ANNALES
UNIVERSITATIS SCIENTIARUM BUDAPESTINENSIS DE ROLANDO EÖTVÖS NOMINATAE

SECTIO GEOLOGICA

TOMUS XXV
1983

REDIGUNT
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B. GÉCZY
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BUDAPEST
1985

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UNIVERSITATIS SCIENTIARUM BUDAPESTINENSIS DE ROLANDO EÖTVÖS NOMINATAE

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NOTES TO THE I., II., III. TYPE EULER ANGLES OF PLAGIOCLASES

by

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(Recived: 22nd October 1983)

Abstract

The EULER angles introduced by C. BURRI – R. PARKER – E. WENK (1967) make more fast and much more exact the evaluation of the optically measured data of the plagioclase crystals using U-table. Using EULER angles the An-content can be calculated by computer.

C. BURRI in 1974 corrected the earlier marking of the first type of EULER angles. The marking of the second and third types of EULER angles has not been corrected till now. Author suggests the application of the EULER's thesis in the case of plagioclase in EULER's conception. The data of the first table of this paper have been obtained by the rotation of the two coordinate systems one into another according to EULER's definition.

Introducing the Euler angles in their 1976 book "Die optische Orientierung der Plagioklase" C. BURRI – R. PARKER – E. WENK have highly facilitated the work of plagioclase specialists using microscope for their research.

The authors fixed mathematically by numeral data thus more exactly formulated a feature of plagioclases. Namely that the mutual position of crystallographic orientation and optical indicatrix in space is depending on An content.

In 1974 professor C. BURRI (see lit.) has corrected the method of rotation of the two coordinate systems into each other so as this rotation happened according to the rules of rotation to the right.

From practical point of view values given in the first study are very useful since the magnitude of migration of optical axes is not usually sufficient to transfer them from one quadrant to the other according to change in chemical composition with the exception of nβ, which is located around 80 – 100% An content percentage not in quadrant IV but in quadrant II, in BURRI's XYZ coordinate system.

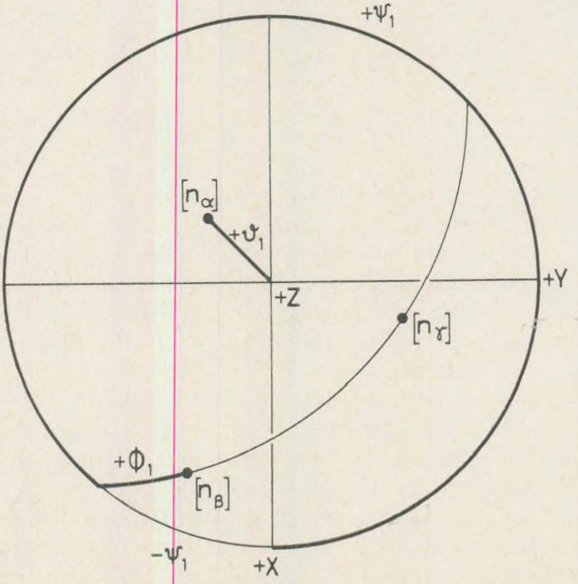
Mathematically criticizable rotations usually do not cause problems in defining the An content and twinning law. I think it is necessary to use EULER's theorems in connection with felspars according to this original conception, definitions.

In case of rotation of two rectangular, right handed rotation systems of common origin into each other it is subject to decision with which axis of one of the systems should one of the other system's axis be brought into same position. According to these there are three possibilities as C. BURRI determined all the three types of values for the Euler angles for plagioclases. Rotated position of the other two coordinate systems are due to the position of the first axis if rotation is effected consequently clockwise. That's the reason why axis X in case of Burri's type II and III Euler angles is impossible to rotate in direction $n\alpha$. In case XYZ and n_α, n_β, n_γ are right handed coordinate systems clockwise rotation means·

Type I	Type II	Type III
Z → n_α	Z → n_β	Z → n_γ
X → n_β	X → n_γ	X → n_α
Y → n_γ	Y → n_α	Y → n_β

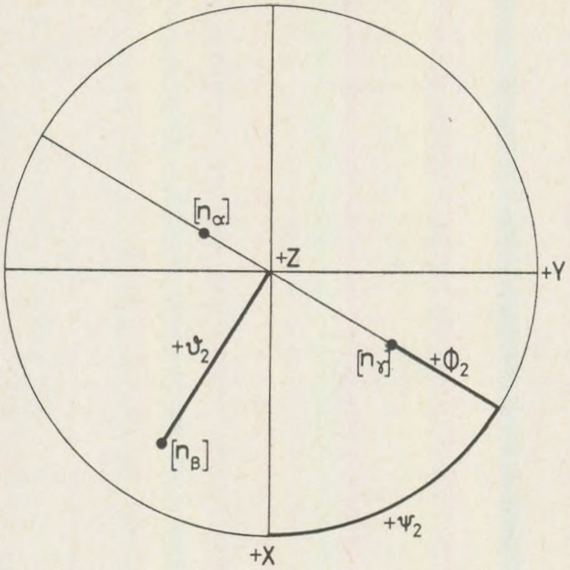
Thus in case of type I, II, III Euler angles axis of coordinate system xyz are correlated with different directions of oscillation. Positive end of socalled nodal line, the line of intersection of the plane square with z is defined by Euler as follows. The positive end of this line is the end looking from which as from the rotation axis Z could be rotated into z against the clock with an angle smaller than 180°.

In 1974 study of professor C. Burri type I Euler angles are strictly correlated with the requirements of Euler. The first rotation is effected around + Z, when + X reaches nodal line, rotating around the resulting + T nodal line + Z gets into direction n_α and finally rotating around n_α + X covers n_β. In case of type II Euler angles the other end of nodal line becomes positive and axis + X must get into position of n_γ. In case of type III Euler angles, too, the opposite end of nodal line becomes positive.

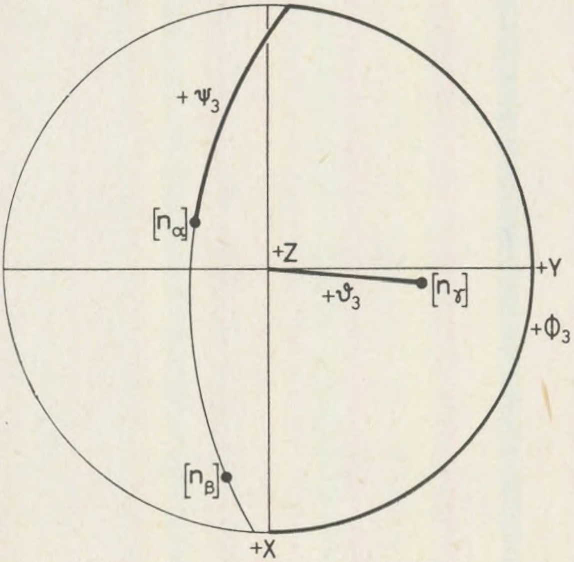


1A

I suggest to use the original EULER symbols for the three types of EULER angles and that the types I, II, III be marked by index (fig. 1.A – C).



1B



1C

Fig. 1. A – C The three types of Euler angles according to BURRI – PARKER – WENK – (1967)

Values of EULER angles interpreted and marked in this way are shown in table 1.

Table 1

The three types of Euler angles obtained by different rotation

			φ_1			φ_2			φ_3	
		ϑ_1	φ_1	ψ_1	ϑ_2	φ_2	ψ_2	ϑ_3	φ_3	ψ_3
An 0	T	84.0	106.5	−89.2	17.5	−69.7	161.4	106.4	6.3	182.5
	H	72.5	109.4	−94.5	25.9	−46.5	135.0	108.5	18.5	181.4
An 2.5	T	83.9	106.3	−89.2	17.4	−69.2	161.8	106.2	6.4	182.5
	H	72.8	104.3	−94.7	22.2	−38.6	126.1	103.6	17.7	179.6
An 5.0	T	83.4	105.4	−89.1	16.7	−66.5	158.3	105.3	6.8	182.6
	H	72.4	100.5	−94.9	20.4	−29.9	116.6	100.0	17.9	178.3
An 10.0	T	79.1	101.5	−89.8	15.8	−46.0	137.3	101.3	11.1	182.3
	H	71.5	93.7	−95.0	18.9	−10.9	96.5	93.5	18.5	176.2
An 15.0	T	74.6	97.2	−90.7	17.0	−24.5	114.7	96.9	15.5	181.1
	H	69.3	86.7	−95.3	20.9	8.7	75.4	86.9	20.7	173.5
An 20.0	T	69.2	91.3	−91.3	20.8	−3.4	92.4	91.2	20.8	179.2
	H	67.5	80.5	−94.5	24.3	21.7	61.9	81.2	22.8	171.8
An 25.0	T	65.2	82.5	−90.4	25.8	15.8	72.2	83.2	25.0	176.4
	H	66.7	74.5	−93.7	27.7	31.8	51.3	75.8	24.1	170.0
An 30.0	T	62.8	74.5	−89.6	31.0	27.5	59.2	76.2	28.1	173.2
	H	65.3	70.6	−92.4	31.0	35.8	47.5	72.4	26.0	169.2
An 35.0	T	58.9	70.9	−88.3	36.0	28.5	57.9	73.7	32.6	171.6
	H	62.0	66.8	−91.2	35.8	36.5	46.4	69.6	30.0	167.4
An 40.0	T	53.6	65.8	−84.8	42.8	29.1	58.1	70.7	38.9	170.3
	H	56.3	61.2	−87.6	43.2	35.8	47.7	66.4	37.3	165.4
An 45.0	T	48.6	60.0	−79.7	49.5	29.6	59.2	68.0	35.5	169.4
	H	52.3	56.5	−83.9	48.7	35.5	48.9	64.2	42.8	164.1
An 50.0	T	43.8	53.6	−73.8	56.1	29.6	60.6	65.7	52.3	168.2
	H	46.8	51.2	−78.8	55.4	33.7	51.6	62.8	50.3	162.4
An 55.0	T	39.4	45.5	−66.1	63.1	29.9	62.1	63.6	59.6	166.7
	H	41.5	44.2	−70.5	62.5	32.4	55.6	61.6	58.3	161.9
An 60.0	T	35.8	35.4	−58.5	70.2	30.5	61.5	61.5	67.3	162.7
	H	37.3	36.5	−62.3	68.9	31.5	58.2	60.8	65.6	160.6
An 65.0	T	34.7	23.9	−48.7	76.7	32.3	61.3	58.6	74.3	159.6
	H	35.5	27.2	−53.2	74.6	32.4	59.5	58.9	71.9	159.1
An 70.0	T	34.1	13.5	−39.9	82.5	33.4	61.3	57.0	81.0	156.3
	H	34.9	18.6	−45.3	79.5	33.5	60.1	57.2	77.5	157.0
An 75.0	T	34.6	10.1	−37.2	84.3	34.2	61.1	56.0	83.1	155.0
	H	34.8	9.3	−37.1	84.7	34.4	60.6	55.7	83.6	154.2
An 80.0	T	35.5	3.6	−32.3	87.9	35.4	60.6	54.6	87.4	152.1
	H	35.5	0.1	−28.8	89.9	35.5	61.3	54.5	89.9	151.3
An 85.0	T	36.4	177.6	−27.3	91.4	36.4	60.8	53.6	91.8	149.7
	H	36.1	174.7	−23.6	93.1	36.0	62.1	54.1	93.9	149.9
An 90.0	T	37.2	175.3	−24.0	92.8	37.1	62.3	52.9	93.6	150.1
	H	36.3	174.1	−23.1	93.5	36.2	62.1	53.9	94.3	149.6
An 95.0	T	37.5	173.5	−22.4	94.0	37.3	62.4	52.8	95.0	149.4
	H	36.9	172.7	−20.6	94.4	36.7	63.5	53.4	95.5	150.2
An 95.0	T	nincs adat								
	H	37.9	169.5	−17.1	96.4	37.4	64.6	52.8	98.1	149.7
An 100	T	nincs adat								
	H	35.9	170.7	−20.5	95.4	35.5	61.9	54.6	96.7	148.1

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THE FORAMINIFERA OF THE TYPE SECTIONS OF NOVAJ AND EGER

by

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(Received: 10th April 1984)

Abstract

The Hungarian Egerian stratotype-profiles show different lithological and microfaunistic characteristics. As evidenced by both the foraminiferal faunistic studies and the approximately exact determination of the ecological parameters of the Eger and Novaj sections, the post-Kiscellian Clay regression resulted in a succession of superimposed lithological units of different pattern. The regression is indicated by glauconitic sandstone in the Eger and Novaj profiles. Of relatively short duration, the regression phase (during which only glauconitic sandstone was formed at Eger and sandstone and limestone at Novaj) was followed in both areas by an increased subsidence which resulted in development of the sea of molluscan clay. In spite of the similar enviromental factors, its depth, however, did not attain that of the Kiscell Clay (as evidenced by the diversity of Miliolidae). The new regression of the Egerian can only be traced in the Eger profile, being recognizable in both the lithological characteristics and a foraminifera fauna turning to a brackish-water associations or totally lacking. The Oligocene/Miocene boundary cannot be defined in the type sections described here.

Introduction

After the RCMNS Congress in Bologna, 1967 a regional stage-system of the Central Paratethys was proposed and the appointment of their stratotypes. These were accepted at the RCMNS Congress in Bratislava, in 1975. BÁLDI (1968) offered the Egerian regional stage, as a transitional stage between Oligocene and Miocene. However, the problem of defining the boundary between Oligocene and Miocene is not solved yet.

The definition of the regional stages of the Central Paratethys was begun paralelly with the acception and the results were published in the series "Chronostratigraphie und Neostratotypen" The "Egerien" volume has been also issued in this series, where BÁLDI and SENEŠ (1975) defined the boundaries of the stage Egerian. The foraminifera-faunas of three Hungarian type-sections (Eger, Novaj-Nyárjas, and Budafok-2. borehole) were published in this volume, but not in details, only in summaries.

This paper contains the description of benthonic and planktonic smaller foraminifera fauna, the results of the coenological and paleoecological investigations on the base of the sections of Eger, Wind-brickyard and Novaj-Nyárjas. The micropaleontological results of the Budafok-2. section were already published (BÁLDI, HORVÁTH and T. MAKK 1974, HORVÁTH and T. MAKK 1974).

1. Historical review

The age of the fauna and flora of the Eger, Wind-brickyard were strongly discussed already at the beginning of this century (Telegdi Roth 1912, 1914; Gábor 1936, Noszky 1936, 1951; Schréter 1939, Benkőné Czabalay 1958, Bogsch 1961). The mollusc-fauna of the surface outcrop and the borehole, drilled at the court of the brickyard, was published by Báldi (1966). Andreánszky (1966), Nagy L.-né and Pálfalvy (1963) dealt with the macroflora, Báldi-Beke (in Báldi and Seneš 1975) described the nannoflora.

Majzon (1942) investigated the foraminifera fauna at first. In his opinion ,,The Eger fossiliferous layers and their underlying clay beds belong to the Kattian, which stage must be ranged into the Miocene according to its foraminifera fauna". Nyirő (1962) worked on the foraminiferas of the borehole-samples, but her results remained in manuscript.

At first Schréter (1939) described the Novaj-Nyárjas section, as Upper Eocene larger foraminifera-bearing beds. Drooger (in Báldi et al. 1961) published the first miogypsinas of Hungary from this section. During the redetermination of the macrofauna Báldi (in Báldi-Beke and Báldi 1974) modified his early opinion, and determined the age of the overlying beds of the Kiscell Clay as Egerian. The planktonic foraminiferas of both sections were published originally by Kenawy (1968).

2. The description of the type sections

2.1 *Eger, Wind-brickyard (Fig. 1)*

This is the holostratotype of Egerian. The description of the foraminiferas of this profile follows Báldi's (1966) lithological division.

2.1.1. Kiscell Clay

Its explored thickness is about 35 m in the borehole, consists of mainly marly silt. At its upper part the sand content is higher No macrofauna was found.

The foraminifera fauna is very rich, *Uvigerina gallowayi* association, with abundancy of *U. gallowayi* and heterolepas *(H eocaena, H costata, H. simplex)*. In the borehole section the cyclamminas *(C. acutidorsata, C. rotundidorsata)*, two vulvulinas *(V nummulina, V haeringense)*, and two tritaxias *(T. havanensis, T. haeringensis)* disappear at 45 m. The main cause of the faunal change is the changing of the facies, i.e. the appearing of glauconite, the glauconitic sandstone.

Among the planktonic forms the *Globigerina ouachitaensis ouachitaensis* and *Globigerina praebulloides* group are frequent. Kenawy (1968) described the *Globigerina ouachitaensis* zone from this interval of the section. According to this paper the known part of the Kiscell Clay corresponds to the upper part of *Turborotalia munda* endemic plankton zone, after Sztrákos (1974, 1978), and to the P 21 zone (partly) after Blow (1969, 1979).

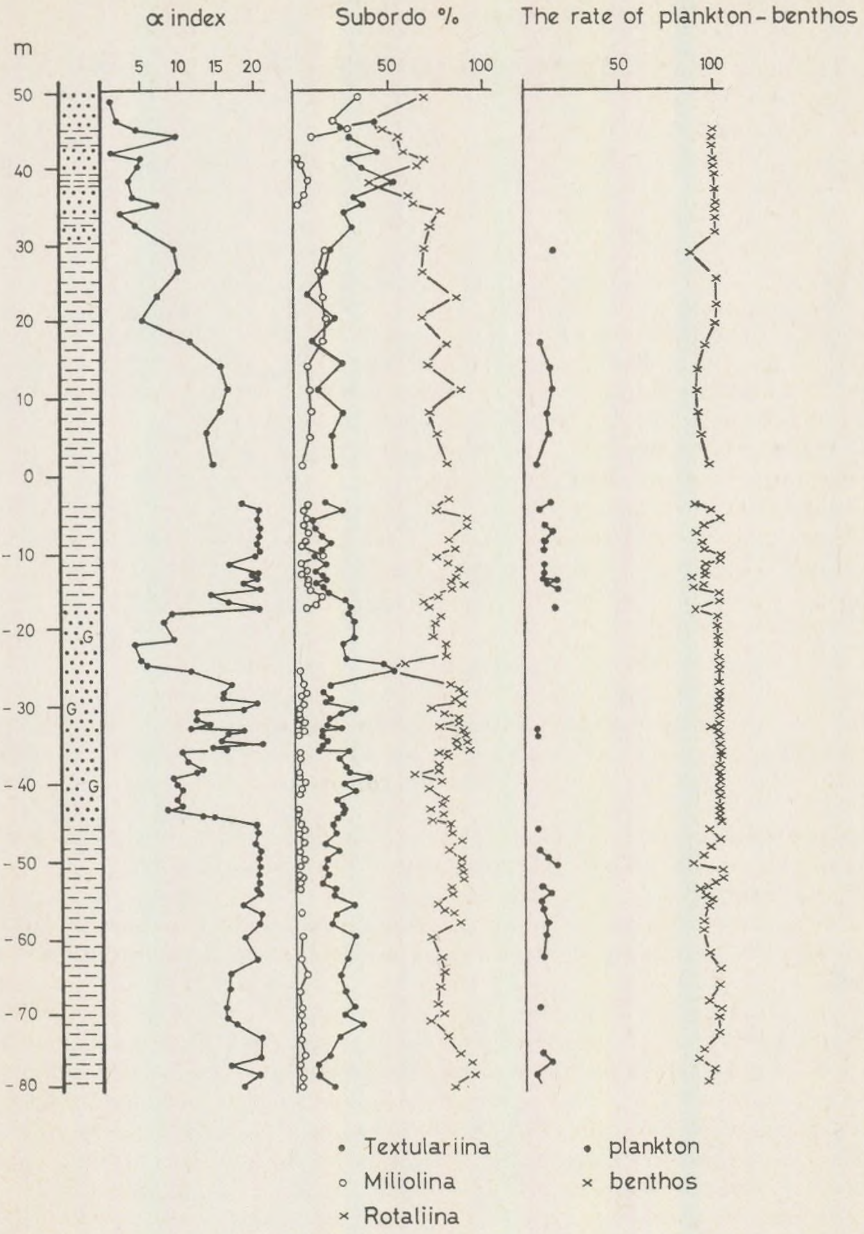

Fig 1. The profile of the Wind-brickyard at Eger. Characteristic parameters of the foraminifera faunas

2.1.2. Eger Formation

It overlies the Kiscell Clay conformably. Four members were observed, becaming upwards gradually shallower.

