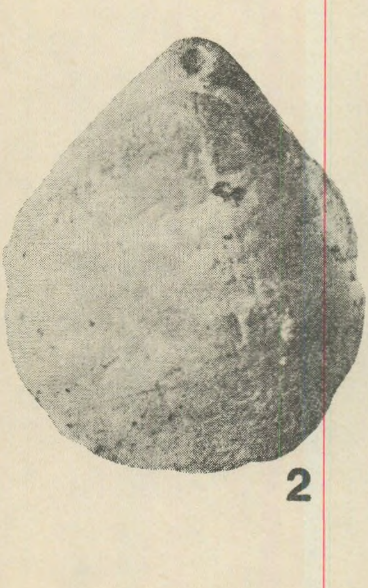

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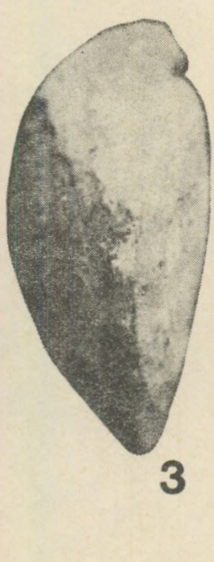

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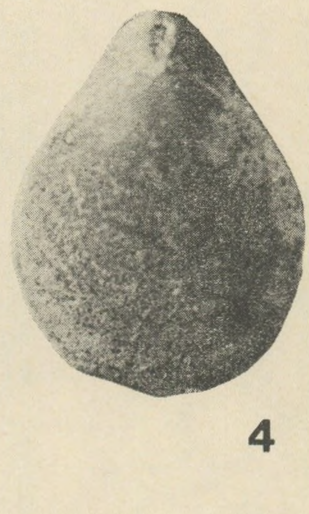

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PLATE II.

Fig. 1. Bullatimorphites sp. (natural size)
Fig. 2. Cererithyris sp. aff. *intermedia* (SOWERBY, 1812) (2x)
Fig. 3. Lateral view of Fig. 2.
Fig. 4. Cererithyris sp. aff. *intermedia* (SOWERBY, 1812) (2x)

Acknowledgements

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REFERENCES

BILIK, I. (1966): Problems of nomenclature of Lower Cretaceous volcanites in the Mecsek Mts. – Annual Report Hung. Geol. Inst. for 1964, 59 – 75, Budapest (Hungarian with English abstract)

BÖCKH, J. (1881): Geologische und Wasser-Verhältnisse der Umgebung der Stadt Fünfkirchen. – Mitteilungen der Kön. Ung. Geol. Anstalt, Bd. IV, 151 – 328, Budapest

BÖCKH, J. (1880 – 81): Contributions to the knowledge of Jurassic deposits of the Mecsek Mts. I – II. – Értekezések a Természettudományok köréből, X – XI, Budapest (in Hungarian)

FŐZY, I., LANTAI, CS., SCHLEMMER, K. (1985): A Pliensbachian – Lower Cretaceous profile at Zobákpuszta, Mecsek Mts., Hungary. – Annales Univ. Sci Budapest, Sect. Geol. 25, 97 – 115, Budapest

GÉCZY, B. (1973): The origin of Jurassic faunal provinces and the Mediterranean plate tectonics. – Annales Univ. Sci. Budapest., Sect. Geol. 16, 99 – 114, Budapest

GÉCZY, B. (1984): Jurassic ammonite provinces of Europe. – Földtani Közlöny 114/3, 257 – 262, Budapest (Hungarian with English abstract)

HETÉNYI, R. (1969): Étude géologique de la Montagne Mecsek en 1967. – Annual Report Hung. Geol. Inst. for 1967, 189 – 204, Budapest

KOVÁCS, L. (1953): Les couches du Dogger supérieur de la Montagne Mecsek. – Annual Report Hung. Geol. Inst. for 1950, 89 – 94, Budapest (Hungarian with French abstract)

NAGY, I. (1966): Les rásultats d'études de microfacies en vue d'une subdivision du Jurassique supérieur des Montagnes Mecsek. – Annual Report Hung. Geol. Inst. for 1964, 53 – 59, Budapest (Hungarian with French abstract)

NAGY, I. (1967): Sur le rapport entre le Jurassique supérieur et des roches volcaniques crétacées dans la Montagne Mecsek. – Annual Report Hung. Geol. Inst. for 1965, 149 – 168, Budapest (Hungarian with French abstract)

PATAKY, N., JÓZSA, S., DUNKL, I. (1982): The Jurassic sequence of Coal Valley (Kohl-Thal) at Ófalu. – Földtani Közlöny 112/4, 383 – 394, Budapest (Hungarian with English. abstract)

SIDÓ, M. (1966): Mikropaläontologische Untersuchungen am Lias-Dogger-Profil von Zengővárkony. – Annual Report Hung. Geol. Inst. for 1964, 31 – 51, Budapest (Hungarian with German abstract)

VADÁSZ, E. (1935): Das Mecsek-Gebirge. – Magyar Tájak Földtani Leírása I, Budapest (Hungarian and German)

THE CHARACTERISTICS OF BANK-FILTRATION AQUIFERS

by

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Abstract

Nowadays special rock sampling enables us to take comparatively full samples from riverbank-filtration aquifers. These samples will contain the silt fraction of gravelly sand, which is most influencing on the chemical character of the ground-water concerned. Analytical data bearing on the chemical, mineralogical and mechanical features of the silt fraction show the distribution in space of the hydrochemical characteristics. This could not be attained to when dealing only with the gravel and sand components of the aquiferous rock.

Examining and comparing the quality and quantity of the silt fraction with the favourable and unfavourable chemical properties of water stored in two bank-filtration aquifers along the river Danube, a definite relation could be found between them, by means of which the water quality can be predicted for a long time.

Introduction

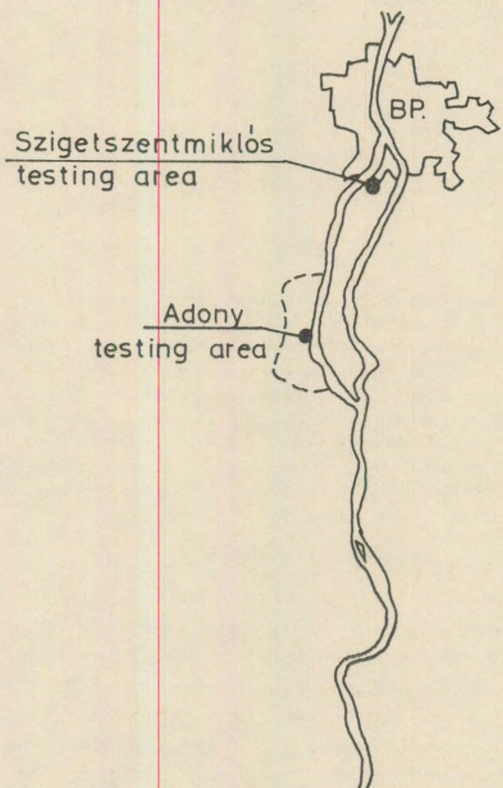
When drilling producing or observation wells with the usual method, the silt fraction, that is most likely to determine the chemical properties of water, leak away while taking out samples. Thus we will get only the gravel and sand fraction. That is why there is no correlation between the spatial differences of water-chemical properties and the chemical and mineralogical-lithological properties of the gravel-sand samples in bank-filtration aquifers.

Since there are also other factors controlling the chemical properties of water (e. g. operational conditions by production or pumping tests, the morphology of the underlying impervious rock surface, the thickness of the water-bearing bed, different kinds of impact from the ground surface etc.), all effects not related to rock quality have been put in correction.

We examined two sites along the Danube; the first one is between km marks 1593 and 1612 on the right side, while the second is between km marks 1632 and 1633 on the left side *(Fig. 1.)*. We can find areas with and without water production on either site.

Localization of investigated territories

Fig. 1.



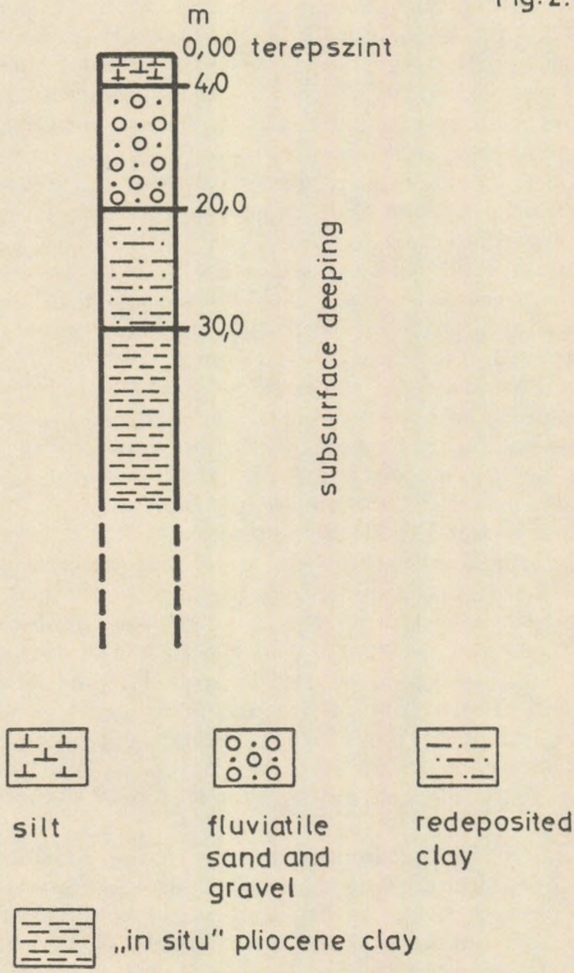
The geological – hydrogeological description of the test sites

The oldest formation we examined was a clay deposited within hyposaline environment and assigned to the Middle Pannonian Stage (*Congeria ungula caprae* biozone). However, this clay of brackish-water deposition can only be found as autochtonous in the deeper horizons. We could observe in the test sites that due to soaking the upper part of the clay have become loose and turned out to be redeposited by river erosion *(Fig. 2.)*. That resedimentation is verifiable upon the following considerations:

a) The bedding is different from that of the Pannonian deposits. In the vicinity of the Pannonian inland water basin the rhythmicity of stratifi-

Characteristic sequence of investigated territory

Fig. 2.



cation falls between 10^{-1} and 10^{0} m, while in the resedimented sequence it varies between 10^{-3} and 10^{-2} m. Anyway, there are also signs of crossbedding on core samples.

b) Characteristically coarse-grained accessory materials are present in sand and gravel lenses of lamellar bedding.