2.1.2.1. Glauconitic sandstone member

Its glauconite-content is variable. In its lower third, at 36,2 m, is the first appearance of *Flabellipecten burdigalensis*, that defines the lower boundary of Egerian (BÁLDI 1966, 1973; BÁLDI and SENEŠ 1975)

Between 45 – 27 m there is *Spiroplectammina carinata-Heterolepa dutemplei* association in glauconitic sandstone. The characteristic heterolepas of the Kiscell Clay are followed by *Heterolepa dutemplei*. In few levels *Uvigerina gallowayi*, *Alabamina tangentialis*, *Almaena osnabrugensis* s.l., *Hoeglundina eocaena* are frequent. At the upper part of this interval *Baggina philippinensis* disappears and the number of *Rectobolivina zsigmondyi* decreases.

This level may correspond to the "*Discorbis ambiguus*"-level of MAJZON (1966). The *Discorbis (=Planulina) ambiguus* has the first appearance at 50 m, and it can be found with low frequency in every sample between 45 – 27 m.

At the higher, coarse, glauconitic level of the sandstone *Lenticulina-Heterolepa* association is observed, with high frequency of *Lenticulina inornata*, *Heterolepa dutemplei* and *Spiroplectammina carinata*. This association consists of the persistent taxa, without new species.

KENAWY (1968) supposed to recognize Bolli's *Globigerina ampliapertura* zone in the glauconitic sandstone and in the lowest part (12 m) of the molluscan clay member According to my recent investigations the typical forms of *Globigerina ampliapertura* are absent in these levels. The level of the disappearance of *Globigerina ampliapertura* is probably in the lower Kiscell Clay (HORVÁTH 1983). After the transitional level, free of planktonic forms, *Globigerina ouachitaensis ciperoensis* and *Gg. praebulloides* group become characteristic. At 36 m the typical forms of *Globorotalia (T.) obesa* has their first appearance, together with *Flabellipectan burdigalensis*.

BÁLDI-BEKE (in BÁLDI and SENEŠ 1975) recognized the NP 25 chronozone in the glauconitic member of Eger Formation. This member is equivalent to the *Miogypsina complanata* zone, as BÁLDI (in BÁLDI and SENEŠ 1975) established.

2.1.2.2. The molluscan clay member

Its thickness is about 50 m, monotonous clay, clayey marl with silt, silty clay intercalations ("x_1" and "x_2" layers of LEGÁNYI). The mollusc fauna is very rich, *Hinia-Cadulus* association is characteristic (BÁLDI 1966, 1973; BÁLDI in BÁLDI and SENEŠ 1975). The so-called "lower flora level" also can be found in this member (NAGY L.-NÉ and PÁLFALVY 1963)

Two foraminifera associations can be distinguished in the molluscan clay member. The deeper, the *Spiroplectammina carinata-Heterolepa dutemplei* association is observed in a 40 m thick interval. The amount of *Sp. carinata* and *H. dutemplei* is higher than 2 – 5% of the total foraminifera fauna. The quinqueloculinas and triloculinas are most important in this interval of the profile. The same frequency of Miliolina was observed in the upper member of Törökbálint Sandstone Formation (HORVÁTH in HORVÁTH and T. MAKK 1974). The following important taxa have their first appearance in this association: *Trifarina tubulifera, Miogypsina septentrionalis, M. formosensis, Cassidulina crassa, Elphidium crispum, E. flexuosum* s.l.

The diversity and number of planktonic forms is lower than the benthonic ones. Some important taxa are as follows· *Globigerina angulisuturalis, Gg. ciperoensis ciperoensis, Globigerinoides quadrilobatulus primordius.* KENAWY (1968) described this level as belonging to the *Globorotalia opima opima* zone. According to my opinion this interval can be identified as the upper part of P 21 zone or lowermost part of P 22 zone.

In the upper, 10 m part of the molluscan clay member *Caucasina-Cassidulina* association was observed. It develops from the association below it, by decreas of diversity *Cassidulina crassa* and *Caucasina elongata* are abundant, *Lenticulina inornata, Fursenkoina schreibersiana, Cibicidoides pseudoungerianus* are frequent. The planktonic forms are also similar to the lower fauna, but the low diversity is also characteristic. BÁLDI-BEKE (in BÁLDI and SENEŠ 1975) determined the NN 1 nannoplankton zone from the upper 20 m of the molluscan clay member of the Eger Formation.

2.1.2.3. Alternating clay and sand member

This member involves the so-called “x” layer, the horizont of the “middle flora”, the “k” layer and the “Tellina clay” (BÁLDI 1966).

The foraminifera fauna is characterized by the *Caucasina elongata* association, in which *Cassidulina crassa Haplophragmoides canariensiformis, Textularia gramen, Cibicides pseudoungerianus* and *Heterolepa dutemplei* are frequent beside *Caucasina elongata.*

2.1.2.4. Uppermost member of the formation

The thickness of this member is 40 m, it consists of alternating clay-sand-gravel. About at the middle part of this member 20 m cross-bedded, coarse-grained sand is exposed, with gravels, and calcareous clay-concretions, without macro- and microfauna.

The following forminifera fauna was recognized in this layers with characteristic macrofauna:

– “c” or “Cerithium-bed” (after TELEGDI ROTH) – *Ammonia beccarii*

– under the “c”-bed – few *Rotalia propinqua, Cribrononion minutum,* more *Ammonia beccarii*

– under “k”-bed, the “Turritella bed” – *Ammonia beccarii*

In the lower part of the “k_1”-bed (after BÁLDI 1966) marine macrofauna was observed with *Flabellipecten burdigalensis* (BÁLDI 1966, 1973). This part of the section shows the short time reprise of the marine conditions. It is confirmed also by the foraminifera fauna. The *Caucasina* association is characteristic, *Caucasina elongata* and *Haplophragmoides canariensiformis* are frequent.

The Eger Formation is overlain unconformly by the Gyulakeszi Rhyolite Tuff Formation (“lower rhyolite tuff”), its radiometric age is 19,6 + 1,4 MA (HÁMOR 1978, BALOGH in HÁMOR et al. 1979).

2.2. *Novaj-Nyárjas section (Fig. 2)*

This section was proposed as the faciostratotype of the stage Egerian (after Báldi et al. 1961, Drooger 1961). The new excavations in 1972 gave possibility to more exact lithological, flora-and fauna investigations (Báldi-Beke and Báldi 1974, Horváth 1977, Horváth in Báldi and Seneš 1975, Horváth 1980, 1983).

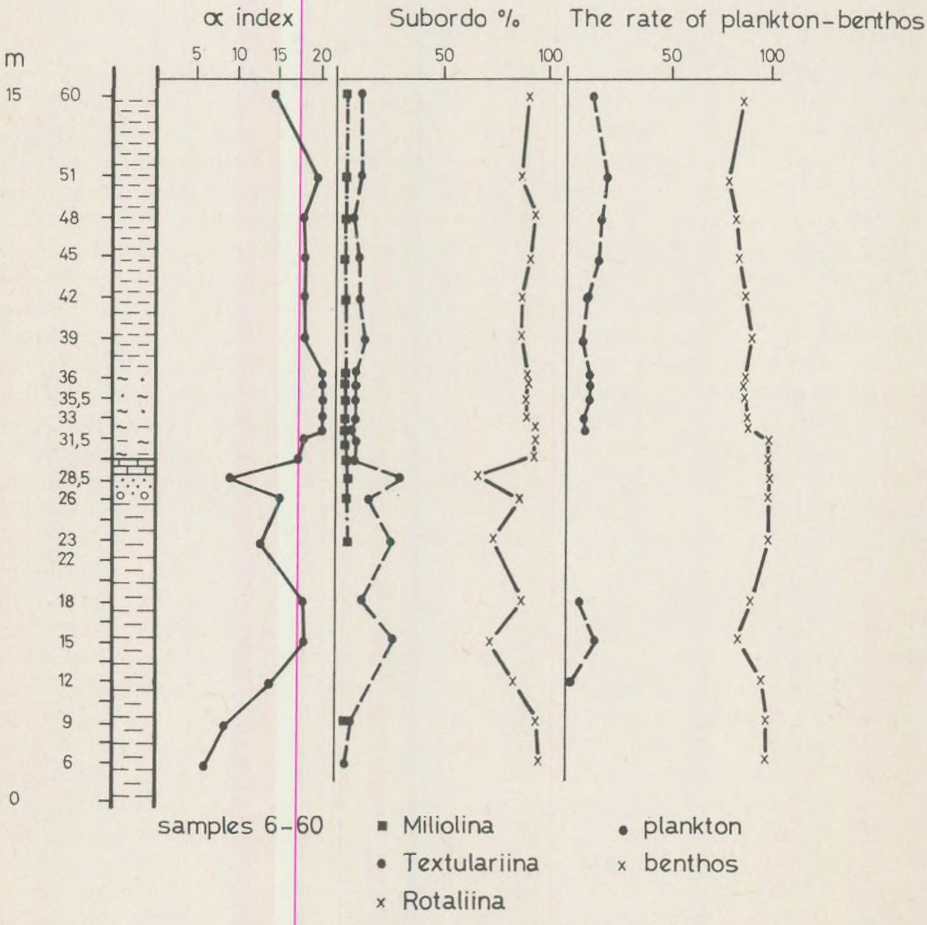

Fig. 2. The profile of the Nyárjastető at Novaj. Characteristic parameters of the foraminifera faunas

2.2.1. Kiscell Clay

Its exposed thickness is 5 m in this outcrop. There are two tuffitic and benthonite-tuffitic intercalations in it. This horizont belongs to the NP 24 nannoplankton zone (Báldi-Beke in Báldi-Beke and Báldi 1974, Báldi-Beke in Báldi and Seneš 1975).

The foraminifera fauna is similar that of the Kiscell Clay of the type-section in Eger in every characteristics. An *Uvigerina gallowayi* association was observed, with high frequency of *U gallowayi* and heterolepas (*H. costata, H bullata, H eocaena, H. simplex)*. The diversity of planktonic forms is low, *Globigerina praebulloides* group, and *Globorotalia (T.) munda* is characteristic.

2.2.2. Eger Formation

2.2.2.1. Novaj member of Eger Formation (Báldi 1979, 1983).

The Kiscell Clay is overlain by the Novaj member conformly, their boundary is very sharp. The boundary Kiscellian and Egerian coincides with the lithological change (Báldi in Báldi-Beke and Báldi 1974).

The Novaj member of the Eger Formation is lithologically diverse. It consists of glauconitic sandstone, Lepidocyclina- and Corallinacea limestone, Miogypsina marl, glauconitic-clayey fine sandstone.

The Kiscell Clay is overlain by the coarse glauconitic sandstone of Novaj member with *Spiroplectammina-Planulina* association. *Sp. carinata* and *P. costata* are abundant. This association corresponds to the *Spiroplectammina-Heterolepa* association in the lower part of the glauconitic sandstone of Eger type-section. They differ only in the number of specimens and in the larger foraminifera content of the Novaj member. The following species have their first appearance: *Bolivina liebusi, Cassidulina laevigata, Cancris turgidus, Operculina complanata,* quinqueloculinas and triloculinas. These later taxa are very important and characteristic in the Novaj member.

The coarse glauconitic sandstone is overlain by the Lepidocyclina- and Corallinacea-bearing limestone. The *Lepidocyclina*-fauna was determined by Drooger (1961), and Kecskeméti (in Báldi et al. 1961) The thin limestone bed is followed by a marl-layer with lepidocyclinas, and heterosteginas (Papp in Báldi and Seneš 1975). The *Miogypsina (M) septentrionalis* has its first appearance in the upper part of the Novaj member The small-foraminifera fauna is characterized by the *Amphistegina lessoni* association, with high abundancy of *A. lessoni*. Frequent taxa are: *Bolivina liebusi, Cassidulina laevigata, Trifarina tubulifera, Neoconorbina tequemi, Rosalina globularis, Discorbis discoides, Asterigerinata planorbis, Elphidium crispum.* The last specimens of *Tritaxia szabói* occur together with miogypsinas. Globorotalias (Turborotalias) are abundant among the planktonic forms, such as *Gr. (T.) opima opima, Gr (T.) opima nana, Gr. (T.) obesa.* The first appearance of *Globigerinoides* is noticed also in this level.

The clayey, glauconitic, fine grained sandstone is the final layer of the Novaj member Its foraminifera fauna is characterized also by the *Spiroplectammina-Heterolepa* association. Though amphisteginas are frequent yet, but miogypsinas, and most other taxa of the Lepidocyclina-marl disappear.

2.2.2.2. The upper member of the Eger Formation

The molluscan clay is exposed in a thickness of about 5 m. It is characterized by a *Spiroplectammina carinata-Heterolepa dutemplei* association, in which *Praeglobobulimina ovata*, *P pyrula*, *Allomorphina trigona*, *Cibicides lobatulus*, and globorotalias (turborotalias) are frequent. *Globigerinoides quadrilobatulus primordius* also has been found.

3. Paleoecology

3.1. The methods applied

The paleoecological investigations were carried out on the base of the following data:

– the number of specimens
– the relative abundancy
– α diversity index value using the diagram of Murray (1973), Murray and Wright (1974)
– the percentage of Miliolina, Textulariina and Rotaliina, figured in the triangular plot (after Murray 1973, Srurrock and Murray 1981, Murray in Hedley and Adams 1976)
– the ratio of the planktonic and benthonic forms (Hughes in Neale and Brasier 1981).

The foraminifera faunas were grouped according to the relations of the frequency of the species. The associations were distinguished by the term: “abundant”, “frequent” and “others”.

3.2. The description of the fossil foraminifera associations

3.2.1. Littoral communities

3.2.1.1. Ammonia beccarii association

Abundant species: Ammonia beccarii

Frequent species: Rotalia propinqua, Cribrononion minutum

Occurence: the uppermost member of the Eger Formation (Eger, Wind-brickyard).

Recent ecological data: The species of *Ammonia* are euryhalin and eury-term organisms, adapted themselves to different marine environments, from the lagoons till self environments (Murray and Wright 1974, Boltovskoy et al. 1980, Boltovskoy in Hedley and Adams 1976). They tolerate the changes in temperature, between 15 – 30 °C (Murray 1973, Bradshaw 1975, 1961). *Ammonia beccarii* lives within the sediment, sometimes in 3 m depth under the sediment surface (Brooks 1967). The species gives the 4 – 33% of the total fauna in the intertidal zone (Murray 1970). *Ammonia beccarii* association lives in the Black Sea, between 20 – 100 m in depth, where the salinity is 15 – 18‰, the substratum is silty sand, and in the Gulf of Mexico its biotope is the coastal “province” (Culver and Buzas 1983, Thomas and Schaffer 1982, Boltovskoy in Hedley and Adams (1976).

Paleoecological conclusions: The low diversity of the foraminifera fauna is not characteristic to the normal marine environment. The presence of a hyposaline lagoonal facies is precluded by the absence of *Miliammina fusca* (Le Campion 1970). The biotope of the *Ammonia beccarii* association of the Eger type-section was in the littoral, or eulittoral zone, 0 – 10 m in depth, where the salinity was 15 – 30%, and the water-temperature was not colder than 12 – 15 °C.

3.2.2. Medium to deep sublittoral communities

3.2.2.1. Caucasina-Cassidulina associations

Abundant taxa: Caucasina elongata, Cassidulina crassa

Frequent taxa: Textularia gramen, Haplophragmoides canariensiformis, Lenticulina div. sp., *Fursenkoina schreibersiana, Florilus boueanus, Nonionella liebusi, Epistominella oweyi*

Other taxa: Cibicidoides pseudoungerianus, Alabamina tangentialis, Cancris auriculus

Occurence: in the molluscan clay member and alternating clay-sand member of the Eger Formation (Eger, Wind-brickyard).

Recent ecological data: Cassidulina obtusa (the analogon form of *Cassidulina crassa*) occurs between 10 – 1000 m, similarly to *Bulimina (=Caucasina) elongata* (MURRAY 1965, 1970, 1971, 1979). In the Adriatic Sea *Nonionella opima* (the analogon form of *N. liebusi*) was observed between 42 – 100 m, where the salinity was 35 – 38%, and the water temperature 12,5 °C (CHIERICI et al. 1962). In the northern Mediterranean Sea the biotope of *Cassidulina crassa* ranges from 50 to 150 m in depth, above the lower limit of the distribution of the vegetation (BLANC – VERNET 1969). According to the observations of BANDY and ARNAL (1957) *Cassidulina minuta* association lives in the outer shelf environments, between 45 – 120 m. The bolivinas without ornamentations live in the inner shelf environment (BANDY 1960). The textularias live in the different regions of the shelves and the upper bathyal zone, between 50 – 640 m (after MURRAY 1973). The recent form of *Haplophragmoides canariensis* can be found in the inner shelf, and it is tolerant to the salinity-changes (PHLEGER 1960).

Paleoecological conclusions: On the base of the different composition and diversity values of the two *Caucasina-Cassidulina* associations two different paleoenvironments were determined.

The biotope of *Caucasina elongata-Cassidulina crassa* associations in the molluscan clay member of the Eger Formation is supposed having ranged from 50 to 100 m at normal salinity (32 – 37%). The indicators of the water depth less than 100 m are *Textularia gramen, Nonionella* and *Epistominella* too. These associations show shallower biotope than the *Spiroplectammina* associations of the lower two-third of the molluscan clay.

The *Caucasinia elongata* association represents shallower biotope than the *C. elongata – C. crassa* association. On the base of the high percentage of Textulariina (max. 51,3%), the high frequency of *Haplophragmoides canariensiformis* the biotope of the *Caucasina elongata* association was in the shallow to middle sublittoral zone (between 30 – 60 m on depth, or maybe less than 30 m).

3.2.2.2. Amphistegina lessoni associations

Abundant taxa: Amphistegina lessoni. A. hauerina, Bolivina liebusi, Cassidulina laevigata, Reusella spinulosa, Neoconorbina terquemi, Asterigerinata planorbis

Frequent taxa: Trifarina tubulifera. Heterolepa dutemplei, Spiroplectammina carinata, Bolivina fastigia, Elphidium crispum, Cibicides tenellus, Anomalia div. sp., *Almaena osnabrugensis*

Other taxa: Miogypsina septentrionalis, Lepidocyclina div. sp., *Heterostegina* div. sp., *Operculina complanata, Quinqueloculina* div sp.

Occurence: in the Novaj member of the Eger Formation (Novaj–Nyárjas)

Recent ecological data: In the Mediterranean the *Amphistegina* associations live in the area together with vegetation. *Planorbulina, Discorbis, Elphidium* and *Asterigerinata* specimens are frequent in these associations (Blanc–Vernet 1969). In the lagoon area between British Honduras and Barrier-reef (max. 6 m in depth) *Amphistegina lessoni* and *Asterigerina carinata* (the analogon form of *A. planorbis*) are dominant in the biofacies, together with *Discorbis, Planorbulina, Quinqueloculina* and *Triloculina* (Cebulski 1962, 1969). In the calcareous litofacies of the Batabano Bay (Cuba) the rate of Textulariina is very low, *Elphidium* and Miliolidae are frequent. The *A. lessoni – A. carinata – Rotorbinella rosea* association is characteristic to the reef complex (Bandy 1964). In the "back reef" facies of the Texas Bay (4,5 – 15 m in depth) the Amphisteginidae and Buliminidae are frequent, and Anomalinidae are rich, Cassidulinidae appear in the "fore reef" facies (>18 m in depth) (Moore 1957). *Amphistegina lessoni* association is described from the middle shelf by Nota (1958). Walton (in Imbrie and Newell 1964) described the distribution of the *Amphistegina* association between 20 – 200 m, in the open-sea with normal salinity.