Since the material is the same as that of the Pannonian clay (apart from the accessory sand and gravel parts), it also contains the same minerals and chemical components. Iron-sulphide is the most important of them. It appears as pyrite or marcasite in a crystallized form (FeS_2) and as colloidal melnikovite or hydrotroilite ($FeS_{1-2} \cdot nH_2O$) in its less crystallized form. None of these are stable under oxidizing conditions. Being oxidized they turn to be ferrioxihydroxide and sulphuric acid. This sulphuric acid reacts with the $Ca-Mg$ carbonates "in statu nascendi", thus forming poorly watersoluble $CaSO_4 \cdot nH_2O$ (gypsum) and well soluble $MgSO_4 \cdot nH_2O$ I washed out and centrifuged the microscopic and submicroscopic crystals of gypsum found in the underlying layer. The $MgSO_4$ solvent migrates upwards to the water-bearing layer and increases its hardness and sulphate content. As gypsum is poorly soluble in water (2.6 g/l at ground water temperature), it serves as a potential calcium and sulphate pollutant for longer periods of time. The solubility of dolomite is 0.3 g/l, that of the calcite is 0.1 g/l so we can assume that the high degree of water hardness in the underlying bed is mainly due to processes starting with the oxidation of the pyrite. Because of the present sulphate concentration the clay minerals change their structure; montmorillonite turns into kaolinite. We could reveal this process - already well known from the mineralogical literature - by means of direct X-ray examination and indirect ion-exchanger absorption capacity measurements (The ion-exchanger absorption capacity of the primary Pannonian clay is $40-60$ mekv/100g, and that on the upper part of the redeposited sequence is $27-29$ mekv/100g) *(Fig. 3.)*.

The grain size in the water-bearing gravel and sand mixture is varied *(Fig. 4.)*. The mixture also contains the mud fraction coming from the suspension load of the original sedimentary basin, but we could not examine this fraction because of adopting the usual drilling method. The sandy gravel belongs to Terrace System 2/b of the Late Holocene. Its material is dominated by metamorphic quartzite, eroded from the Tauern-Alps. Quartzite is chemically indifferent for ground water, it gains importance only because of its incrustration. On higher reliefs congelational incrusting is characteristic, limonite (FeO/OH), and pyrolusite (δMnO_2) form chemosorbtional surfaces. I could not find any congelation crusts in the examined River Terrace 2/b.

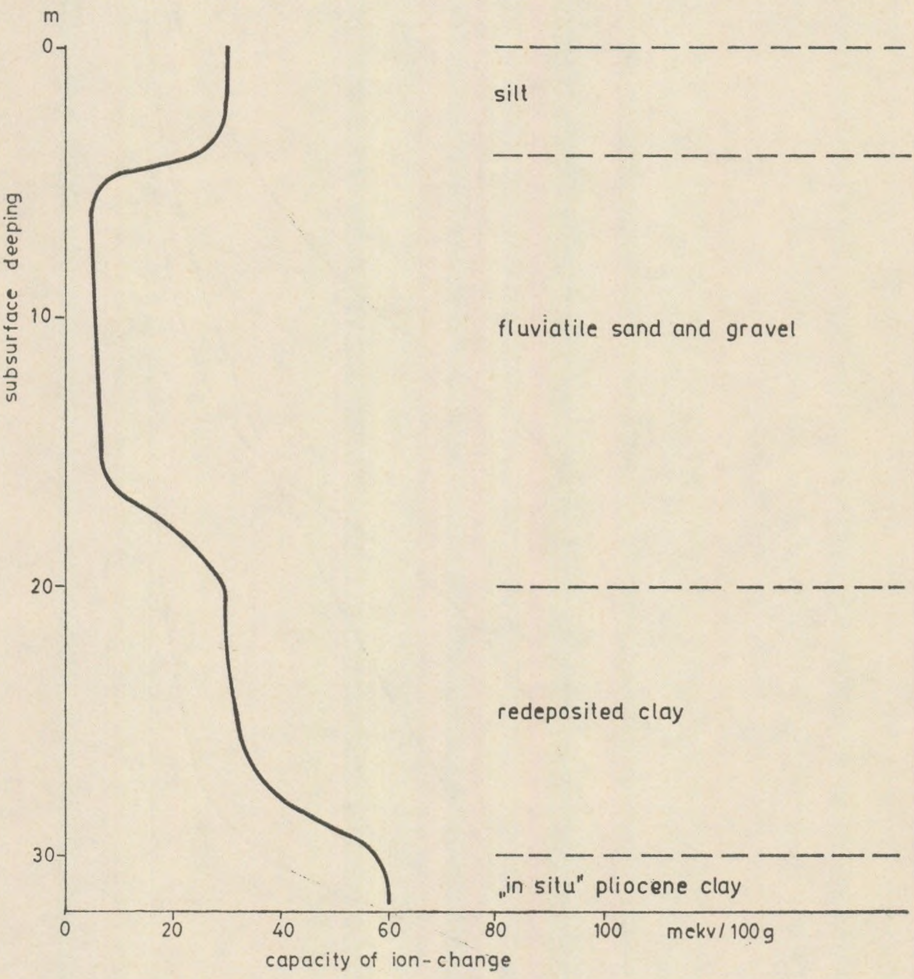
The oxidation – precipitated ferrioxihydroxide coatings are mainly in colloidal phase and hardly mineralizated at all, therefore they are reversible and easily pass into solution for reductive or acidic effects.

Manganese does not form coatings by oxidation, because the actual redox potential of the bank-filtration aquifer ($+150-+450$mV) is smaller than the reduced normal redox potential of the manganese. The quantity of the ferrioxihydroxide coat depends on the extension of the specific surface; the smaller the grain size is, the bigger it gets. This is the primary, water-chemical effect of grain distribution.

The small amount of andesite grains on the gravel and sand fraction is strongly weathered and still keeps on weathering. We investigated this process earlier because the technical literature presumed that ions are to be lost during weathering. As a result of a profound investigation we realized that the potential amount of the released iron and manganese is so small

Relation between capacity of ion-change and deeping

Fig. 3.

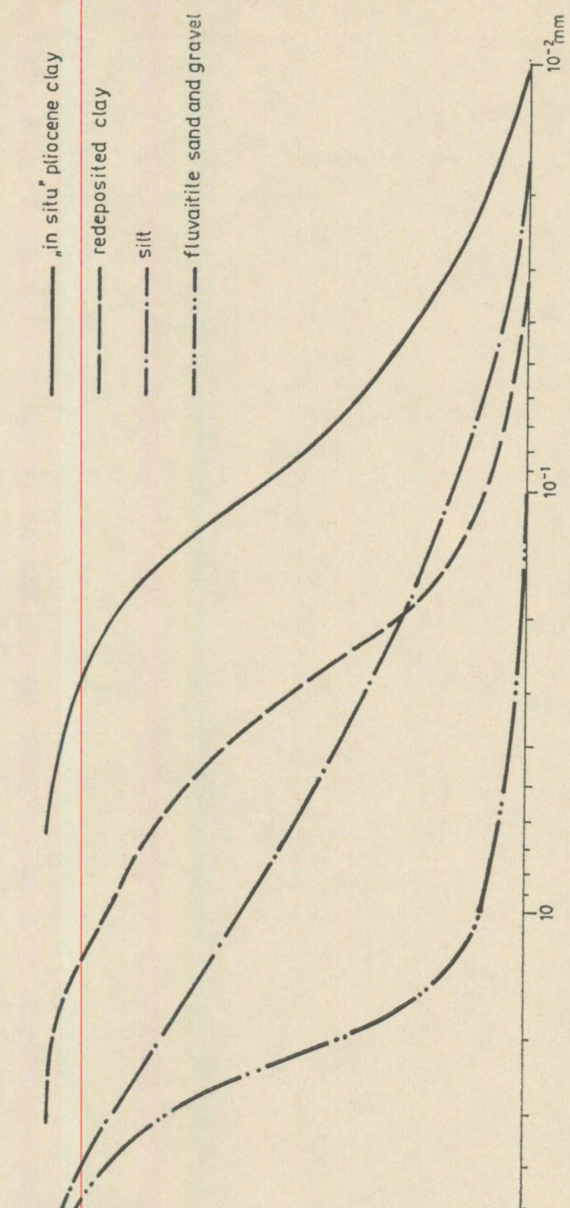


that it can be neglected, the ion concentration of the solution due to slow weathering is insignificant. We are not going to doubt the importance of the released ions (mainly Fe, Mn, K, Na) in the primary accumulation but in the case of recent processes we can neglect them.

Among the grains we can also find dolomite and limestone grains of any size, in less than 0.1 percent. Chemically they act similarly to the carbonates of the underlying bed already discussed, that is, they neutralize

Fig. 4.

Typical granulometric composition of investigated geological formations



acids. Both the calcium and the magnesium reacts with sulphate; gypsum is formed in the first case and water soluble salts in the other. However, the solubility of the original carbonate is not known because the underground water is much less saturated than the theoretical solubility of the carbonates would indicate and in addition we could not observe a considerable degree of solution on the pebbles, neither under natural conditions nor in laboratory. Comparing this with the solubility of artificial limestone and dolomite grains of the similar size this difference is very remarkable. Therefore we presume but cannot substantiate that either an alkalophillic and chemolithotrophic bacterium culture appears around the carbonate grains in bank-filtration aquifers or the humic acid forms chelate-complex with the calcium, thus serving as a protective colloid.

The most important fraction of the reservoir is the silt-fraction. According to the practice of engineering geology we separated it with rinsing by means of a sieve with 20 μm meshes (sieve standard Fritsch Afnor NFX 11 – 501. No 14.) but also examined the 20 – 50 μm fraction if it turned out to be useful in some way.

The silt content of the sandy gravel can be of different origin. Recent colmatation can be observed in the vicinity of the present riverbed and fossil colmatation near the fossil one. As our previous investigation of different purpose showed, the colmatated layer is very thin, n. 0.1 m, max. 1.5 m. This was revealed in several places along the Danube by means of drillings along recent and fossil riverbeds and hoeing along the bank. In this article we do not intend to go into details concerning this problem, just mention that – according to our investigation – the change in the quality of the water, filtering from the Danube, is obviously in connection with the colmatated layer and its dwelling time has less importance than the special literature presumes.