The optimum conditions of the biotopes for the living larger foraminiferas occur at the reef complexes, to the 60 m in depth (Myers 1943, Nemkov 1960). According to Murray (1973) the distribution of the living larger foraminiferas is only 25 m in depth, in the Mediterranean, and their employing for the temperature is 25 °C in the oceans and 22 °C in the Mediterranean.

In the *Amphistegina lessoni* associations of the clayey-marly beds of the Novaj member there are the sessile forms attached to the vegetation or hard substrata in high amount (i.e. *Rosalina globularis, Planorbulina mediterranensis, Patellina corrugata, Asterigerinata planorbis, Amphistegina lessoni,* etc.; Murray 1968, 1971, 1973; Blanc–Vernet 1969, Atkinson 1969, Reiter 1959, Le Campion 1970). *Neoconorbina terquemi, Escornebovina cuvlillieri, Cycloloculina annulata* belong also to this group on the base of the morphologic analogies. *Cibicides, Cibicidoides, Heterolepa* are also sessile forms. These sessile benthonic foraminiferas can be deposited in the deep sublittoral and deeper zone by the postmortem transportation (Saidova 1976).

Paleoecological conclusions: The Novaj member of the Eger Formation is characterized by noticable variability of the facies. Considering the distribution of the living Rhodophyta (MILLIMANN 1974, LE CAMPION 1970, KRIVÁN–HUTTER 1961) the Corallinacea-bearing limestone of this member was deposited in the shallow sublittoral environment, in 30 m depth.

According to the larger foraminifera records the depth of the deposition of the Lepidocyclina limestone did not reach 25–30 m, and demonstrates an O_2 rich, normal salinity environment, without current activity

In some types of the *Amphistegina lessoni* associations deep sublittoral and bathyal forms can be found in high amount. i.e. *Martinottiella communis. Uvigerina gallowayi. Trifarina tubulifera. Globocassidulina globosa, Baggina philippinensis, Pullenia bulloides, Alabamina wolterstorfi, Gyroidina soldanii.*

Those *Amphistegina lessoni* associations, in which the sessile forms attached to the vegetation are dominant, indicate shallow-, maybe middle-, sublittoral zone with a max. of 40 to 50 m depth, and a supposed water temperature of 20 ± 5 °C, with vegetation and O_2 rich environment. Where deep-sublittoral and bathyal forms occured in *Amphistegina lessoni* associations, the water depth may have reached even 100–150 m.

3.2.2.3. Spiroplectammina associations

Abundant taxa. Spiroplectammina carinata, Heterolepa dutemplei, Lenticulina inornata, Planulina costata, Textularia gramen, Quinqueloculina div sp., *Triloculina* div sp.. *Sigmoilina celata*

Frequent taxa. Bolivina div sp., *Uvigerina gallowayi, Gyroidina soldanii, Almaena osnabrugensis, Ceratobulimina contraria, Neoeponides schreibersii*

Other taxa. Bulimina aksuatica, Cibicidoides conspiciendus, Trifarina globosa, T tubulifera, Valvulineria complanata, Miogypsina div sp.

Occurence: in the glauconitic layers, and in the molluscan clay of the Eger Formation (Eger, Wind-brickayard, Novaj Nyárjas).

Recent ecological data. The foraminifera fauna of the lower two-third of the glauconitic sandstone of the Eger Formation can be estimated as *Bolivina–Bulimina Uvigerina Cassudilina* association, because it contains lo Bolivina species. According to WALTON (in IMBRIE and NEWELL 1964) the faunas with such compositions are dominant between 200–600 m. *Bolivina Bulimina Cassidulina Uvigerina* associations characterize a depth more, than the 600 m. The appearance of the *Planulina, Cassidulina* is noted at the outer edge of the shelf, in the tropic area (NOTA 1958, TODD 1979).

Sigmoilina celata occurs between 65–1000 m in the Adriatic Sea (CHIERICI et al. 1962) The trifarinas live on muddy sediment between 0–400 m (MURRAY 1973).

The "Bolivininae"-associations are characteristic between 1000–150 m in the Pacific Ocean, 200–1400 m in the California Bay, 80–500 m at San Diego, 370–590 m at Santa Barbara (SAIDOVA 1976, KUWANO 1963, PHLEGER 1964); they occur between 83 200 m in the Florida shelf of the Gulf of Mexico, 100 500 m in the NE part of the Gulf of Mexico, 200–

1200 m in the foreland of the Mississippi delta (BANDY 1956, PARKER 1954, PHLEGER 1965).

According to MURRAY (1973) and MURRAY et al. (1981) the quinqueloculinas and triloculinas are euryterm and euryhalin organisms. They live in hypersalin lagoons and in different zones of the shelves, mainly on the temperate and tropic area, but there are arctic taxa too. The high diversity was reported only in the inner shelf ranging to the 100 m in depth, and only few species range to the lower sublittoral and bathyal zone (CURTIS 1955, PHLEGER 1960, CHIERICI et al. 1962). The *Praeglobobulimina* associations belong to lower sublittoral and bathyal environments (MILLER and LOHMANN 1982).

Paleoecological conditions: The foraminifera fauna of the glauconitic sandstone of the Eger Formation is similar to the foraminifera fauna of the underlying Kiscell Clay. During the deposition of the glauconitic sandstone the depth of sea become shallower and the ecological parameters also changed, becoming more different from the lower sublittoral-upper bathyal environments of the Kiscell Clay. The appearance of some taxa attached to the vegetation and hard substratum – i.e. *Planulina ambiqua, Escornebovina legányii, E. cuvillieri, Rosalina globularis, Asterigerinata planorbis* –, the disappearance of large cyclamminas, the first appearance of the *Textularia gramen* proves a decrease in the depth. The sessile benthonic forms suggest the increase of the bottom-current activity, which is demonstrated by the appearance of the glauconite too (PORRENGA 1966).

The formation of the glauconite increases – in the upper third of glauconitic sandstone of the Eger section – the poorer foraminifera fauna occurs.

The foraminifera associations of the glauconitic sandstone in Novaj show better the decrease in the sea-depth.

Summary: the foraminifera faunas of the glauconitic sandstone facies of Eger and Novaj indicate middle and lower sublittoral zone. The water temperature was about 15 °C (after the presence of glauconite). The salinity of the sea-water was normal (34–35%).

The miliolinas are very important elements in the analysis of the depth, describing the biotope of the *Spiroplectammina carinata–Heterolepa dutemplei* associations in the molluscan clay of the Eger section. In the *Sp. carinata–H. dutemplei* associations of the molluscan clay of the Novaj section there are frequent *Praeglobobulimina pyrula, P. ovata, Fursenkoina schreibersiana, Allomorphina trigona, Florilus boueanus.*

During the formation of the molluscan clay in Eger and Novaj the gradual decrease of the depth was proved by the foraminifera fauna. The water depth of the lower part of the molluscan clay member could have been near to the lower sublittoral zone (>120 m), on the base of the diversity of bolivinas, and the occurence of the *Uvigerina gallowayi, Gyroidina soldanii*, praeglobobuliminas, *Allomorphina trigona*. Toward the top of the molluscan clay the diversity of the quinqueloculinas, triloculinas, and the appearance of *Ammonia, Elphidium, Caucasina* suggest the gradual decrease of the depth, and the existence of the middle (and lower) sublittoral environment.

3.2.3. Upper bathyal associations

3.2.3.1. Uvigerina gallowayi association

Abundant taxa: Uvigerina gallowayi, Tritaxia szabói, Heterolepa costata, H. bullata, H. eocaena, Globocassidulina globosa

Frequent taxa: Cyclammina acutidorsata, C. rotundidorsata, Marginulinopsis fragaria, Lenticulina div. sp., *Sphaeroidina bulloides, Cibicidoides ungerianus*

Other taxa: Vulvulina div. sp., *Bolivina* div. sp., *Anomalina* div. sp., *Planulina costata*

Occurence: in the Kiscell Clay of Eger and Novaj sections.

Recent ecological data: the biotope of *Uvigerina peregrina* with buliminas, cyclamminas, globocassidulinas is on the outer shelf and on the upper part of the continental slope around the British Isles (MURRAY 1970, 1971). According to CHIERICI et al (1962) the uvigerinas dominate under 100 m depth in the Adriatic Sea. On the outer shelf and slope area the *Uvigerina peregrina* is a dominant element of the foraminifera fauna with the buliminas (CULVER and BUZAS 1981, STREETER and LAVERY 1982). In the Ligurian Sea *Cassidulina – Bulimina – Uvigerina* association lives in 135 m, the rate of the planktonic forms of this association is 10% (GINUTA 1955). In the N – Mediterranean *Bolivina – Bulimina – Uvigerina* association lives in muddy sediment facies (between 320 – 2400 m), where the rate of the lenticulinas, nodosarias, marginulinas, vaginulinas, dentalinas is 10% The primitive species and forms with labyrinthic inner structure of the agglutinated taxa (*Saccammina, Rhabdammina, Bathysiphon* and *Cribrostomoides, Cyclammina*) are frequent is this depth-interval (BLANC – VERNET 1969, HAIG 1982). According to WALTON (in IMBRIE and NEWELL 1964) the occurence of the bolivinas and uvigerinas ranges between 60 – 200 m, the *Uvigerina* associations dominated under 200 m.

The recent *Cyclammina cancellata* (the analoge form of *Cyclammina acutidorsata*) is known between wide temperature and depth conditions (BRADY 1884, GOES 1896, CUSHMAN 1920, NORMANN 1876, ASANO 1951, AKERS 1954, etc.).

The abundancy of the uvigerinas has been observed under 100 or/and 200 m in some recent biotopes in the seas (PHLEGER 1960, MURRAY 1973, SAIDOVA 1976, BOLTOVSKOY 1980). The cyclamminas, gaudryinas, karreriellas, martinottiellas, bathysiphons dominate mainly under 100 m in depth and they are of cold-water character (MURRAY 1973, GOODAY 1983, BOLTOVSKOY and WRIGHT 1976). The cibicideses with coarse perforation (recent group of heterolepas) can be observed from the middle shelf to the different part of the bathyal zone (SEJRUP et al. 1981, SAIDOVA 1976).

Paleoecological conditions: the high diversity itself in the *Uvigerina gallowayi* association refer to the lower sublittoral or upper bathyal zone (BANDY 1960, MURRAY 1970). The biotope of the *Uvigerina gallowayi* association can be placed to the lower sublittoral or upper bathyal zone, under 150 – 200 m in depth. The water temperature seems to have been about at 10 °C or less, the salinity and O_2 content might be normal. However, sometimes the O_2 content could have been less, than normal (LOHMANN 1978).

4. Summary

The stratotype-sections of the Egerian in Hungary show different lithological and microfaunistic characteristics.

As it was evidenced by both foraminiferal faunistic studies and the approximately exact determination of the ecological parameters of the Eger and Novaj sections (similarly to the Budafok – 2. section; BÁLDI et al. 1974, HORVÁTH and T. MAKK 1974, HORVÁTH 1980, 1983), the post-Kiscellian regression resulted in a succession of superimposed lithological units of different pattern in Hungary. The beginning of the regression is indicated by the glauconitic sandstone in the Eger and Novaj sections. The differences between the two sections are as follows:

– only glauconitic sandstone deposited in the Eger area

– in the area of Novaj (and Demjén – Bogács; KRIVÁN – HUTTER 1961, SZTRÁKOS 1974, MAJZON 1966) small calcareous bodies were deposited (Corallinacea and *Lepidocyclina* limestone) at the gradual uplift of the depositional basin. This short interval of the regression phase was followed by the deepening of the sea in the both areas (sea of the molluscan clay). Its depth, however, did not reached the depth of the Kiscell Clay, as it was evidenced by the diversity of Miliolina, despite of the similar environmental factors.

The second regression phase of Egerian can be traced only in the Wind brickyard profile. The regression is recognizable in both the lithological characteristics and the foraminifera fauna, whether turning into a brackish-water associations (*Ammonia beccarii* associations) or its total absence (in the fresh-water beds).

Three biostratigraphical intervals can be separated by benthonic foraminiferas in the marine beds of the holostratotype section:

– the foraminifera fauna of Kiscell Clay is Paleogene character, with the dominance of cyclamminas, vulvulinas, heterolepas, tritaxias. The last appearance of *Tritaxia szabói* occured after the boundary of Kiscellian and Egerian, near to the first appearance of *Miogypsina formosensis*

– the foraminifera fauna of sandy, glauconitic beds shows transitional interval, in which the first appearance of the Miocene taxa (i.e. *Asterigerinata planorbis*) can be observed. This observation supports the opinion of BOLTOVSKOY (1980) about the evolution of the Recent foraminifera fauna.

– the third interval is shown by the foraminifera fauna of the molluscan clay, in which there are the first appearances of *Miogypsina formosensis, Globigerinoides.*

On the base of the distribution of the plankton foraminiferas the holostratotype section of Eger and the parastratotype section of Novaj belong to the P 21 and P 22 zones. The presence of the N 4 zone is not proved, because of the lacking of marine sediments of the Upper Egerian at Eger and Novaj.

The Oligocene/Miocene boundary can not be defined in these sections described here, because of the pre-Eggenburgian denudation (BÁLDI and

Radócz 1965). The Eger Formation is overlain unconformly by Miocene rhyolite tuff (Hámor 1978).

Acknowledgements

I should like to thank Prof. T. Báldi, Mr. A. Nagymarosy, Mrs. R. Nyirő and Mrs. M. Liszka for helping in the formulation of this paper.

LIST OF FORAMINIFERAS

Rhabdammina eocaenica Cushman et Hanna, 1927	1
Bathysiphon filiformis M. Sars, 1870	1
Bathysiphon taurinense Sacco, 1893	1, 3
Saccammina sphaerica M. Sars, 1870	2, 8
Ammodiscus incertus d'Orbigny, 1839	1, 3
Glomospira charoides (Parker et Jones, 1860)	1, 2, 3, 8
Glomospira gordalis (Parker et Jones, 1860)	3
Haplophragmoides canariensiformis Sztrákos, 1978	3, 4, 5, 8
Haplophragmoides deforme (Andreae, 1884)	1, 3
Haplophragmoides latidorsatus (Bornemann, 1855)	1
Cyclammina acutidorsata (Hantken, 1868)	1, 2, 3
Cyclammina placenta (Reuss, 1851)	1, 3, 8
Cyclammina rotundidorsata (Hantken, 1875)	1, 2, 3
Spiroplectammina carinata (d'Orbigny, 1846)	1, 2, 3, 4, 6, 7, 8
Spiroplectammina deperdita (d'Orbigny, 1846)	1, 2, 3, 4, 6, 7, 8
Spiroplectammina pectinata (Reuss, 1850)	1, 2, 3
Vulvulina capreolus d'Orbigny, 1826	1, 2, 6, 7
Vulvulina haeringensis (Gümbel, 1868)	1, 2, 6
Vulvulina pectinata Hantken, 1875	1, 3, 4, 6, 7
Textularia agglutinans d'Orbigny, 1839	1, 2
Textularia bronniana d'Orbigny, 1846	3
*Textularia gramen*d'Orbigny, 1846	1, 2, 3, 4, 6, 7, 8
Textularia pala Czjzek, 1848	1, 2, 7
Textularia sagittula Defrance, 1824	3
Textularia speyeri (Reuss, 1865)	1, 6
Textularia spinulosa d'Orbigny	1
Textularia turris d'Orbigny, 1840	1
Bigenerina nodosaria d'Orbigny, 1826	1
Planctostoma oligocaenica Sztrákos, 1978	1, 2
Siphotextularia concava (Karrer, 1868)	3
Trochammina globigeriniformis (Parker et Jones, 1865)	1
Trochammina nobensis Asano, 1951	3
Gaudryina rugosa d'Orbigny, 1846	1
Tritaxia haeringensis (Cushman, 1936)	1, 6
Tritaxia havanensis (Cushman et Bermudez, 1937)	1, 6
Tritaxia szabói (HantKen, 1868)	1, 2, 6, 7
Dorothia parri Cushman, 1936	1, 2, 7
Dorothia textilaroides (Hantken, 1875)	8
Karreriella chilostoma (Reuss, 1852)	1
Karreriella hantkeniana Cushman, 1936	1
Karreriella siphonella (Reuss, 1851)	1, 2, 3, 4, 6, 7, 8
Tritaxilina reussi (Hantken, 1868)	1, 2
Martinottiella communis (d'Orbigny, 1826)	1, 2, 4, 6, 7, 8
Cyclogyra involens (Reuss, 1850)	1, 2, 3
Spiroloculina canaliculata d'Orbigny, 1846	1, 2, 3, 7
Spiroloculina dorsata Reuss, 1865	1
Spiroloculina tenuissima Reuss, 1867	1, 2, 3, 4, 7, 8,
Quinqueloculina agglutinans d'Orbigny, 1839	1, 2, 3, 6, 7

Quinqueloculina akneriana d'Orbigny, 1846	2, 3, 4, 7
Quinqueloculina badenensis d'Orbigny, 1846	3
Quinqueloculina bicarinata d'Orbigny, 1826	3
Quinqueloculina carinata d'Orbigny, 1850	1, 2, 3,
Quinqueloculina impressa Reuss, 1851	2, 3, 4, 7
Quinqueloculina juleana d'Orbigny, 1846	2, 3, 4, 7, 8
Quinqueloculina longirostra d'Orbigny, 1826	3
Quinqueloculina ludwigi Reuss, 1865	7
Quinqueloculina seminula (Linne, 1758)	2, 3, 4, 6, 7, 8
Sigmoilina celata (Costa, 1850)	1, 2, 3, 4, 6, 7, 8
Sigmiolina tenuis (Czjzek, 1848)	2, 3, 4, 7
Triloculina consobrina d'Orbigny, 1846	1, 3, 4
Triloculina gibba d'Orbigny, 1826	1, 2, 3, 7
Triloculina tricarinata d'Orbigny, 1826	2, 3, 7, 8
Triloculina trigonula (Lamarck, 1804)	3
Scutuloris oblongus (Montagu, 1803)	2
Nodosaria acuminata Hantken, 1875	1, 2, 7
Nodosaria bacillum Defrance, 1825	1, 2, 3, 7,
Nodosaria bacilloides Hantken, 1868	1, 2, 3
Nodosaria badenensis d'Orbigny, 1846	7, 8
Nodosaria exilis Neugeboren, 1852	1, 2, 3, 8
Nodosaria hispida d'Orbigny, 1846	3
Nodosaria latejugata Gümbel, 1868	1, 2, 3, 4, 7, 8
Nodosaria minor Hantken, 1875	1, 7
Nodosaria pyrula d'Orbigny, 1826	1, 2, 3
Nodosaria radicula (Linne, 1758)	1
Nodosaria scalaris (Batsch, 1791)	1, 3, 8
Nodosaria spinicostata d'Orbigny, 1826	1, 2, 3, 4, 6, 7, 8
Amphicoryna marginuliniformis Nyirő, 1961	3
Amphicoryna tunicata (Hantken, 1868)	1, 3
Astacolus kochi (Reuss, 1865)	3
Astacolus recurrens (Reuss, 1865)	1
Chrysalogonium longiscatum (d'Orbigny, 1846)	1, 2, 3, 7, 8,
Dentalina acuta d'Orbigny, 1846	1, 2, 3, 7, 8
Dentalina approximata (Reuss, 1865)	1, 2, 3, 4, 7, 8,
Dentalina bifurcata d'Orbigny, 1846	1, 2, 6
Dentalina budensis Hantken, 1875	3
Dentalina capitata (Boll, 1846)	1, 8
Dentalina ehrenbergiana Neugeboren, 1856	7
Dentalina guembeli Hantken, 1875	1, 2, 3, 6, 7
Dentalina inornata d'Orbigny, 1846	1, 2, 3, 4, 7, 8
Dentalina intermedia Hantken, 1875	1, 3, 6, 7
Dentalina oblequestriata Reuss, 1858	1, 2, 7
Dentalina pungens Reuss, 1851	1, 3, 8
Dentalina soluta Reuss, 1851	1, 2, 3, 7, 8
Dentalina spinescens Reuss, 1851	3
Dentalina subtilis Neugeboren, 1856	3
Frondicularia budensis (Hantken, 1875)	1, 2
Frondicularia tenussima Hantken, 1875	1
Lagena clavata (d'Orbigny, 1846)	3, 7, 8
Lagena globosa (Montagu, 1803)	1, 2, 3, 6, 7, 8
Lagena hispida Reuss, 1858	1, 2, 3, 4, 7, 8
Lagena isabella (d'Orbigny, 1839)	1, 2, 3, 6, 7
Lagena laevis (Montagu, 1803)	3
Lagena striata (d'Orbigny, 1839)	1, 2, 3, 4, 6, 7, 8
Lagena sulcata (Walker et Jacob, 1798)	1, 2, 3, 6, 7, 8
Lenticulina arcuatostriata (Hantken, 1868)	1, 2, 3, 6, 7, 8
Lenticulina calcar (Linne, 1758)	1, 2, 3, 8
Lenticulina crassa (d'Orbigny, 1846)	1, 7