The more or less evenly dispersed silt content of the reservoir is syngenetic and originates from the suspension matter content of the sedimentary substance of the gravelly sand of the fossil river. This seems to contradict the principles of sedimentation which states that different fractions would have to separate (gravel and sand as well as mud), yet it is very well known from our experience that this can be seen neither in recent nor in fossil deposits, probably because it is covered by the dinamics of slurry movement.

We examined the suspended matter content of the Danube. The chemical compound of the filtered and rinsed (ie free of soluted salts) dry matters are the followings:

SiO_2	8.8%
Al_2O_3	4.9%
Fe_2O_3	0.4%
CaO	14.3%
MgO	2.9%
Na_2O	9.8%
K_2O	2.1%

Cl^-	6.4%
SO_4^{2-}	12.3%
ignition losses:	38 %
	99.9%

(Note: At about two third of the ignition losses is C-org and one third is CO_2)

A considerable part of the ignition losses is detritus which reacts very quickly for H_2O_2 treatment. Chemical oxygen demand (COD) measurement gave the proportions mentioned above, after the extraction of the carbonates.

The concentration and compound of the suspended matters in the Danube change according to the water level and cause small deviations from those in the silt-fraction of the reservoir.

The ion-exchanger absorption capacity of the clay minerals is estimated to be as common but cannot be measured properly because it can hardly be separated from the other components, and because the bearing materials of the organic matters also have surface activity and absorption.

By means of X-ray examination we could see, that the compound of the clay minerals is varied and on an average contains 50 percent of montmorillonite, 20 percent of kaolinite and 30 percent of illite.

We can not measure at what rate is montmorillonite able to react with organic matters since it cannot be separated with the available methods, therefore, we presumed that clay-minerals and detritus form their absorptive systems separately. (Otherwise the two systems would neutralize each other, thus making absorption impossible.) Indirect measurements made our presumption plausible.

The surface activity of the suspended matters have two effects. It assists some chemical processes (mainly reductive ones), and accumulates the produced materials on the surface while making the activities of bacteria possible at the same time. The environmental conditions, needed for the optimal life-functions of these bacteria does not meet the actual environmental conditions; they could find stable micro-conditions (pH, pE, etc.) for their survival only in the silty nodes, where the low speed of current and diffusion (due to bad fluid transmission) does not keep up the balance between the different chemical environments.

Overlying formations

The overlying bed of the reservoir is alluvial clay. Depending on its sand content it is either bound or friable. Our permeameter has shown a high vertical conductivity ($1.2 \cdot 10^{-6} - 4.9 \cdot 10^{-8}$ m/sec), which means that the descender waterflow may take huminic and carbonic acids from the humous soil and these together cause natural contamination.

We can also find antropogene contamination on cultivated lands (eg. artificial manure, plant protective agents, etc.) though we can neglect their effects because borehole KI is within the hydrogeological protective zone for waterwork.

Testing the Material

Sampling

As it was already discussed in the last chapter, the chemical quality of the groundwater is basically predetermined by the silt fraction of the water-bearing detritus. (Our study does not include the examination of pollutants carried by the ground water.)

In case of the usual drilling methods (bailer, washing), when the samples are lifted out from under the static level of the ground water, the silt-fraction usually leaks out together with the water. Thus the water-chemical and hydraulic parameters of these samples are not complete.

The sampling method which will satisfy our needs is the following: The samples are taken by means of a sludger, than are placed in a bail where sand, pebbles, silt and water will be together. After settling for several hours the surplus water will be poured off. So the solid phase will be left behind, which will be packed air- and water-tight. Every sample will weight 6 – 10 kg!

It is probable that even these samples will not entirely represent the layer, but a more efficient method could only be adopted by means of refrigeration.

Preparation of the sample, separation

During the investigation we classified the samples according to their grain-size. The grains were selected by dry screening and sieving in the case of grains less than 50 μm in diameter. The fraction, where the grain size was between 50 – 20 μm in diameter, was separated by wet sieving, and if the grain size was even smaller we adopted decantation.

At the fraction where grains were bigger than 50 μm in diameter, we tried to remove the surfaceactive grains by means of clarification. Before the sludge analysis (Stokes-rule) aluminium sulphate or protective colloid water glass was added (coagulation or dispergation) to each sample. When using these two methods together (one after the other), the efficiency of the separation was about 60 – 70 percent only.

During our previous investigations (in the area of Szigetszentmiklós, Tököl, Ráckeve) it became clear, that though the elements of the so-called heavy minerals (magnetite, garnet, zircon, tourmaline etc.) and the melanocratic rockforming minerals (pyroxene, hornblende, biotite, etc.) accumulate in the rocks of the reservoir (transported or not transported), the speed of the weathering of these minerals in the ground water is so small comparing with the length of time the water exploitation takes, that the concentration of their elements is negligible here. For this reason we did not separate these minerals but learned their effects from the data of the water-bearing rock formations.

We similary considered the effects of the andesite, limestone and dolomite grains of the gravel and coarse-sand fraction, i.e. we examined the soluble amount together, without separation.

Examination of the samples

The separation methods discussed in former chapter (screening, dry and wet sieving, sedimentation) were not only good for separation but also gave information about the properties of the material itself. We can also mention that we could not adopt the Atterberg-Köhn and hydrometer analysis at the $d < 50\ \mu m$ fraction, because we had too small samples at disposal. On the other hand the amount of the samples were too much to use sedimentation balance so we adopted a procedure that had been worked out in our department. In this procedure the slurry is filled into a glass cell and the temporal change of the extinction is measured. Even if we can get a result using for calculation the Stokes' rule in dealing with photomeric records, the comparison with standards has been found more reliable.

The mineralogical composition was determined by means of combined methods, since we did not know a specific method, which alone would be suitable to determine each mineral in any concentration. The most important method we used was derivatography (suitable for detecting clay minerals, carbonates, sulphide (and X-ray diffraction) for detecting silicates — except phyllosilicates —, quartz, feldspar). Additionally we made optical tests with polarizing microscope and, in case it was necessary, we also made more simple mineralogical examinations (measurement of hardness, density, refraction of light, etc.).

The first step of the chemical examinations was to determine the concentration of the potentially soluble iron and manganese. Since not only oxides, carbonates, sulphides, but also silicates are present among these ions we had to adopt alkaline treatment instead of acidic. We put the samples in a crucible made of platinum or high — alloy steel, added anhydrous Na_2CO_3 to it and melted it in Bunsen flame. So the melted material became acidophile. After evaporation and dissolving in distilled water, we used the usual water-analytical methods. Along the traditional titration we also adopted electrochemical, photometrical, colorimetrical and microchemical reactions. The last one is often used in mineralogical analysis.

We described the plasticity of the clayish rocks on both the over-, and underlying bed-sides with the Atterberger's plasticity coefficient (known as Ip in the soil mechanics).

The ion-exchanger absorption capacity, known as one of the best index numbers for the characterization of surfaces activity, was determined by ammonium-ion exchange and retitration.

The porosity of the samples was counted from their volumes, weights and average specific gravity.

The descendent seepage water of the overlying bed may sontain humic acid and free carbonic acid, therefore we examined a special solution sequence, where the ground water solving material was saturated with CO_2 and humic acid (extracted from peat). However the concentration of such solutions in the nature are smaller, so the results we obtained in the laboratory are maximum values, and are always bigger than in the nature.

The best way to imitate natural conditions is to study solutions made of natural ground water The speed of convection is slow in the bank-filtration aquifers; this can be imitated either in statical situation, which is similar to dead water condition, or within slow convection, that is, circulation.

The second one has a disadvantage that we cannot disregard the possibility that ground water contacts oxygene (i. e. air), therefore the actual redox potential of the solving material is bigger than that of the ground water. Besides, it is hard to stabilize the CO_2 content on the given level.

Iron and manganese is best dissolved by dead water, and calcium magnesium is best dissolved by circulated water, but the difference is small and considering other factors of certainty, we gave a standard value for the solubility of the ground water.

Evaluation of the results

It is very remarkable that the analytical results have a deviation even in the case of a single well. (We could see this at each (20) previous examinations of the similar purpose.

This is probably due to the genetic inhomogeneity of the reservoir which is in correlation with both the grain distribution and the chemical conditions.

The underlying, water-bearing and overlying layers are essentially the same in each well, only their quantity is different. Neither chemical parameters nor other data do not explain the difference in water quality between the well Kl and the other wells, but peculiarly, their joint effect has this tendency.

We think that the depth of the underlying layer and the thickness of the water-bearing layer is very important at the different wells but there is no significant difference in the thickness of the overlying layer.

	K1	K2	F14
depth of the underlying	24.6	19.8	17.5
layer below the surface in metres	25.8	20.7	17.9
thickness of the waterbearing layer in metres	20.5	16.1	14.4