Lenticulina cultrata (MONTFORT, 1808)	1, 2, 3, 4, 6, 7, 8
Lenticulina declivis (BORNEMANN, 1855)	1, 2, 3, 6
Lenticulina deformis (REUSS, 1851)	1, 2, 3
Lenticulina depauperata (REUSS, 1851)	1, 2, 3, 6, 7, 8
Lenticulina galeata (GÜMBEL, 1868)	1
Lenticulina inornata (D'ORBIGNY, 1846)	1, 2, 3, 4, 5, 6, 7, 8
Lenticulina limbosa (REUSS, 1863)	1, 2, 3, 6, 7
Lenticulina princeps (REUSS, 1865)	1, 2, 3
Lenticulina simplex (D'ORBIGNY, 1846)	3, 4
Lenticulina vortex(FICHTEL et MOLL, 1798)	1, 2, 3, 6, 7, 8
Marginulina behnmi (REUSS, 1865)	1, 2, 3, 6, 7, 8
Marginulina bullata REUSS, 1845	1
Marginulina glabra D'ORBIGNY, 1826	1, 3, 7, 8
Marginulina hirsuta D'ORBIGNY, 1826	1, 2, 3, 6, 7, 8
Marginulina indifferens HANTKEN, 1875	1, 2
Marginulina minuta HANTKEN, 1875	1
Marginulina pediformis BORNEMANN, 1855	1, 2, 3, 6, 7, 8
Marginulina splendens HANTKEN, 1875	3
Marginulina subbullata HANTKEN, 1875	1, 2, 3, 8
Marginulina tumida REUSS, 1851	1, 2, 3
Marginulina variabilis NEUGEBOREN, 1851	1, 3
Marginulinopsis fragaria (GÜMBEL, 1868)	1, 2, 3, 6, 7, 8
Palmula oblonga (ROEMER, 1838)	3, 8
Planularia bullata (HANTKEN, 1875)	1, 2, 3
Planularia budensis (HANTKEN, 1875)	1, 2, 3
Planularia kubinyii (HANTKEN, 1868)	1, 2, 6
Pseudonodosaria acuta (LEROY, 1941)	1, 2, 3
Pseudonodosaria aequalis (REUSS, 1863)	1, 2, 3, 7, 8
Pseudonodosaria disrecta (REUSS, 1850)	1, 2, 3
Saracenaria hantkeni CUSHMAN, 1933	1, 2, 3, 6, 7, 8
Saracenaria italica DEFRANCE, 1824	3, 7, 8
Saracernaia propinqua (HANTKEN, 1875)	1
Saracenaria senni HEDBERG, 1937	1, 2, 3
Vaginulina plana NYIRŐ, 1961	1, 2, 7
Vaginula sp. 1. (n. sp.)	1, 2, 3, 6, 7
Vaginulinopsis gladius (PHILIPPI, 1843)	1, 2
Vaginulinopsis pseudodecorata HAGN, 1952	3, 8
Vaginulinopsis schwageri (HANTKEN, 1875)	1, 2, 3
Bolivinella rugosa HOWE, 1930	2, 7
Glubulina gibba (D'ORBIGNY, 1826)	1, 2, 3, 6, 7, 8
Globulina gibba globosa (MÜNSTER, 1838)	1, 2, 3, 7
Globulina gibba punctata D'ORBIGNY, 1846	1, 7
Globulina gibba granulosa (EGGER, 1857)	7
Globulina inaequalis REUSS, 1850	1, 2, 3, 8
Guttulina hantkeni CUSHMAN et OZAWA, 1930	1, 2
Guttulina problema (D'ORBIGNY, 1826)	1, 2, 3, 6, 7, 8
Guttulina problema deltoidea (REUSS, 1865)	1, 2, 3, 4, 6, 7, 8
Pseudopolymorphina obscura (ROEMER, 1838)	1, 3
Pyrulina fusiformis (ROEMER, 1838)	1, 3, 4, 5, 7
Pyrulina cylindroides (ROEMER, 1838)	8
Sigmomorphina regularis (ROEMER, 1838)	1, 2
Glandulina dimorpha (BORNEMANN, 1855)	1, 6
Glandulina laevigata (D'ORBIGNY, 1826)	1, 2, 3, 6, 7, 8
Oolina marginata (MONTAGU, 1803)	1, 2, 3
Oolina orbignyana (SEGUENZA, 1862)	2, 3, 6
Fissurina leavigata REUSS, 1850	1, 2, 3, 6, 7, 8
Neobulimina budensis (HANTKEN, 1875)	1, 2
Sphaeroidina bulloides D'ORBIGNY, 1826	1, 2, 3, 4, 5, 6, 7, 8
Bolivina antiqua D'ORBIGNY, 1846	1, 2, 3, 7, 8

Bolivina beyrichi beyrichi Reuss, 1851	1
Bolivina beyrichi carinata Hantken, 1875	1, 2, 3, 4, 7, 8
Bolivina crenulata trunensis Hofmann, 1967	2, 3
Bolivina dilatata dilatata Reuss, 1850	7
Bolivina elongata Hantken, 1875	1, 2
Bolivina fastigia Cushman, 1936	1, 21, 3, 7, 8
Bolivina liebusi Hofmann, 1967	2, 3, 6, 7
Bolivina nobilis Hantken, 1875	1, 2
Bolivina oligocaenica oligocaenica Spandel, 1909	1, 2, 3, 7, 8
Bolivina reticulata Hantken, 1875	1, 2, 3, 7, 8
Bolivina semistriata Hantken, 1875	1, 2, 7
Bolivina versatilis versatilis Hofmann, 1967	8
Rectobolivina zsigmondyi (Hantken, 1868)	1, 2, 6, 7
Cassidulinoides oblongus (Reuss, 1850)	3, 7, 8
Stilostomella adolphina (d'Orbigny, 1846)	1, 2, 3, 4, 8
Stilostomella consobrina (d'Orbigny, 1846)	1, 2, 3, 6, 7, 8
Stilostomella elegans (d'Orbigny, 1846)	1, 2, 3, 4, 6
Stilostomella egregia (Franzenau, 1889)	1
Stilostomella pauperata (d'Orbigny, 1846)	1, 3
Stilostomella verneuili (d'Orbigny, 1846)	1, 3
Bulimina affinis d'Orbigny, 1839	1, 3, 8
Bulimina alsatica Cushman et Parker, 1937	1, 2, 7
Bulimina aksuatica Morozova, 1939	1, 2
Bulimina kasselensis Batjes, 1958	1, 2, 3, 4, 8
Praeglobobulimina ovata (d'Orbigny, 1846)	1, 2, 3, 8
Praeglobobulimina primitiva (Todd, 1952)	1
Praeglobobulimina pupoides (d'Orbigny, 1846)	3, 4
Praeglobobulimina pyrula (d'Orbigny, 1846)	1, 3, 4, 7, 8
Reusella spinulosa (Reuss, 1850)	1, 2, 3, 4, 7
Uvigerina farinosa Hantken, 1875	1, 2, 3, 6, 7
Uvigerina gallowayi Cushman, 1929	1, 2, 3, 6, 7, 8
Uvigerina steyri steyri Papp, 1975	2, 3, 4, 7, 8
Trifarina angulosa (Williamson, 1858)	1, 3, 4, 5, 7
Trifarina bradyi Cushman, 1923	7
Trifarina globosa (Stoltz, 1925)	3
Trifarina gracilis (Reuss, 1851)	1, 2, 3, 7
Trifarina tenuistriata (Reuss, 1870)	1, 2, 3, 7
Trifarina tubulifera (Kaaschieter, 1961)	2, 3, 7
Discorbis biapertura (Pokorny, 1956)	2, 7
Discorbis discoides (d'Orbigny 1826)	2, 7
Discorbis squamula (Reuss, 1867)	7
Neoconorbina terquemi (Rzehak, 1888)	7
Escornebovina cuvillieri (Poignant, 1965)	2, 7, 8
Escornebovina legányii (Kenawy et Nyirő, 1967)	1, 2
Rosalina globularis d'Orbigny, 1826	2, 3, 7
Baggina philippinensis (Cushman, 1921)	1, 2, 7
Cancris auriculus (Fichtel et Moll, 1789)	1, 2, 3, 7, 8
Cancris turgidus Cushman et Todd, 1942	2, 3, 6, 7
Valvulineria complanata (d'Orbigny, 1846)	1, 2, 3, 6, 7, 8
Siphonina reticulata (Czjzek, 1848)	1, 2, 6, 7
Siphonina pseudocarinata Nyirő, 1961	3
Asterigerinata falcilocularis (Subbotina, 1960)	1
Asterigerinata planorbis (d'Orbigny, 1846)	2, 3, 7, 8
Patellina corrugata Williamson, 1858	7
Rotalia propinqua Reuss, 1856	5, 7
Ammonia beccarii (Linne, 1758)	3, 4, 5
Pararotalia audouini (d'Orbigny, 1850)	7
Elphidium advenum (Cushman, 1922)	6, 7
Elphidium crispum (Linne, 1758)	3, 7

Elphidium flexuosum s. l. (d'Orbigny, 1846)	3, 7
Elphidium latidorsatum (Reuss, 1864)	2
Elphidium ungeri (Reuss, 1850)	7
Cribrononion dollfusi (Cushman, 1936)	7
Cribrononion hiltermanni (Hagn, 1952)	2, 5, 7
Cribrononion minutum (Reuss, 1865)	5
Cribrononion subnodosum (Roemer, 1838)	7
Protelphidium subgranosum (Egger, 1857)	2, 4, 5
Operculina complanata (Defrance, 1822)	7
Heterostegina costata d'Orbigny, 1846	7
Miogypsina (Miogypsinoides) formosensis Yabe et Hanzawa, 1928	3
Miogypsina (Miogypsina) septentrionalis Drooger, 1960	3, 7
Globorotalia (Turborotalia) munda (Jenkins, 1965).	1, 2, 3, 7, 8
Globorotalia (Turborotalia) obesa (Bolli, 1957)	2, 3, 7, 8
Globorotalia (Turborotalia) opima nana (Bolli, 1957)	1, 2, 3, 7, 8
Globorotalia (Turborotalia) oipima opima (Bolli, 1957)	2, 3, 7, 8
Globorotalia (Turborotalia) permicra (Blow et Banner, 1962)	3, 7, 8
Globigerinita dissimilis dissimilis (Cushman et Bermudez, 1937)	1, 3, 7, 8
Globigerinita martini scandretti (Blow et Banner, 1962	1, 3, 7, 8
Globigerinita unicava primitiva Blow et Banner, 1962	3, 8
Globorotaloides suteri Bolli, 1957	1, 2, 3, 7, 8
Globigerina anguliofficinalis Blow, 1969	1
Globigerina angulisuturalis Bolli, 1957	3, 7, 8
Globigerina angustiumbilicata Bolli, 1957	1, 2, 3, 7, 8
Globigerina euapertura Jenkins, 1960	1, 2, 3
Globigerina gortanii gortanii (Borsetti, 1959)	1
Globigerina officinalis Subbotina, 1953	1, 2, 3, 7, 8
Globigerina ouachitaensis ciperoensis Bolli, 1954	1, 2, 3, 7, 8
Globigerina ouachitaensis ouachitaensis Howe et Wallace, 1932	1, 2, 7, 8
Globigerina ouachitaensis gnaucki Blow et Banner, 1962	1
Globigerina praebulloides leroyi Blow et Banner, 1962	1, 2, 3, 4, 7, 8
Globigerina praebulloides occlusa Blow et Banner, 1962	1, 2, 3, 7, 8
Globigerina praebulloides praebulloides Blow, 1959	1, 2, 3, 4, 7, 8
Globigerina senilis Bandy, 1949	1, 2, 3, 7
Globigerinoides quadrilobatulus primordius Blow et Banner, 1962	3, 8
Neoeponides schreibersii (d'Orbigny, 1826)	1, 2, 3, 4, 7
Amphistegina chochtawensis (Cushman et Mcglamery, 1938)	7
Amphistegina hauerina d'Orbigny, 1846	7
Amphistegina lessoni d'Orbigny, 1826	7
Planulina ambigua (Franzenau, 1888)	1, 2
Planulina costata (Hantken, 1875)	1, 3, 6, 7, 8
Planulina wuellerstorfi (Schwager, 1866)	1, 2, 3, 6, 7, 8
Cibicides americanus (Cushmann, 1981)	1, 2, 6, 7
Cibicides borislavensis Aisenstat, 1954	7
Cibicides lobatulus (Walker et Jacob, 1798)	1, 3, 8
Cibicides pygmeus (Hantken, 1875)	1, 2, 3, 6, 7
Cibicides roemeri (Reuss, 1856)	1, 2, 3, 6, 7
Cibicides tenellus (Reuss, 1865)	3, 6, 7
Cycloloculina annulata Heron – Allen et Earland, 1908	7
Dyocibicides cubensis Cushman et Bermudez, 1936	1, 2
Planorbulina mediterranensis d'Orbigny, 1826	7
Pleurostomella acuta Hantken, 1875	3
Pleurostomella eocaena (Gümbel, 1868)	1
Fursenkoina schreibersiana (Czjzek, 1848)	1, 2, 3, 4, 5
Coryphostoma limbata (Brady, 1884)	2, 8
Coryphostoma sinuosa (Cushman, 1936)	2, 7
Caucasina elongata (d'Orbigny, 1826)	1, 2, 3, 4, 5, 8
Cassidulina crassa d'Orbigny, 1939	1, 2, 3, 4, 5, 8
Cassidulina laevigata d'Orbigny, 1826	2, 7

Globocassidulina globosa (Hantken, 1875)	1, 2, 6, 7, 8
Chilostomella ovoidea Reuss, 1850	8
Allomorphina trigona Reuss, 1850	3, 8
Florilus boueanus (d'Orbigny, 1846)	3, 4, 5, 7, 8
Florilus buxovillana (Andreae, 1885)	1, 2
Nonionella liebusi Hagn, 1952	3, 4, 5, 8
Pullenia bulloides (d'Orbigny, 1826)	1, 2, 3, 6, 7, 8
Pullenia quinqueloba (Reuss, 1851)	1, 2, 3, 6, 7
Alabamina tangentialis (Clodius, 1922)	1, 2, 3, 4, 6, 7, 8
Alabamina wolterstorffi (Franke, 1925)	1, 2, 6, 7
Gyroidina soldanii d'Orbigny, 1826	1, 2, 3, 4, 6, 7, 8
Gyroidina soldanii girardana (Reuss, 1851)	1, 2, 3, 4,
Gyroidina soldanii mamillata (Andreae, 1884)	1, 2
Svratkina perlata (Andreae, 1884)	1, 2, 3, 4
Osangularia umbonata (Reuss, 1815)	1, 2, 3
Gyroidinoides parvus (Cushman et Renz, 1941)	1, 3
Gyroidinoides planulatus (Cushman et Renz, 1941)	1, 7
Anomalina affinis (Hantken, 1875)	1, 2, 6, 7
Anomalina crassiseptata Cushman et Siegfus, 1935	3, 6, 7
Anomalina cryptomphala (Reuss, 1850)	1, 2, 3, 6, 7, 8
Anomalina similis (Hantken, 1875)	1, 2, 3, 8
Anomalinoides granosus (Hantken, 1875)	1, 2, 3, 6, 7, 8
Anomalinoides grosserugosus (Gümbel, 1868)	1, 2, 3, 6, 7
Cibicidoides conspiciendus (Pishvanova, 1959)	1, 2, 3, 6, 7, 8
Cibicidoides pseudoungerianus (Cushman, 1922)	1, 2, 3, 4, 6, 8
Cibicidoides ungerianus (d'Orbigny, 1846)	1, 2, 3, 7, 8
Hanzawaia boueana (d'Orbigny, 1846)	2, 3, 6, 7
Hanzawaia americana (Cushman, 1918)	1, 7, 8
Heterolepa bullata Franzenau, 1884	1, 2, 3, 6, 7
Heterolepa costata Franzenau, 1884	1, 2, 3, 7, 8
Heterolepa dutemplei (d'Orbigny, 1846)	2, 3, 4, 5, 7, 8
Heterolepa eocaena (Gümbel, 1868)	1, 2, 3, 6, 7
Heterolepa simplex Franzenau, 1884	1
Melonis affinis (Reuss, 1851)	1, 2, 3, 6, 7, 8
Melonis soldanii (d'Orbigny, 1846)	1, 2
Almaena osnabrugensis s. l. (Roemer, 1838)	1, 2, 3, 4, 6, 7, 8
Ceratobulimina contraria (Reuss, 1851)	1, 2, 3, 7, 8
Hoeglundina eocaenica (Cushman et Hanna, 1927)	1, 2
Hoeglundina elegans (d'Orbigny, 1826)	3, 7, 8
Stomatorbina concentrica (Jones et Parker, 1864)	7
Robertina declivis (Reuss, 1863)	8
Alliatina nitida (Tollmann, 1957)	3, 4, 8

Legend:

1 = Kiscell Clay (Eger, Novaj)
2 = glauconitic sandstone, Eger Formation, Eger
3 = molluscan clay, Eger Formation, Eger
4 = alternating sand-clay member, Eger Formation, Eger
5 = uppermost member, Eger Formation, Eger
6 = glauconitic sandstone of the Novaj member, Eger Formation, Novaj
7 = Novaj member, of the Eger Formation, Novaj
8 = molluscan clay, Eger Formation, Novaj

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THE CORRELATION OF THE BADENIAN IN HUNGARY BASED ON NANNOFLORAS

by

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(Recived: 10th April 1984)

Abstract

Studying the nannofloras of Transdanubian and North-Hungarian sections the author has fixed the base of the Badenian stage in the deeper part of Martini's NN5 nannozone. This zone (NN5) corresponds to the Lagenid-zone of GRILL while the NN6 goes for the Spiroplectammina-zone. The equivalent of the NN7 zone is GRILL's Bolivina-Bulimina zone. The paper gives the age of the beginning of the Badenian volcanic activity in Hungary and that of some formations using nannozones.

1. Introduction

The stratigraphic investigations of calcareous nannoplankton associations – the Miocene nannoflores included – in Hungary have begun not long ago, although the nannoplankton assemblages are valuable markers and enable good correlation between distant territories. The introduction of the Neogene regional stages of the Paratethys needed the examination of the correct biostratigraphic position of the geological formations and events by all the fossil evidence available.

In this paper, the goal was to study the value of the nannofloras in the timing gained from the middle Miocene Badenian formations in Hungary. The greater part of the results was published in Hungarian language in 1980. This version was enlarged by involving data of some newer studies.

I am indebted to R. LEHOTAYOVÁ (Bratislava, Geol. Inst. Dion. Štur) who made the greatest part of the scanning electron photomicrographs.

2. Definition and subdivision of the stage Badenian

Before the introduction of the stage-name Badenian, a number of other names were in usage:

The Upper Mediterranean stage (Obere Mediterranstufe) was named after the recognition of the second great Indopacific "mollusc-invasion" in the Miocene. In 1857 MAYER–EYMAR (in PAPP and THENIUS 1959) published first the stage-name of Tortonian ("Tortoniano") in relation with the blue marls (blaue Mergel) found nearby the Italian village of Tortona, containing *Cardita jouanetti. Conus canaliculatus* and *Ancillaria glandifor-*

mis. The virtual similarity between the mollusc fauna of the stratotype and the Middle-European fauna now dated as Badenian, led some authors to use the name Tortonian in the area of the Central Paratethys too and namely to the Vienna basin. PAPP et al. (1968) and CICHA et al. (1968) were first to publish the stage Badenian. According to their definition, the formations younger than the first appearance of *Orbulina* and older than the appearance of the Sarmatian mollusc fauna can be regarded as Badenian. According to the newest aggreement, the lower limit of the stage Badenian is marked by the first appearance of *Praeorbulina glomerosa* BLOW.

The complex stratigraphic studies of the stratotypes led to the clearing up of the correlation between the stages of the Paratethys and those of the "Tethys" by using planktonic foraminiferas. According to CITA and BLOW (1969) the Langhiano corresponds to the upper part of zone N8 and to the zone N9. The Serravalliano ranges from zone N10 approximately to the middle of zone N15 and the Tortoniano follows it till the middle of zone N17. Although the Paratethys stages have no rich planktonic foraminifera faunas, the BLOW zones can be demonstrated here as well. The lowest Badenian corresponds to the Langhiano in the zone N 8. and this date is well defined by the first appearance of the species *Praeorbulina glomerosa*. The upper stage boundary is probably in the zone N 13, because fossils indicating younger zones have not been found yet. (RÖGL 1975). This proves that the stage Badenian and the Tortoniano are not overlapping each other in time at all.

Nannofloras of Badenian formations have been investigated for three decades. The pioneers in this field were KAMPTNER and STRADNER

In their works, STEININGER, RÖGL et al. (1976) and PAPP (1975) confirm, that the Lagenid zone of GRILL fits completely to the zone NN 5 of MARTINI. From the upper Badenian of Romania, FUCHS (in PAPP 1975) described the zone NN 7, where *Discoaster challengeri* and *Scyphosphaera apsteini* occur together with *Globigerina druryi* and *Velapertina indigena*. Detailed studies of the Badenian nannofloras of the Central-Paratethys are published by FUCHS and STRADNER (1977), LEHOTAYOVÁ, MOLČIKOVA, STRADNER and FUCHS (1978). In Hungary, it was BÁLDI – BEKE, who first described rich Miocene and among them Tortoniano nannofloras in 1960. In 1964 BÓNA J. and BÁLDI – BEKE published nannoflora-lists from the Miocene of Mecsek Mountains. Since the paper of BÓNA J. and KERNERNÉ (1966) dealing with the nannoflora of the borehole Tekeres – 1, no paper concerning Badenian nannoplankton in Hungary was published.

3. The investigated Badenian sections and their nannofloras

3.1. Sajó-valley

The coal-prospecting boreholes having explored the Miocene brown coal bearing sequence int he Sajó-valley usually penetrate some meters in the deepest known underlying formation of the glauconitic (Pétervására) Sandstone. *Pecten pseudobeudanti* DEP. et ROM and *P. hornensis* DEP. et ROM.

were described by Schréter (1929) and Csepreghyné – Meznerics I. (1959) from this sandstone, thus proving its Eggenburgian ("lower Mediterranean") age. The sandstone is overlain by the lower rhyolite tuff which is very thin or absent in many places. In Schréter's opinion, its maximal thickness is between 20 and 40 meters. This rhyolite tuff is the direct underlayer of the coal deposit of "lower Helvetian" (Ottnangian) age.

The overlying strata of the coal sequence are of Karpatian age (Schréter 1929) according to the species *Chlamys scabrella* Lamarck and *C. scabriuscula* Math. This series composed of clayey sandstone and sandstone has a thickness of 100 – 150 meters and passes upwards gradually into schlier.

The middle-rhyolite tuff horizon does not separate sharply the Karpatian schlier and the overlying, Badenian, white, foraminifera-bearing clayey marl, but appears as pumiceous or tuffitic disseminations in the sediments. In the surroundings of Ózd, this clayey marl is covered by patches of Leithakalk.

The white marly strata are overlain conformly by the final member of the whole sequence. the piroxen-andesitic tuff, agglomerate and the tuffitic conglomerate, which covers most of the surface. Andesitic pebbles of diameters ranging from some millimetres to some dozens of cm-s are the constituents of the formation which was deposited in a high energy substance (fluviatile crossbeddings). Not regarding some *Acer* and *Salix* leafprints, the formation is barren for fossils. Schréter (1929) considered its age as Sarmatian, although some years before he had put the formation in the Middle-Miocene. Led by paleogeographic considerations, Vadász (1929) also put the formation in the Sarmatian. This opinion was based on the fact that in the surroundings no pre-Sarmatian volcanism is known, which could have produced the andesitic blocks sometimes of several cubic metres. This argument is sustained by Alföldi et al. (1975) as well.

The Badenian nannoplankton of the area was examined in the boreholes of Sajóvelezd – 49 (Sv – 49) and Bánhorváti – 17 (Bh – 17). (Only limited material was available from borehole Bh – 17). The profile of the borehole Bh – 17 was described by Goda (1975) and the profile of the borehole Sv – 49 was described by Goda (1975) and the author.

A more complete rock colummn can be observed in borehole Sv – 49 (fig. 1.):

0.5 – 64.7 m	pebbly andestic tuff, agglomerate, sometimes crossbedded
64.7 – 153.4 m	white silty clay, clayey marl
153.4 – 194.0 m	tuffaceous, clayey and pebbly sand
194.0 – 267.0 m	silty clay, clayey marl ("schlier")
267.0 – 417.0 m	alternation of pebbly sand, silty clay and brown-coal
417.0 – 426.0 m	(lower) rhyolite-tuff
426.0 – 437.0 m	tuffaceous, pebbly green sandstone and sand.

Very frequent tuffaceous and puromiceous intercalations occur between 100 and 247 meters.

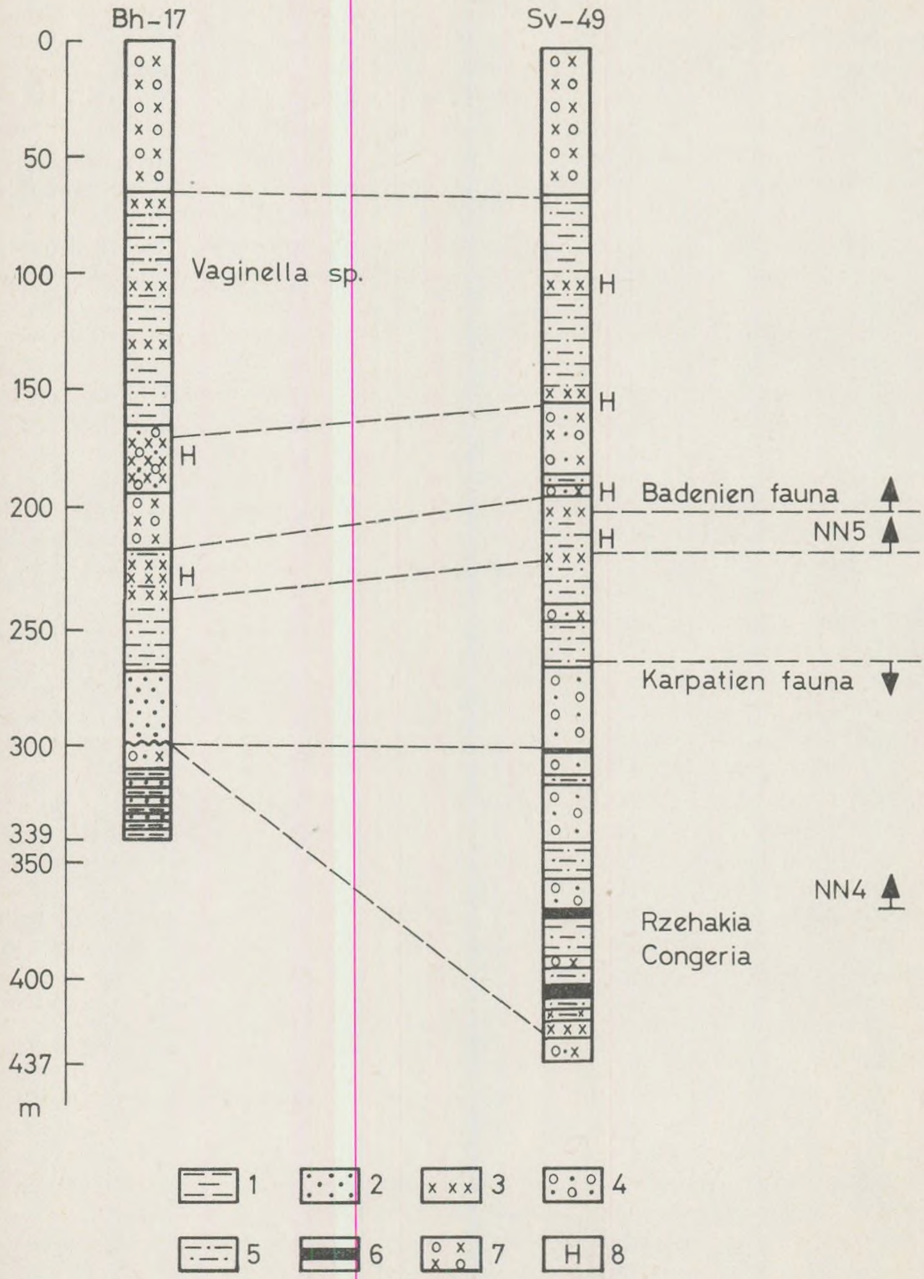


Fig 1. Lithological sections of the boreholes Sajóvelezd-49 and Bánhorváti-17. Legend: 1. Clay, 2. Sand, sandstone, 3. Tuffite, tuff, 4. Gravelly sand, sandstone, 5. Silty clay, 6. Brown coal, 7. Tuffaceous, gravelly andesite agglomerate, 8. Pumice

The following age-and facies-units were separated by Báldi (pers. comm.) based on macrofauna:

360.0 – 399.7 m	*Congeria*, *Oncophora* and *Cardium* bearing brackish water sediments with *Rzehakia socialis* and *Cardium edule* (upper Ottnangian age)
349.0 – 354.0 m	normal marine shallow neritic facies (Karpatian age)
266.0 – 344.0 m	lagoonal deposits of approx. 10 – 15% salinity (Karpatian age)
161.7 – 203.0 m	marine deposits of turbulent water, containing Pectinids, Balanids and *Chlamys scabrella:* water depth of 10 – 30 m (Badenian age)
69.5 – 131.8 m	marine deposits of 80 – 120 m water depth with Pteropods, *Vaginella austriaca* (Badenian age)

Kernerné Sümegi K. (in Goda 1975) found *Globigerina bulloides*, *G apertura*, *Globigerinoides trilobus*, *G. ruber*, *Globorotalia mayeri* in 75 m. The latter can be placed into Grill's upper Lagenid zone (Blow's N 9 zone). The presence of *Uvigerina acuminata* Hosius, which occurs in the Karpatian of the Vienna basin, is most probably due to reworking. Concerning the nannoflora (Table 1.), the greatest part of the rock column can be assigned to Martini's nannoplankton zones. No index fossil was found in the underlying green pebbly sandstone (431,9 m).

Sphenolithus heteromorphus S. cf. belemnos, *Helicopontosphaera ampliaperta* and *Reticulofenestra pseudoumbilica* occur in the *Rzehakia* and *Congeria* bearing sequence (390 m) overlying the lower rhyolitic tuff. According to Martini and Müller (1975*a*) these indicate upper Ottnangian or lower Karpatian age (overlaping interval of the NN3 MARTINI and CN3 OKADA and BUKRY zones).

The age of the section between 390 and 218 m was not exactly determined, due to the poor nannofloras and to gaps in the sampling. In Báldi's opinion, the age of the macrofauna of the silty clay in 266 m is Karpatian. while that in 203 m is of Badenian.

The occurrence of *S heteromorphus* and *Discoaster exilis* together with the "*nannoplankton invasion*" (fivefold increase of the number of species) in 218 m indicates zone NN 5. Thus, we can conclude, that the lower limit of the stage Badenian is in the zone NN 5, and in this area this limit coincides with the "planktonic invasion" and with the dominance of marine environment. The limit of zones NN 4 and NN 5 thus can be drawn in the mentioned (390 – 218 m) interval. (Unfortunately the poor nannoflora does not enable us to fix more exactly this limit).

The nannoplankton assemblage found in the interval of 218 – 64.7 m is characteristic of the NN 5 zone. Beside *S. heteromorphus*, the most frequent index species are *Discoaster lautus*, *D. formosus*, *D. variabilis*, *D. exilis*, however their diversity is far exceeded by the usual persistent species of the middle Miocene. It's worth to mention, that the very rare species *Coccolithus radiatus* occurs in 218 and 161 m-s and *Helicopontosphaera mediterranea* is also present from 218 m on. It's curious, that the increase of the number of reworked Paleogene species coincides with the increase of the number of autochtonous species. The environment becoming suddenly open marine was probably accompanied by a more intense transgression, which caused abrasion-erosion and the reworking of fossils from older sediments.

The reduced rock-column of borehole Bh – 17 is as follows (fig. 1.):

1.5 – 65.5 m	pebbly andesitic tuff and agglomerate
65.5 – 164.0 m	white foraminifera-bearing clay, clayey marl
164.0 – 216.0 m	tuffaceous pebbly sand, sandstone
216.0 – 268.0 m	clayey silt
268.0 – 300.0 m	loose grey sand (quicksand)
300.0 – 310.0 m	pebbly sand with traces of rhyolitic tuff
310.0 – 339.7 m	alternation of sandstone and silty clay

From 232 m downwards, tuffaceous and pumiceous traces are frequent.

In 300 m GODA described unconformity and he put the lower formations in the "Burdigalian" or in the upper Oligocene.

According to the macrofauna investigations of BÁLDI, the interval of 328.4 – 336.6 m is composed of normal marine, shallow shelf formations, and those between 71.9 and 159.4 m are of deep normal marine and of Pteropoda facies.

From 328 m KERNERNÉ described species of *Uvigerina* aff. *bononiensis* FORM. and *U. marocarinata* PAPP et TURNOVSKY, which correspond approximately to the stage Karpatian. The species *Globigerinoides sicanus* from 274 m indicates the vicinity of the Karpatian – Badenian boundary.

On the basis of the occurrence of *Uvigerina venusta* and *Globorotalia mayeri* from 148.9 m upwards, this part of the rock column can be placed into GRILL's upper Lagenid zone.

The age of the nannoplankton (Table 1.) from the two samples between 336 – 334 m-s can not be upper Oligocene as it was proposed by GODA, but it is approximately the highest part of the lower Miocene. This assumption can be based on the general faunal impression and on the presence of species *R. pseudoumbilica*, however zone marker species were not present. The lack of the coal sequence can be caused by the denudation mentioned by ALFÖLDI (1959) from several other localities of the Sajó valley. Considering the analogies of Diósgyőr and Sajókaza, we can state that this denudation was of short time interval in this rock column, and could not reach the upper Oligocene strata, but on the other hand it could destruct the coal bearing sequence.

The *S heteromorphus* is a species continuosly present in the segment between 153.9 m and 71.9 m. Since its disappearance defines the upper limit of the zone NN 5, so this marine, complete sequence of the rock column is not younger than zone NN 5.

Summing the study of the two borehole profiles, one can conclude, that – according to the macrofauna and nannoflora – the age of the *Rzehakia* and *Congeria* bearing coal sequence laying on the lower rhyolitic

Table 1

List of the nannoplankton recovered from Sajó valley samples

	Sajóvelezd(Sv) – 49																	Bánhorváti(Bh) – 17.							
	431,9 m	390,0 m	360,5 m	344,0 m	315,0 m	266,0 m	218,0 m	200,3 m	189,0 m	187,0 m	172,0 m	161,0 m	131,0 m	104,0 m	75,0 m	73,5 m	69,5 m	336,5 m	334,0 m	153,9 m	141,2 m	103,4 m	94,4 m	80,6 m	71,9 m
Reticulofenestra minuta	R	K		K	A	K	A	S		K	K	S	S	S	S	S		K	S	S	S	S	S	S	S
R. pseudoumbilica		K			R	R	K				R	K	R	A	K	A			K	K	K	K	K	K	K
R. cf. *pseudoumbilica*					R							R	K		S	A	A			A		K	S	K	A
Coccolithus eopelagicus					K		K		A				A	K		K		R		K		K	K	R	
C. pelagicus		R	R	R	K	K	S	S	A	A	S	S	S	S	S	S	S	K	S	S	S	S	S	S	S
C. radiatus							R					R												K	K
Cycloccoccolithus jafari							S	A		R		R	A	A	A				K	A	A	A		K	
C. leptoporus							K		R		R	K			R	R			R	R	K	R	K		
C. rotula							S	K	R			R	A	A			K	R	K	A	S	A	A	S	A
Thoracosphaera sp.							R												R						
Rhabdosphaera pannonica							K			R		K	K	A	K		K		K					A	A
R. poçuli								R																	
Disçolithina multipora							K	A	K	K		K	A	K	S	K	K			R		K		A	A
D. sparsiferota																	R	R	R	R	A		R		
Helicopontospharea ampliaperta		K																							
H. kamptneri		K					S	S	K	K	S	S		S	S	S	S		S	S	A	S	A	S	S
H. mediterranea							K				R	A	R							R				R	
Syracosphaera pulchra									R	R		K		K	K					R			R	K	R
Sphenolithus heteromorphus		R					A	K	R	R				K	A	K	R			R	R	R	R	K	K
S. moriformis					R	R	K	R	R	R				K	K	K	K					K		R	R
Micrantholithus flos										R			R	A						K	A				
M. vesper								K			R		A	A	A	K	K			A		K	K	A	
Braarudosphaera bigelowi							R			R		R		K	R	K				K			K		
Discoaster adamanteus					R		R																R		
D. deflandrei							R																		
D. dilatus						R																			
D. druggii											cf												cf		
D. exilis						A						R								R			R		R
D. formosus											R		R		R						R		K		
D. lautus							R	R	R		K	K	K							R					
D. musicus							R				R									R			K		
D. trinidadensis												R	R		R	R		R			R				
D. variabilis							R								R	R				R		R	K	R	
Perforocalcinella petali											R														
Lithostromation triangularis													R	K						R					
Coronocyclus nitescens													R			R									
Cricolithus jonesi					R		K					K	K		A	A	K		K	K	K	A	A	A	A
Holodiscolithus macroporus							K		R		R				K				R	A	A	A	K	S	K
reworking from Paleogene		R	R		R	R	K	R	R	R	R	K	K	K	A	A	K		R	R	R	R	K	A	R
reworking from Cretaceous	R	R	R	R			R	R	R	R	K	R	K	R	R	R	R						R	R	R