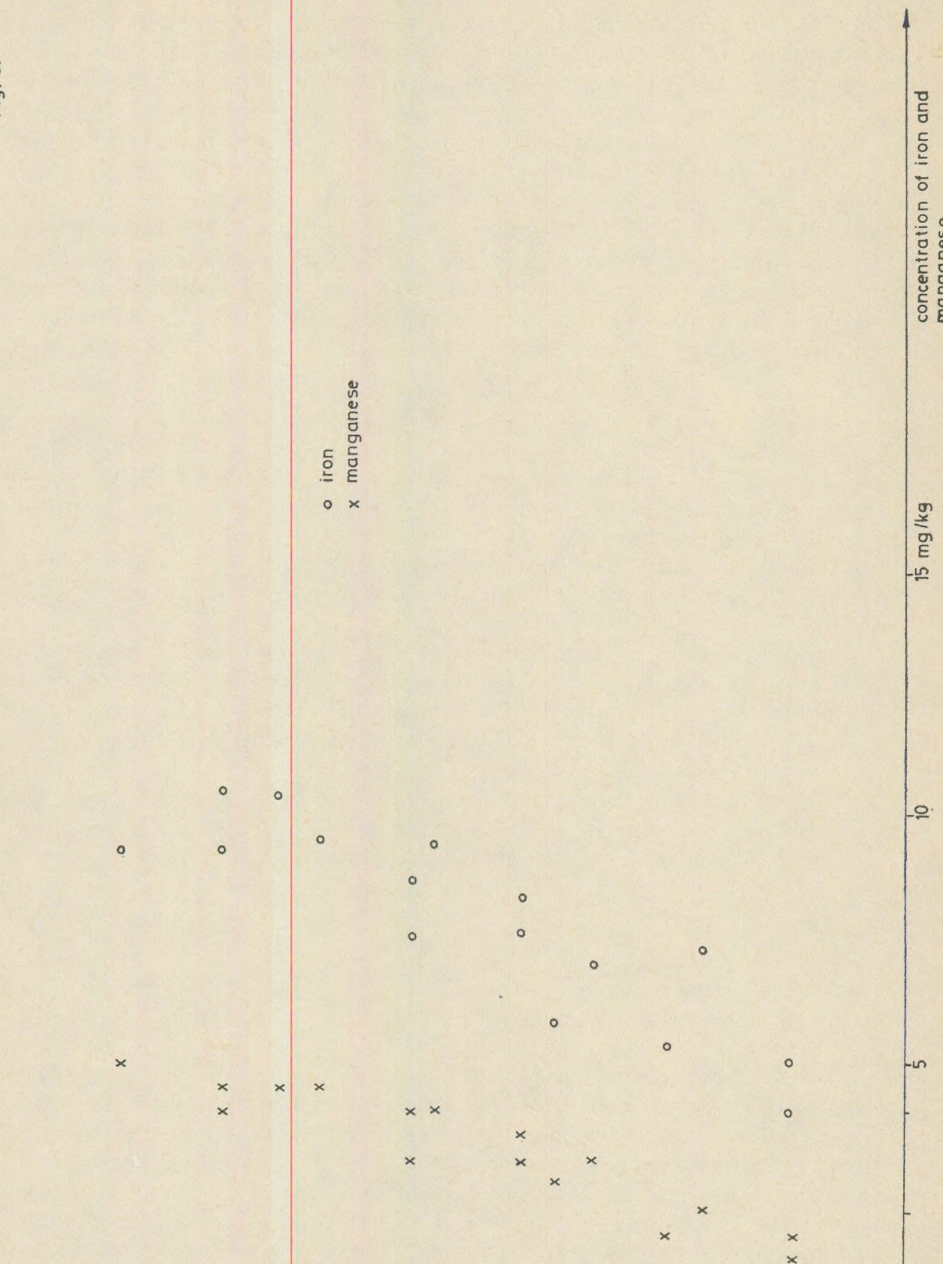
Where the water-bearing layer is thick the effect of the overlying and underlying layer has relatively less importance; the deeper the underlying layer is the less it is outwashed by the slow currents in the ground water.

On the upper part of the underlying layer of the well K1 (between 24.6 – 26.2 m – our sample is from 25.8 m) we can find grey clay of different characteristics than the other, which we think is of great importance. It contains far less pyrite and carbonate than the lower parts of the same well or the underlying layer of the other wells.

There is also a remarkable difference concerning grain-distribution. The water soluble coating is on the surface of the gravel and sand grains, thus the amount of the solved matter depends on the extent of the surface

Connection between silt-content of gravelly sand and contcentration of iron and manganese

Fig. 5.



and not on the weight of the grains as our previous examination had shown. The smaller the grain size the bigger the specific surface is.

There is an obvious correlation with the relative amount of the mud content *(Fig. 5)*. Ions are accumulating on the grains of the mud-fraction (clay mineral and detritus) by ion exchange and adsorption. Besides, this fraction offers favourable conditions for bacteria. Because of the coating the process of solution takes a long time and is reversible. There were essentially the same amount of soluble ions in the silt fraction, which is plausible if we know the material. It is probably because at those processes where ion exchange or adsorption result a balance, this balance will set in at a smaller level if the soluted ion concentration of the ground water is small. Therefore we can conclude that it is not the quality but the quantity of the mud-fraction that is determinant in our case.

Processes in the aquifer

The effect of descendant water

Since the CO_2 concentration of the soil is about 60 times as much as that of the air, the infiltrated precipitation is saturated with CO_2 in the A + B zone of the soil. The speed of the infiltrating water is so slow that its dwelling time is long enough for all the possible chemical reactions. Thus the water dissolved the solid $CaCO_3$ phase of the overlying alluvial clay (originally it also contains loess) in the form of $Ca(HCO_3)_{2-}$ which also contributes to the varying hardness of the ground water.

Huminic acid is washed out from the soil and forms (as humate) chelate complexes with several alkaline earth metals and siderophil elements. This reaction is very important because this is the counterpart of the reversible process. The decomposition is slow and if eg. the concentration is small the dissolved oxygene can not oxidize iron! Huminic acid is able to form protective colloide around the ions even without chemical reaction. Because of this, the occasional putwashing and those chemical reactions which would result solid phase, will become slower and last longer.

The effect of the impervious underlying layer

The outwashed Pannonian Clay contains a relatively big amount of accessory matter like eg. stream sand and loess (eroded from the surrounding hills). Because of its loess content the Pannonian Clay contains a lot of $CaCO_3$, mainly in the form of calcareous nodules. On the other hand even its ferro-sulphide content is washed out.

Ferro-sulphide occures sometimes in the form of crystallized pyrite or marcasite, but more often it appears as less crystallized, almost colloidal, melnikovite ($FeS_2 \cdot nH_2O$) and hydrotroilite ($FeS \cdot nH_2O$). Because of the oxygene-bearing water they oxidize easily. Sulphate is oxidized into sulphuric acid (Thiobacillus ferrooxidans) by the participating bacteria,where there is 2 – 6 pH. This sulphuric acid forms gypsum with the calcium or liquid salt with the magnesium in statu nascendi. Depending on the speed of the ground water (directly above the aquifer) they get into the aquifer, so the deeper the underlying layer is, the bigger the outwashing will be. Though this is only a very little difference, these effects together may strenghten or weaken each other.

Summary of the hydrochemical process

Huminic acid and $Ca(HCO_3)$ (and artifical manure, plant protective agents and other antropogene materials we will not take any notice of) can get into the aquifer from above and $Ca(HCO_3)_2$, $Mg(HCO_3)_2$?, $Fe(HCO_3)_2$, $Fe(OH)_2$?, $CaSO_4 \cdot nH_2O$, $MgSO_4$, $Mn(HCO_3)_2$?, $Mn(OH_2)$?, H_2SO_4? from below.

Depending on the accessory CO_2 content $Ca(HCO_3)$ remains dissolved or separates as a solid matter. This process is reversible. The solubility of $CaCO_3$, is at about 100 mg/liter, so it is in a permanent balance. The solubility of the Mg – Ca carbonate ("dolomite") is at about 300 mg/litre, so if there is enough dissolvable material the hardness will be chaging at a remarkable rate without any special solvent effect.

The solubility of $CaSO_4 \cdot 2H_2O$ (crystal phase) is 2600 mg/litre, that means about 975 mg/litre SO_4^{2-} ! In the ground water $MgSO_4$ can be dissolved completely. This gives the main part of the hardness and the sulphate content.

The ferro – and ferri – forms of iron transform reversibly, depending on the actual redox potential, which is measured to be +150 – +400 mV instead of +770 mV. The difference is due to the formal-potentials and mainly to bacterial processes. Those bacteria that oxidize iron (Gallionella, Leptothrix, Cladothrix, Clenothrix genera) do that along with Corg consumption, which means that $Fe(OH)_3$ will be precipitated. This precipitation takes part in the reversible processes, so it is reducible. But more often the case is, that bacteria fix this precipitation in their bodies, and it can only be released after the decay of the bacteria and the decomposition of the biomass. It is usually released in dissolved form because of the reductive environment.

Manganese is similar to iron in this respect.

The examination of the samples from the observational wells on Csepel gave similar results, though the thickness of the aquifer is the same at the different wells there, thus the differences in the water-chemical parameters and in the mud fraction of the water-bearing rock gave an obvious correlation.

Summary

The origin of the iron and manganese ions can be explained, if we take complete samples and make more investigation.

Sulphate originates from the oxidation of the ferro-sulphide content (partly bacterial) of the underlying layer.

Iron is released during the same oxidization, and similarly to the manganese, it also becomes mobile. Because of the spontaneous dissolving of the

carbonate the changing hardness of the water will be bigger with 40 mg/litre. Furthermore, if CO_2 is present, dissolved $Ca(HCO_3)_2$ will also cause hardness.

The sulphuric acid (from the oxidation of the pyrite) and calcium form gypsum, which is far more soluble than its concentration in the ground water would indicate.

Magnesium originates from the dissolving of dolomite pebbles and from the carbonate content of the loess in the overlying and underlying layers. The solubility is determined by the CO_2 balance. Together with sulphate it dissolves completely.

We cannot explain the origin of chloride ions with the erosion of minerals, but their amount is basically similar to their concentration in the river; only some 2–4 times more than that.

REFERENCES

Bidló G. (1959): Über die Entstehung der chemischen Zusammensetzung des Grundswassers Hidrológiai Közlöny 6. pp. 459–461.

Bidló G. (1970): The influence of silicate minerals and rocks on the chemical composition of water. 2nd Conference on Water Quality and Technology Budapest

Gondos Gy. (1970): Relationship between the dissolved iron and manganese compounds in water and the mineralogical composition of the aquifer. 2nd Conference on Water Quality and Technology

Hallberg, R.–Lindström, M. (1982): Transformation of iron in aquatic environments. Acta Univ. Stockholmiensis XXXVII. 6. pp. 67–78.

Homonnay A. (Mrs.) (1970): Studies into the factors affecting variations in the iron and manganese content of water obtained from the gravel terrace wells of the Budapest municipal Waterworks. 2nd Conference on Water Quality and Technology

Kecskés T. (1970): Geological conditions and water quality. 2nd Conference on Water Quality and Technology Budapest

Orsovai I. (1985): Contributions to the origin of iron and manganese contents in bank-filtration aquifers. Ann. Univ. Sci. Budapestinensis XXV. pp. 269–280.

Orsovai I. (1985): Influence of the bottom sediment on quality of the seepage water. Ann. Univ. Sci. Budapestinensis Sect. Geol. XXV. pp. 245–257.

Rónai A. (1970): The Quality of the Subsoil Water in loose rocks. 2nd Conference on Water Quality and Technology Budapest

Rott, U. (1976): Physikalische, Chemische und Biologische Grundlagen beim Transport von Schwermetallen im Grundwasser-Technische Berichte Sonderforschung im Küstenbereich. Technische Universitat Hannover pp. 1–48.

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