Legend: =R rare, K=few, A=common, S=abundant

List of the nannoplankton species from

	Szokolya – 2.											
	114,0 – 115,3	102,0 – 104,7	93,0 – 95,0	84,7 – 85,5	74,3 – 75,1 m	64,0 – 65,5 m	54,3 – 55,1 m	43,9 – 44,7 m	34,7 – 34,0 m	22,5 – 24,5 m	16,5 – 19,1 m	5,4 – 7,2 m
Reticulofenestra minuta	A	A	S	A	S	S	S	S	S	S	S	S
R. pseudoumbilica		K	K	K		R	R	R	R			K
R. cf. *pseudoumbilica*				R			A	K	S	A		A
Coccolithus eopelagicus	R			R		R					R	A
C. pelagicus	S	S	S	S	S	S	S	S	S	S	S	S
Cycloccolithus cricotus		R										
C. jafari			R				A		S	S	S	
C. leptoporus			R									
C. mirabilis									R			
C. rotula	R	R	K		R		K		K	R	R	
Thoracosphaera sp.	R	R	S								R	
Rhabdosphaera clavigera											R	
R. pannonica	A			R	K	K	K					
R. poculi	A											
Discolithina multipora		K	R	R	R	R	A					
D. sparsiforata												
Helicopontosphaera kamptneri	K	A	A	A	A	A	A	S	S	A	K	R
H. wallichi												
H. mediterranea	K				A	K	R	K				
Syracosphaera pulchra	R				R		K	R				
Sphenolithus heteromorphus	K	A	K	K		K	K		K			
S. moriformis	K	K	K	K		R	R					
Micrantholithus flos					R	R	A	K				
M. vesper	S	K	K	A	A	S			A	R		
Braarudosphaera bigelowi	A	K	A	K	K	K	K			K		
Discoaster adamanteus			K	K								
D. deflandrei									R			
D. exilis	R	R	K	A								
D. formosus	R	A	K	K						K		
D. lautus				K								
D. musicus	R	R	R							R		
D. trinidadensis										K	R	
D. variabilis	A	R										
Perforocalcinella petali		R	R				R	R				
Lithostromation triangu laris		R	R				R					
Coronocyclus nitescens												
Cricolithus jonesi	K	R		K	K		K		K	K		R
Holodiscolithus macroporus				R								
reworking from Paleogene	R	R	R	R	R		K		R	R	R	
reworking from Cretaceous			R	R			K					

Legend: R = rare, K = few, A = common, S = abundant

the Szokolya and Nógrádszakál area *Table* 2

Szokolya surface						Szokolya – 3.								Nógrádszakál – 2.			
Mf	Me	Md	Mc	Mb	Ma	69,6 – 71,0 m	64,7 – 64,8 m	60,8 – 63,8 m	55,6 – 58,7 m	41,0 – 42,5 m	37,0 – 38,5 m	28,0 – 28,3 m	21,0 – 23,0 m	felszín	122,0 – 123,0 m	93,0 – 95,0 m	62,2 – 66,0 m
	K		S	A	K				R	K	K	A		S		K	
	R			R	R							R		K			
	R	K	A	A	K					K					K		
			K						R			K					
K	S	S		S	A				R						S	K	
										R							
		K								K		K					
			K	R						R							
										K	K						
	K									K	K						
		A	K			R				K	A				K		
	K	K	R							K					R		
	K	A	A	A	K					K	K	R		A	S		
														R			
A		K								K	K				K		
										R							
	K			K		R				R	A	R		K	K		
		K	K			K				R	K	K		R	R		
						R											
		K	A				R			R		K		K			
		K							R	K	A	K		K			
	A									K				R	R		
										A				K	K		
															R		
										R				R	A		
										R					R		
														R			
										A				K			
						K											
		R													R		
		R	K		R												
	A		A	K	R					K				A			
K	A	K								K	A	K		K			
	R	R	R							K	R			R	R	R	
		R	R							R				K		R	

tuff is either upper Ottnangian or lower Karpatian. In the same time of the deposition of coarse detrital rocks, some of the tectonic blocks of the area were uplifted and eroded. The pebbly-sandy sequence changes gradually upwards into white clayey marl, which the first tuffaceous layers correspond approximately to the lower limit of the Badenian.

This segment ranging till the volcanic sequence can be assigned to the nannozone NN 5, which corresponds to the lower part of the Badenian stage.

According to the argument described above, the volcanic agglomerate, which was presumed Sarmatian till now, is scarcely younger than the zone NN 5 so it can be middle-Badenian as the youngest The formation, spreaded over in Tchechoslovakia as well, is said to be of upper Badenian age, (SENES et BUDAY in MATĚJKA 1968) however no certain fossil was found proving this.

3.2. *Nógrádszakál*

The Badenian rock column of the area begins with the middle rhyolite tuff of variable thickness, which lies on the Garáb schlier

In the neighbourhood of Nógrádszakál this tuff is 4 – 5 m thick. It is followed by the tuffaceous fossiliferous Badenian marl, then the tuffaceous sand. The rock column is ended by andesitic tuffit and agglomerate.

From the "Tortonian" tuffaceous marl of the Betrece-valley, BOGSCH and MAJZON (1936), described rich fauna. In their opinion, the fauna of the formation is of deeper neritic facies. From the sixty-six mollusc species, eleven were known only from the Badenian of the Vienna basin. On the basis of these species the age of the formation was defined as upper "Tortonian".

In this work I examined two samples from the locality described above, and three from the sedimentary sequence of the borehole Nógrádszakál – 2 (Table 2.).

The rock column of the borehole based on the description of HÁMOR G. (1975) is as follows:

0 – 5.2 m	Holocene alluvial deposit
5.2 – 62.2 m	pumiceous andesitic agglomerate- and tuffitic sequence
62.2 – 76.1 m	greenish-grey tuffaceous silt
76.1 – 116.0 m	grey micaceous tuffaceous sand, sandstone
116.0 – 125.6 m	grey sandy tuffaceous mollusc – rich marl
125.6 – 142.8 m	grey tuff and tuffite decayed under the sea water
142.8 – 290.0 m	grey silty-clayey marl (Garáb Schlier)

I have examined three samples from the interval between 62.2 and 125.6 m-s. The sample of 122 – 123 m is an equivalent of the one from the outcrop. The appearance of *S. heteromorphus*. *Discoaster exilis* and *D. formosus* (only from the borehole) together indicates the zone NN 5, and thus fixes the age of the volcanic activity. Among the persistent forms, the rich nannoflore contains important species, such as *D lautus*, *D adamanteus*, *D. musicus*. The sample of 93 – 95 m contained only 3 transient species.

while that from the top of the sedimentary cycle, from 62.2 m was completely free of nannoplankton. (Table 2).

3.3. The Szirák – 2/a borehole (SE – Cserhát)

The Szirák – 2/a borehole explored a 2000 m thick Neogene sequence (after SZÁNTÓ 1983) (See figure 2.):

0 – 7.1 m	Quaternary
7.1 – 767.2 m	Pannonian s.l.
767.2 – 1002.3 m	Sarmatian (Kozárd and Tinnye Formations)
1002.3 1150.5 m	Badenian Szilágy Formation (sandstone, silt, clayey marl)
1150.5 – 1566.6 m	Badenian Hidas Formation (clayey marl, silt, sandstones)
1566.6 – 1918.4 m	Badenian Mátra Volcanic Formation (andesites. andesitic tuffs and agglomerates)
1918.4 – 2000.0 m	Karpatian Garáb Schlier (silt, clay, sandstone)

The multilateral investigations of this profile will be published later, in details. This paper deals only with some important notices concerning the nannofloras (see fig. 2.):

- the distribution of *Sphenolithus heteromorphus* between 1383 and 1303 m-s in the continous sequence of Karpatian schlier, Mátra volcanics and the overlying marine sediments confirms, that the volcanic paroxism of the Mátra was beginning and *also ending* within-the zone NN 5. This rather short interval means approximatively 1.5 million years.
- no' index fossils of the zones NN 6 and 7 were traceable in the younger Badenian layers (emersion of *Discoaster exilis*, appearance of *D. kugleri*).

  The occurence of *D.* cf. *kugleri* in some of the samples may be a weak evidence to the zone NN 7 (1205 and 1003 m)
- though JÁMBOR (in SZÁNTÓ 1983) puts the boundary Badenian – Sarmatian in 1002.3 m, the changes in the salinity already show up in the m-s 1099.0 and 1092.5 with the increase of the abundance of *Cyclococcolithus macintyrei* and *Braarudosphaera bigelowi*, respectively Both euryhaline species lived together with a restricted number of marine nannoplankton, but the environment might be especially favourable only for these two organisms.

  The weak decrease of salinity and the absence of index fossils does not enable to fix the exact boundary of the Badenian and Sarmatian stages in this profile.

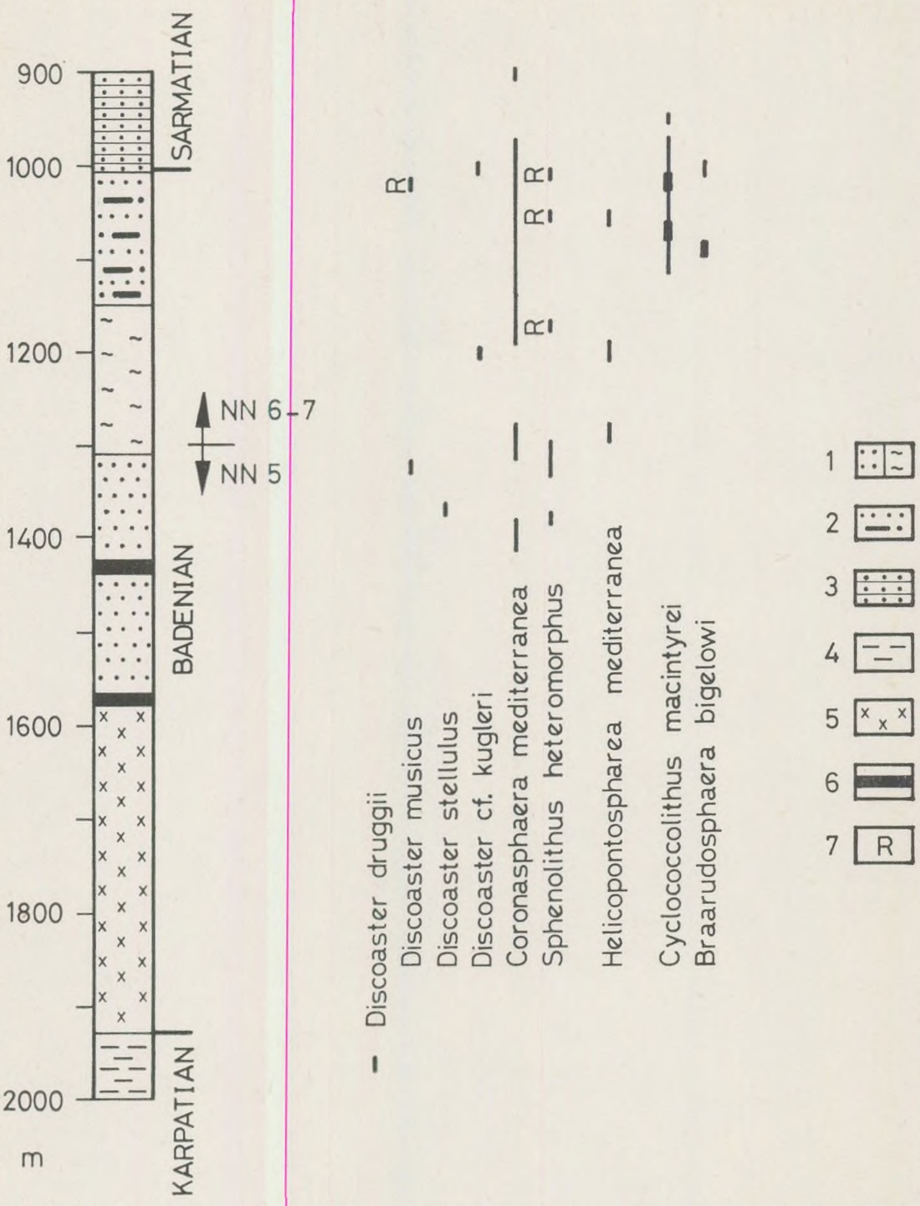


Fig. 2. The profile of the Szirák-2/*a* borehole and the distribution of some important nannofossils. Legend: 1. Hidas Formation (sand, sandstone, clayey marl) (Badenian), 2. Szilágyi Formation (sandstone, silt) (Badenien), 3. Kozárd Formation (Sarmation), 4. Garáb Schlier (Karpatian), 5. Mátra Volcanic Formation (Badenian), 6. Red beds, 7. Reworked specimens

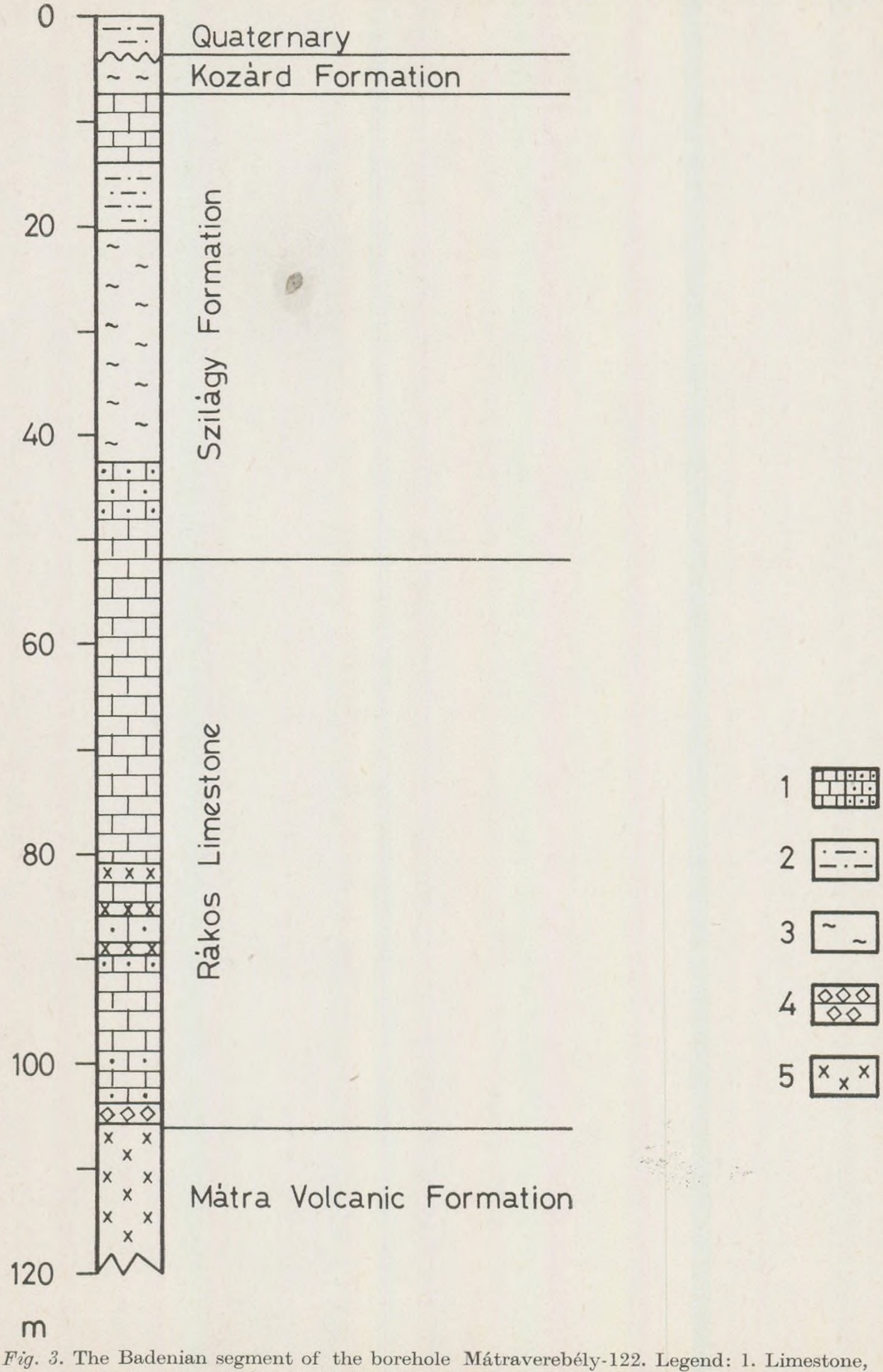


Fig. 3. The Badenian segment of the borehole Mátraverebély-122. Legend: 1. Limestone, sandy limestone, 2. Silt, 3. Marl, 4. Breccia, 5. Andesitic lava, tuff and agglomerata

3.4. *Mátraverebély*

The Mátraverebély (MV) – 122. borehole was drilled in 1978 on the NE margin of the Cserhát Mountains. It penetrated a Middle Miocene sequence of continous sedimentation in a thickness more than 800 m. The description of the profile (after HEGYI 1979) (figure 3.):

0 – 4.0 m	Quaternary
4.0 – 7.2 m	Sarmatian Kozárd Formation (marl and limestone with *Planorbis* diff. sp.)
7.2 – 52.1 m	Badenian Szilágy Formation (marl. limestone. silt with marine molluscs)
52.1 – 105.4 m	Badenian Rákos Limestone (Leithakalk) (limestone, limy sandstone, tuffitic sand)
105.4 – 178.7 m	Badenian and Karpatian Mátra Volcanic Formation
178.7 – 698.0 m	Karpatian Garáb Schlier
698.0 – 791.3 m	Karpatian Egyházasgerge Sandstone
791.3 – 815.4 m	Ottnangian (?) Salgótarján Brown Coal Formation

Table 3.

List of nannoplankton species from the borehole Mátraverebély – 122

Mátraverebély – 122	17,90 m	42,0 m	39,0 m	37,0 m	32,0 m	34,0 m	30,5 m	28,5 m	24,5 m	21,3 m	18,2 m	15,5 m	13,5 m	12,0 m	11,0 m	8,5 m
Reticulofenestra minuta	R	S	A	S	A	S	S	S	S	S	R	K		K	K	K
R. pseudoumbilica	K	R	R	R	R	R	K	R		R					R	
Coccolithus moipelagicus		K	K	K	R	R	R	K	K		K	K				
C. pelagicus	K	A	A	A	A	S	S	S	S	S	K	K		K	A	R
Cyclococcolithus jafari		K	K		K	K	A			K	R	R				
C. leptoporus								R								
C. rotula		K	R	R	K		R			K						
Cyclicargolithus floridanus		A	K	A	A	A	A	A	K		R					
Syracosphaera pulchra			K		R	R	R		R	R						
Coronosphaera mediterranea		A	A		K		A	A	K	K		R		R	R	R
Holodiscolithus macroporus		K														
Discolithina multipora		K	K	K	K	K	K	K	K	A		R			R	
D. sparsiforata		R						R		R						
Rhabdosphaera pannonica					R		R	R		K						R
Sphenolithus heteromorphus	R	R		K	K	R	R	R							K	
S. moriformis		K		R	K		R		R						R	
Micrantholithus vesper		R	K	K	R	K	K	K	R	K		K			R	
Braarudosphaera bigelowi		R	R	R			K	K	K	A					K	R
Discoaster adamanteus			R		R					R						
D. druggii	R															
D. exilis							R		R						R	
D. musicus										R						
D. variabilis			R		K				R	R					R	
Coronocyclus nitescens	R															
Lithostromation triangularis			R	R			R									
Helicopontosphaera kamptneri		S	A	A	A	S	S	S	S	S		R		K	K	
reworking			R		R		R		R		R		R		R	

Legend: R = rare, K = few, A = common, S = abudant

The lowermost investigated nannoflora (179.0 m), from the contact of the Garáb Schlier and the volcanic series proves an age of NN 5, i.e. the beginning of the volcanic activity (Table 3.).

The collecting of samples was not possible from the compact Rákos Limestone.

The nannofloras of the Szilágy Formation can be assigned as a whole, into zone NN 5, because of the permanent presence of *Sphenolithus heteromorphus* throughout the profile. The age determination is supported by the occurence of *Discoaster exilis* from 30.5 – 11.0 m.

Hajós M. (in Hegyi 1979) described brackish water, Sarmatian diatom flora from the uppermcst layers (8.4 – 4.0 m). According to my opinion, the presence of *Planorbis* and brackish water diatoms may not be interpreted as the environmental change in the early Sarmatian, but as a marker of the regression at the end of the lower Badenian. I think to be unexplained in the case described above, why the Middle and Upper Badenian sediments (NN 6 – 7 zones) are lacking in a conform sequence.

On the base of nannofloras, the end of the Badenian sedimentation must be placed into the zone NN 5 in this area.

3.5 The Szokolya area

The Badenian nannofloras of the SW Börzsöny Mountains were studied in three sections and some scattered samples from outcrop localities. The mollusc fauna and the lithology of the section of Magyarma hillslope near Szokolya was thougroughfully investigated by Báldi (1960).

In 1970, Báldi and Kókay fixed the age of the andesitic volcanic activity of the Börzsöny Muontains and made the stratigraphic position of the section more exact. According to them the rock column of the area is as follows:

- crossbedded coarse sand with fine pebbles and *Chlamys scabrella* Lamarck (Karpatian)
- biotite-amphibolé andesitic tuffit (tuffit of Kismaros) of Lower Badenian age
- agglomerate of garnet bearing biotite-amphibole-andesite. This formation contains some coralliferous marly limestone beds of uncertain stratigraphic position in the Feketehegy near Visegrád. (Sample derived from here contained no nannoplankton.)
- siliceous clay, diatomite deposited in brackish and freshwater. In its upper part, it changes into marine facies and contains *Corbula gibba* Olivi and *C. carinata* Ben. The occurrence of the species *Globigerinoides sicanus* indicates the uppermost part Karpatian stage and the lowermost part of the Badenian.
- clay containing *Nassa* and *Pleurotomaria*, in its upper part with the appearance of *Orbulina suturalis* (approx. the lower part of the Lagenid zone)
- marl, limy marl with *Petropods* and *Dentaliums*
- Leithakalk (Lajta-limestone) (fig. 4.)

Not concerning some minor divergences, the rock columns of boreholes Szokolya (Szk) 2 and – 3. are in good accordance with the outcrop described above. Their Badenian sequence is the following (after the description of Hámor (1971) and the author) (fig. 4.):

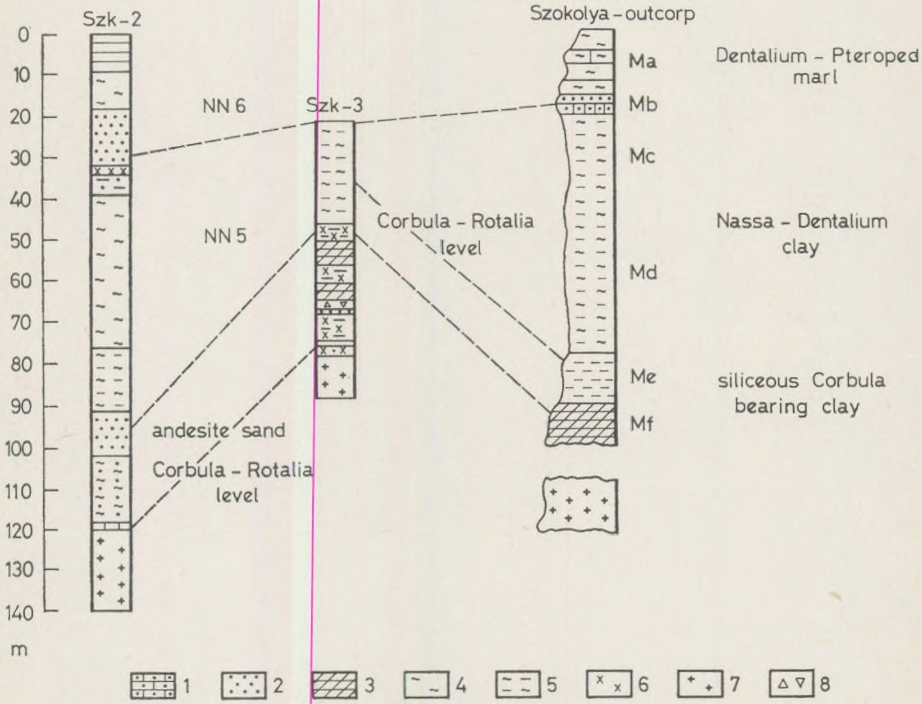


Fig. 4. Lithological sections of the borehole Szokolya-2 and -3 and Magyarma outcrop (partly after T. Báldi 1960). Legend: 1. Sandy limestone, 2. Sand, sandstone, 3. Diatomite, 4. Marl, 5. Clayey-marl, 6. Tuff, bentonic clay, 7. Andesite, pseudoagglomerate, 8. Sandy limestone breccia

Szk – 3:

21.0 – 47.0 m	grey, compact clayey marl, with *Corbula* and fish scales from 28 m-s downwards.
47.0 – 50.6 m	greenish-grey bentonitic clay
50.6 – 55.6 m	microlaminated bentonitic diatomaceous ooze
55.6 – 60.8 m	green, tuffitic bentonitic clay
60.8 – 64.7 m	diatomite
64.7 – 67.6 m	breccia and limestone with *Lithothamnium* and andesite debris
67.6 – 77.5 m	alternation of tuffaceous clay and sand of andesite
77.5 – 87.9 m	andesite pseudoagglomerate.

The lower part of the section contains neither molluscs nor foraminifers up till 47 m. The marine limestone-breccia is overlain by freshwater diatomite. The marine layers between 42 and 29 m contain the species *Globigerinoides sicanus*. On the basis of the foraminifera fauna, Korecz – Laky (in Hámor 1971) put the borehole section in the lower Lagenid zone of Grill.

Szk – 2:

2.8 – 9.5 m	yellowish grey sandy limestone, limy sandstone
9.6 – 19.1 m	sandy, limy marl
19.1 – 38.3 m	yellowish grey sand, sandstone
38.3 – 91.4 m	grey, compact silty clayey marl
91.4 – 102.2 m	grey sand, sand of andesite
102.2 – 118.3 m	grey, marly sandy silt, in its lower 3 m it contains *Corbulas*
118.3 – 120.0 m	*Ostrea* and *Lithothamnium* bearing limestone
120.0 – 140.0 m	andesite pseudoagglomerate

According to Korecz – Laky, the foraminifera fauna of this section can be placed in the lower Lagenid zone of Grill. The nannoplankton of the sections of Szokolya is a very rich one, both in species and individual numbers. The time, when the basal marine formations overstep the andesite agglomerate in the boreholes Szk – 2 and – 3 can be assigned to the NN 5 zone on the basis of *S. heteromorphus*, *D. exilis*, and *D. formosus* (Table 2).

The brackish and freshwater, *Corbula* and *Diatoma* bearing formation overlaying the preceeding one in the borehole Szk – 3, is barren for nannoplankton. This section corresponds to the *Corbula – Diatoma* clay of the outcropping section, and to the alternation of the marine and the *Corbula – Rotalia* bearing beds in the borehole Szk – 2 in the interval between 118.3 and 91.4 m.

The limit of zones NN 5 and 6 defined by the extinction of *S. heteromorphus* coincides approximately with the limit between the *Nassa*, *Pleurotoma* and *Dentalium* bearing clay and the *Pteropod* and *Dentalium* bearing marl, sandy and limy marl. (In the borehole Szk – 2, this limit is between 34.7 and 24.5 m). *Discoaster adamanteus*, *D. lautus* and *H. mediterranea* also very characteristic of the zone NN 5 were described from this interval.

The *Pteropod* and *Dentalium* bearing marl, sandy, limy marl, which can be found in the outcrop locality as well as in the borehole Szk – 2 (9.6 – 19.1 m), can be assigned to the zone NN 6. Their nannoflora is relatively poorer than the preceeding zone's one. The nannoflora of the Lajta-limestone, covering the rock column, is extremely poor, its fossilisation was not promoted by the littoral, turbulent environment. (The Lajta-limestone Bakókút quarry near Zebegény also hardly contained any nannoplankton.)

The very rich macrofauna of the so called "Great outcrop" of Szob was studied by Csepreghyné Meznerics I. (1941). She estimated this *Turritella* bearing sandy clay as "Tortonian" and as the heteropic facies of the Lajta-limestone. Beside the many lower Badenian *Gastropoda* species (p.ex: *Turritella badensis*, *T. partschi*, *Ostrea digitalina* etc.) the presence of *Chlamys elini* indicates the upper part of the lower Badenian.

The complex study of the section was carried out recently by MARSI (1980). In this work, the nannofloras of 13 exposed beds were also examined (Table 4.). Two upper samples (from the beds No.-s 11 and 13) contained *Sphenolithus heteromorphus* while the beds No.-s 1.2.4. contained *Discoaster exilis* and *D. formosus*. This way, the age of the exposed beds can be fixed unambiguously in the zone NN 5.

Thus, we can conclude, that in this area, the lower Badenian volcanic activity and the maximum of the following transgression can be localized in the zone NN 5. The appearance of the regressive, more sandy and littoral facies can be linked to the upper part of the same zone (NN 5 and NN 6).

Table 4.

List of nannoplankton species from the Szob "great ontcrop"

Szob, „great outcrop"	Sample numbers												
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Reticulofenestra minuta	X	X	X	X	X	X	X						
R. pseudoumbilica												X	
Coccolithus eopelagicus						X	X						X
C. pelagicus	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyclococcolithus jafari							X						X
C. leptoporus	X												
C. rotula	X	X	X	X			X						X
Cyclicargolithus floridanus	X		X	X			X						
Rhabdosphaera pannonica				X		X				X		X	
Discolithina multipora	X			X						X		X	
D. sparsiforata						X							
Helicopontosphaera kamptneri	X	X		X		X	X		X			X	X
H. wallichi						X							
Syracosphaera pulchra		X											
Sphenolithus heteromorphus										X			X
S. moriformis	X	X											
Micrantholithus vesper	X												
Braarudosphaera bigelowi	X				X		X						X
Discoaster exilis	X	X		X					X				
D. formusus		X											
D. lautus												X	

3.6. The surroundings of Mecsek Mountains

In the middle Miocene rock column of the Mecsek Mountains, the Ottnangian, Karpatian, Badenian and Sarmatian stages are represented by deposits of three sedimentary cycles. (HÁMOR 1970, FORGÓ et al. 1966).

In the stage Ottnangian, thick terrestic, fluviatile and swampy clay and conglomerate was deposited; this formation contains the first layer of rhyolite tuff. The uplift having caused the end the sedimentary cycle is accompanied by andesitic volcanic activity. The second sedimentary cycle is composed by brackish pebbly, sandy beds, bearing *Congeria* and this is followed by brackish water sediments containing fish scales. The material of the second dacite tuff eruption is intercalated into this formation. The transition upwards into the pelagic marine sediments is represented by the marine coarse detrital Budafa Formation, which lays on top of the fish scale-bearing marl. The pelagic Tekeres (Komló) Schlier interfingers laterally and also vertically with the Budafa formation, and contains the third dacite tuff-level. The cycle is closed by the coarse detrital, so called "regressive formation" In the opinion of the authors mentioned above, this sequence was formed in the stages Karpatian and perhaps in the lower Badenian. A total regression is characteristic of the Eastern Mecsek, while this is only partial in the W-Mecsek. The beginning member of the third sedimentary cycle is the Leithakalk (Lajta-limestone) which is locally very sandy. These marine beds are overlain by the brackish water brown coal deposits. In the rock column upwards, this is followed by the Turritella-Corbula bearing clayey marl or the so called upper Lajta limestone, depending on the shore-distance. These fully marine sediments of upper Badenian age pass swiftly upwards into brackish water limestone and mollusc-bearing clayey marl of Sarmatian age.

The foraminifera and nannoplankton assemblages of the Miocene formations of the Mecsek mountains were studied by BÁLDINÉ (1960, 1964) BÓNA (1964) BÓNA and KERNERNÉ (1966) KORECZNÉ LAKY I. (1970), BÓNA, KORECZNÉ, KERNERNÉ in HÁMOR (1970).

According to the state of knowledge in the nannoplankton stratigraphy, the authors mentioned above could not give zonal age-determinations in those times.

The foraminifera studies showed, that *Globigerinoides sicanus*, having a lifespan covering the Badenian-Karpatian limit, occurs only in the lower part of the schlier, while, *Globigerinoides (=Praeorbulina) glomerosa* is mentioned by KORECZNÉ only from the upper part of the schlier and from the regressive sequence. The latter species is the marker of the lower boundary of the Badenian. On the basis of the general faunistic composition, the Budafa Formation, the Tekeres Schlier and the lower Lajta-limestone formations are assigned by KORECZNÉ to the *Lagenid* zone of GRILL, while the *Corbula Turritella* bearing clay has been put into the *Spiroplectammina* or to the *Bulimina – Bolivina* zone. This last age is supported by the presence of the species *Uvigerina venusta liesingensis*.

The nannoflora and foraminifera fauna of the Tekeres – 1 borehole were examined already by BÓNA and KERNERNÉ SÜMEGI K. (1966). This drilling discovered one of the most complete Miocene sequences in the Mecsek area. The revision of the nannoplankton investigations was justified by the development in the studying-technique and in the progress of the worldwide nannoplankton zonation achieved since that. The section of the borehole is given after the author's and HÁMOR's (1964) description, completed in some places by the macrofauna determinations given by BOHNNÉ HAVAS M. (in HÁMOR 1970) (fig. 5.).

25.6 – 76.1 m	gray, greenish grey, diatomaceous, laminated clayey and limy marl. There is a bentonite intercalation in 68 m. Common fossils are: *Corbula* sp., *Nucula* sp., *Leda* sp., *Turritella* sp. From 45 m, *Vaginella austriaca*, *Amussium cristatum badense* and *Turritella badensis* were described.

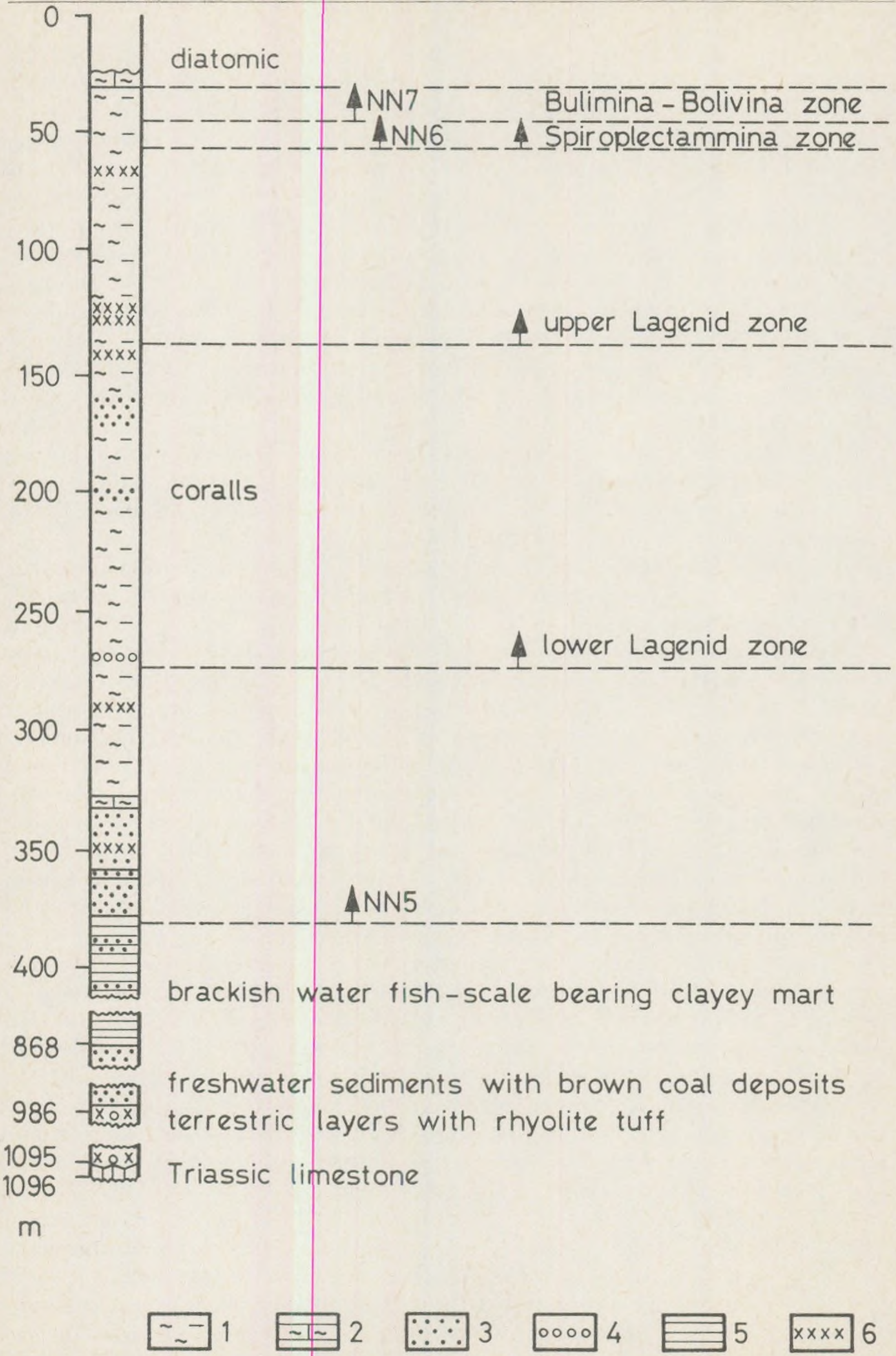


Fig. 5. Lithological section of the borehole Tekeres-1. Legend: 1. Silty clayey-marl (schlier), 2. Calcareous marl, 3. Sand, sandstone, 4. Pebble, conglomerate, 5. Clayey-marl with fish scales, 6. Tuff, tuffite

	(The latter two species are frequent between 45 and 263 m, and the appearance of the last one indicates the lower boundary of the stage Badenian).
76.1 – 328.7 m	grey, compact, fine sandy clayey marl (schlier). *Tellina* sp., *Dentalium* sp., are frequent. From 87 m on, there are some corals locally. Tuffaceous sediments can be found in 125, 128, 144, 289 m. A 40 cm thick, limy marl containing fucoids occurs at the lower boundary of the member.
328.7 – 380.0 m	grey, micaceous silty fine sand and sandstone, with a tuffitic layer in the interval of 346 – 348 m
380.0 – 868.0 m	grey, laminated clayey marl containing fish scales, with rare gravel and sandstone intercalations in it. Its upper part is characterized by tiny *Congerias*. Between 532 and 541 m there are dacite tuffitic and bentonite intercalations.
868.0 – 985.0 m	*Operculum* and *Bulimus* bearing clay, sandstone, with lignite laminae ("Helvetian" fresh-water sequence).
850.0 – 1095.0 m	Terrestric conglomerate- and sandstone formation, with rhyolite tuff on its base altered to bentonite.

The investigations of KERNERNÉ enable us to state some foraminifera datum horizons, however these do not always coincide with results from the Paratethys area. The occurrence of the species *Uvigerina macrocarinata* is between 272 and 114 m-s in the rock column, and although its appearance should coincide with the lower boundary of the lower *Lagenid* zone, KERNERNÉ places this zone only between 136 and 83 m. From 136 m upwards the species *Globigerinoides quadrilobatus*, *Orbulina suturalis* and *O. universa* occur together, but according to RÖGL (1975) this can only be expected in the *Spiroplectammina* zone. KERNERNÉ fixes this zone in between 52.5 and 44.3 m and puts the *Bulimina – Bolivina* zone in the interval of 44.3 and 28.0 m.

The fish-scale bearing formation between 411.5 and 365.0 m. and the overlying *Congeria* bearing brackish later marine sand and sandstone contained no evaluable nannofloras. The *D. exilis* and *S. heteromorphus* first appearing between 363 and 365 m indicate certainly the zone NN 5, also with the presence of *H mediterranea* (Table 5.).

In 272 m, sinchronously with the appearance of the species *U. macrocarinata*-also indicating the lower boundary of the stage Badenian- the characteristic elements of the Badenian mollusc fauna mentioned above also show up. The diversity of the nannoplankton grows, and the species *Discoaster variabilis* and *D. dilatus* were observed. The figure of KERNERNÉ indicates here the "invasion" of the *Lagenidae* family, so opposed to her opinion I regard this horizon as the lower boundary of the lower *Lagenid* zone. The second *Lagenidae* invasion observable in 136 m (the lower *Lagenid* zone of KERNERNÉ) is corresponding to the upper *Lagenid* zone, since the assemblage of species *Orbulina suturalis*, *O. universa* and *Globigerino-*

List of the nannoplankton

	Tekeres – 1.																
	407,8 – 411,5 m	399,7 – 400,0 m	387,4 – 390,2 m	379,0 – 381,0 m	369,0 – 373,0 m	363,0 – 365,0 m	353,0 – 357,0 m	346,0 – 348,1 m	336,0 – 338,0 m	326,0 – 328,1 m	316,0 – 318,0 m	312,0 – 314,0 m	297,0 – 299,0 m	287,0 – 289,0 m	262,0 – 264,0 m	245,0 – 246,2 m	227,0 – 229,0 m
Reticulofenestra minuta				R			A		S	A	S	S	S	S	A	A	S
R. pseudoumbilica															K	K	A
R. cf. *pseudoumbilica*						K	A	R	K		A	S		K	A	A	A
Coccolithus eopelagicus							R				K	K					
C. pelagicus	R	R	R	R	R	S	S	K	S	S	S	S	S	S	A	A	S
C. radiatus														R			
Cyclococcolithus cricotus																	
C. jafari														K	A	K	S
C. leptoporus															K		
C. rotula									R						A	K	
Thoracosphaera sp.																	R
Rhabdosphaera pannonica						R	S	K	K		K		A		A	K	A
R. poculi																	
Discolithina multipora	R						A		R		K	R	A		K		K
D. sparsiforata																	
Helicopontosphaera kamptneri	K					A	S	R	S	A	A	S	S	S	A	A	S
H. wallichi																	
H. mediterranea						K		R	R	R	A	A	K	R	A	K	K
Syracosphaera pulchra							R						K		R		R
Sphenolithus heteromorphus	R					R	K	R					K	K			
S. moriformis	R			R		R		R	K				A	K	K	R	A
Micrantholithus flos																	
M. wesper										R							
Braarudosphaera bigelowi						R	K		R		R	R	K	K	K		K
B. discula																	
Discoaster adamanteus																	
D. aulakos																	
D. brouweri																	
D. deflandrei							R										
D. dilatus															R		
D. divaricatus																	
D. druggii																	R
D. exilis							R										
D. formosus																	R
D. kugleri																	
D. lautus																	
D. musicus																	R
D. trinidadensis															R		
D. variabilis															R		
D. sp.																	
Perforocalcinella petali													S	K			R
Lithostromation triangularis							R							R			
Coronocyclus nitescens																	
Cricolithus jonesi							R		R		K	R	A	A	A		A
Holodiscolithus macroporus															R		
reworking from Paleogene					R	R				R					R	R	
reworking from Cretaceous	R	R	R		K	R				R			K				K

Legend: R = rare, K = few, A = common, S = abundant

Table 5.

of samples from the Mecsek

borehole																		Hidas surface					
206,0 – 208,8 m	187,0 – 189,0 m	164,0 – 165,2 m	149,0 – 151,0 m	136,0 – 138,0 m	116,5 – 119,0 m	96,8 – 98,0 m	91,0 – 93,0 m	85,3 – 87,0 m	76,1 – 78,0 m	63,7 – 65,0 m	60,3 – 61,5 m	56,0 – 57,5 m	52,5 – 54,5 m	46,0 – 48,0 m	41,1 – 42,3 m	32,0 – 34,5 m	28,0 – 29,5 m	Lower Lajta Limestone	Bithynia layers	Melania layers	Tellina layers	Cardita layers	Sarmatian diatomite
S	S	S	S	S	S	A	S	S		K	R	A	S	S	K	S	S	A				K	K
K		K	A		S	A	K	A					S	S			A	K	R		K	S	S
	A	S	S	S	S		A			K		A	S		S	S	S				A	S	K
		K		R	A	K	A	A				K											A
S	S	S	S	S	S	S	S	S		K	R	A	S	S	K	S	S	K			A	S	
															R	K	K					R	
																						R	
	A	K	K		A	S	S	S				A	A	A	A	K		K					
		K				K	R							A		R	K	K					
K		K	K	K	A	S	S	S				A	A	A	A	K	K	A					
A		K	K	S	S	K		S		K		A	S	A	S	A	R	K	R		A	S	
						R									R	R	R						
R	R	K	K	A	A	K	A	K				A	K	A	K	A							
					K							K		K	K	R	R						
S	S	S	S	S	S	A	S	S		K		A	S	S	S	A	S	A				K	
															A		K						
K		R	R		K	R		R		K		A	S	A	A	A	R						
R			R	K		K						K	A	K		R		K					
R	R	R		K	S	A	A	A				K						R					
	K				A	R	K					K	K	S	K								
	R			R			K								R	R	R	R					
					A		A	A	K						R								
				K		R	K	K		R					K	K	K	R					
															R								
						R	R	R															
															R								
							R																
							R						R		R								
					R																		
	R			R		A	A	K				A	A		A								
						R									R								
															R								
	K							K							R		R						
	K	R			R			A							R								
					R	R	R	A				A	K										
															R								
										A					R	A	R	R					
		R	R	R	A	R	K	K		K				K	K	A	R				A	R	R
							R																
K	K	K		K	K	A	S	S					K	K	S	S	S				K	K	K
K	K		A	A	A	A	A	A				A	K	A	K	S	K					R	
					R		R											R			R		R
K			R																				

Legend: R = rare, K = few, A = common, S = abundant

ides quadrilobatus is more acceptable in this zone than in the lower one. (This reambulation was made on the basis of the figure published by Bóna Kernerné (1966), at the same time totally accepting her determinations.) Between 136 and 76 m a sudden rise of the diversity and abundancy of the nannoplankton has been observed (17.20 and even 25 taxons!)

Among the *Discoasters* already mentioned, the presence of *D. lautus*, *D. adamanteus*, *D. brouweri* can be proven, and this is the interval of the first appearance of *Rhabdosphaera poculi* as well.

From approx. 76 m till 60.3 m, the nannoplankton vanishes almost completely, and *Corbula* and *Rotalia* rich biofacies becomes prevalent. This slightly brackish water facies is probably the heteropic equivalent of the general regression of the Eastern Mecsek, containing the lower Lajta-limestone and the brown coal deposits. (This statement is supported by Koreczné (1970) who has found a similar Rotalid facies in the brown coal formation). The nannoplankton of the samples of 56 – 57.5 m-s from the overlying *Turritella – Corbula*-rich clay indicates the boundary of zones NN 5 and 6, with the extinction of the last *S. heteromorphus* (Table 5.).

The zone NN 6 coincides approximately with the *Spiroplectammina* foraminifera assemblage zone, demonstrated between 52.5 and 44.3 m. This is the place of the first appearance of *Helicopontosphaera wallichi*. The 44.3 – 28.0 m interval can be correlated with the *Bulimina – Bolivina* zone of Grill. The enduring occurrence of species *Cyclococcolithus macintyrei* and *Rhabdosphaera poculi* is characteristic of this nannoflora. *The rich assemblage found in between 41.1 and 42.3 m, fixes the age of the Bulimina – Bolivina horizon – that is in the same time the upper boundary of the Badenian stage – in the zone NN 7*. Beside the zone index species *Discoas'er kugleri*, *D. aulakos*, *D. formosus*, *D. exilis*, *D. musicus*, *D. brouweri*, *D. lautus* were also found. and a form not determined yet (*Discoaster* sp.)

From 28 m till 25 m, a Sarmatian limy marl containing *Rotalia*, *Nonion* and diatoms represents the uppermost part of the Miocene sequence.

Six nannoplankton assemblages were examined from the Hidas browncoal area. Its rock column represents the third Miocene sedimentary cycle of the Mecsek area. *The so called lower Lajta limestone, being the base formation of the transgressive sequence was deposited in the zone NN 5. This is proven by the presence of S. heteromorphus. These results, which are in accordance with the information gained from the Tekeres 1 borehole, demonstrate, that the denudation period between the 2^nd^ and 3^rd^ sedimentary cycles and the beginning of the following transgression can be assigned to the zone NN 5* (Table 5.).

The *Bythinia* and *Brotia (Melania)* bearing formations interlayering the brown coal deposit contain no or very scarce nannoplankton. The overlaying clay, clayey marl containing *Tellinas* and *Cardita jouanetti* present no index nannofossils. Many persistent forms were described from it beside *Coccolithus pelagicus*, *Reticulofenestra pseudoumbilica*, *Rhabdosphaera pannonica*, occurring with great abundancy.

The Badenien Hidas sequence is overlain conformly by the brackish water Sarmatian diatomaceous clay, characterized by a small diversity –

great abundancy assemblage, with *R. pseudoumbilica*, *Holodiscolithus macroporus*, *Discolithina sparsiforata*, *Cricolithus jonesi* (Table 5.).

The material of the Tengelic – 2 drilling, having been carried out in 1978/79, north of the Mecsek, was thoroughfully and multilaterally examined by the Hungarian Geological Survey, and the results were published (for nannoplankton investigations, see NAGYMAROSY 1982). In the interval of 701.8 – 680.8 m of the borehole, an important Sarmatian marker horizon was recognized, where a monospecific flora of *Cyclococcolithus macintyrei* was observed. This horizon was mentioned also by STRADNER and FUCHS (1979) from the Vienna basin and by A. ANDREYEVA – GRIGOROVICH (1983) from the Sarmatian beds of the Eastern Carpathians.

Summing up the studies of Badenian nannoplankton from the Mecsek-Mountains, we can conclude, that the formations of the marine phase of the second sedimentary cycle (the Budafa beds, the Tekeres Schlier, the following regressional sequence) and the basal formations of the transgression of the third cycle, all were deposited in the time-interval corresponding to the zone NN 5. The thin sediments of the zones NN 6 – 7 overlay the brown-coal deposits. The presence of zone NN 7 has been proved, as the youngest nannoplankton zone in the Badenian.

In the Badenian sequence of the Mecsek, the zone NN 6 is characterized by the great abundance of *Discoaster exilis* (see MARTINI 1971), as it could ba usually observed in the realm of the Paratethys. The *Discoaster kugleri* in the Central – Paratethys realm was described only from the Mecsek area sofar. It seems that also the occurrence of *Helicopontosphaera wallichi* is restricted to the zone NN 7 in the Mecsek Mountains.

3.7. Nagylengyel area

The nannoplankton of four Miocene core-samples were examined from the boreholes of the Nagylengyel oil field, (from boreholes N1 – 82 – 100, – 112, which were studied and published previously by BÁLDINÉ BEKE M. in 1960).

The three sections are figured in fig. 6. We can state in general, that in all of the three sections, the Badenian overlays the Cretaceous sediments unconformly. The transgression sequence consists of limy sandstone, limestone, limy marl with *Litothamnium* and pebbles, which grade upwards to glauconite-bearing sandstone, except the profile of Nl – 100, where the glauconitic sandstone oversteps directly the Createceous formations. These layers of variable thickness are covered by grey marl, tuffaceous marl, or a brownish-grey marl with lignite-layers, in different succession in the boreholes respectively, but the total thickness of the three formations is approximately the same. The sequence sampled with only episodical cores is assumed to grade continously into the brackish Sarmatian marl. (DUBAY 1956.).

DUBAY determined foraminiferas from the two samples of the basal strata of the Nl – 82 and 112, and from two more samples of the upper part of the brownish grey marls (in N1 – 82 and 100). In all of the four samples the species *Orbulina universa*, *Globigerina bulloides*, *G. biloba*, *Uvigerina*

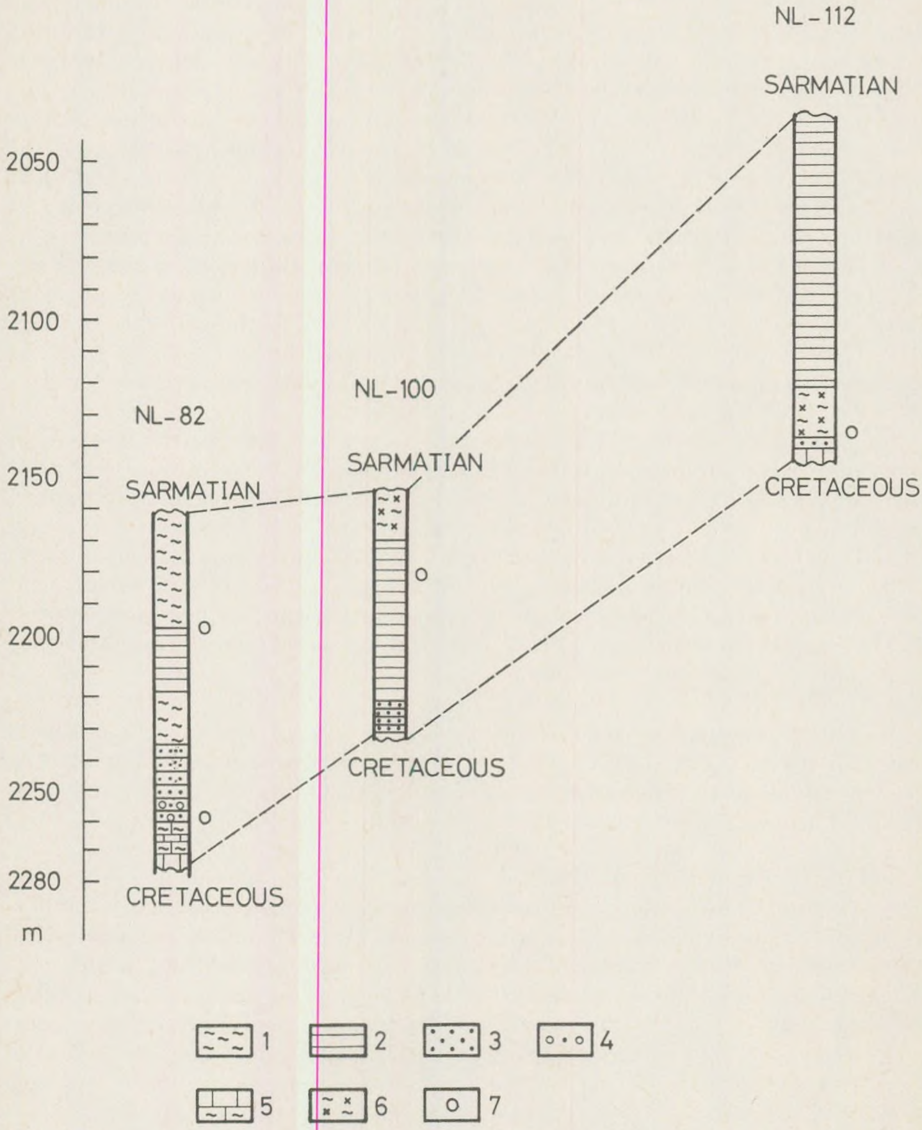


Fig. 6. Lithological sections of the Badenian part of the boreholes Nagylengyel-82, -100 and -112. Legend: 1. Grey marl, clayey-marl, 2. Brownish-grey marl, 3. Glauconitic green sandstone, 4. Lithothamnium-bearing gravelly limestone, 5. Yellowish-grey limestone, calcareous marl, 6. Grey tuffaceous marl, 7. Sampling point

brunensis were found uniformly Their cooccurrence corresponds to GRILL'S *Spiroplectammina* assemblage zone. The age derived from the nannoplankton investigations is not in accordance with that gained from the foraminifera studies. The presence of *S. heteromorphus* in all of the samples discloses the sequence to be younger than the zone NN 5. The age determination is complicated by the presence of *Helicopontosphaera ampliaperta* in the sample from 2183 m of the borehole Nl – 100, and this species, together with *S. heteromorphus* would fix the zone NN 4. However the small individual number of the former species allows to think, that this form is reworked. The foraminifera found together with it also disclose its autochtonous position. (Table 6.) Summarizing, we can conclude on the basis of the Badenian samples of the three boreholes that the age of the Badenian transgression can be fixed in the zone NN 5.

3.8 Bakony Mountains

Only 4 samples were studied from the Badenian sediments of the Bakony.

In the Eastern Bakony the Badenian formations overlie the Karpatian and older rocks unconformly while more westward they follow them conformly with intermittance of transitional freshwater and coal bearing layers.

The lower Badenian sediments of Várpalota marine clay, sand sandstone, limestone, conglomerate evolve from a 5 – 10 m thick terrestrical clay A famous outcrop locality of this sequence is the famous *Szabó-quarry in Várpalota. According to nannoplankton, the rock-column can unambigously be assigned to the zone NN 5*. (Table 6.)

One sample from the tuffaceous, pelitic, *Pereirea*-bearing layers overlying the coal formation near Herend fixes the age of the Badenian transgression also in the zone NN5. Two samples from the upper Badenian browncoal sequence of the E-Bakony (Iszkaszentgyörgy) do not contain any nannofossil, (due to their fresh-water character) (Table 6.).

3.9. The surroundings of Budapest

The Badenian formations overlay the Karpatian gravel, limy conglomerate, Bryozooa bearing limestone layers, and the older formations by erosional and angular unconformity in the surroundings of Budapest.

The material of the volcanic activity occurring at the Karpatian – Badenian boundary can also be traced here, for ex. in the tuffaceous, andesite-sandy outcrops of the Mogyoród wine cellars.

Two types of the local Badenian formations have been set up earlier (SCHRÉTER et HORUSITZKY 1958). the Lajta-limestone and tuffaceous limy marl related to the littoral facies, and the sandy "Baden Clay", belonging to the basin facies. In spite of this, the paleogeography of the Badenian near Budapest is far from clear. The newest boreholes made for the subway line will possibly ensure the material to clear up this subject.

Different authors pretend the Badenian formations in the surroundings of Budapest to be of upper Badenian age, based on the occurrence of

Table 6.

List of nannoplankton species from samples of Transdanubia and Budapest

	Metro – H – 40			Metro – 325				Metro – 309							Metro-Diósd-34,12 m, Lajta Limestone	Nl-82, 2259 m	Nl-112, 2136 m	Nl-100, 2183 m	Nl-82, 2197 m	Herend pereirea clay	Várpalota, Szabó-quarry	Iszkaszentgyörgy
	150,2 m	131,3 m	72,0 – 73,0 m	59,9 m	52,0 m	39,7 m	38,7 m	194,8 m	160,4 m	144,0 m	139,0 m	132,8 m	99,4 m	43,2 m								
Reticulofenestra excavata																						
R. minuta	A		K	A		S			A	S		A		K		S	A		A	S	A	
R. pseudoumbilica	A	A		R	K	S	K		R		K	K	R	A				R	R	K		
R. cf. *pseudoumbilica*			R			S			A	A		K				K	K	K		S		
Coceolithus eopelagicus			R					R	R	K	R		R	R		R		R	R			
C. pelagicus	K	K	R	K		S			R	S	S	A	K	K	R	A	A	S	S	S	A	R
C. radiatus				R		K														S		
C. jafari										K	S							R				
C. leptoporus	K									K			R	K						A		
C. mirabilis								R	R				R	R								
C. rotula	K	A		R					R	K	K	K							K			
Rhabdosphaera pannonica	K	A					R			R										S		
Discolithina multipora	R		K	R		K	R				R	K		K				R	K			
D. sparsiforata	R																					
Helicopontosphaera ampliaperta																		R				
H. kamptneri	K	A		A	A	A	A			A	A		R			S	A	A	S	A	K	
H. mediterranea	R																	R				
Syracosphaera pulchra		K							R			R										
Sphenolithus heteromorphus																A	K	A	S	A	R	
S. moriformis	R	R	R	R	R	R	R	K		R		R		R		A	K	A	A	K		
Micrantholithus flos										K						K						
M. vesper		R														R			R			

Braarudosphaera bigelowi	R		R		R		R							R		K			K	A	
B. discula																			R		
Discoaster adamanteus	R	K									R										
D. aulakos											R										
D. brouweri		K										R									
D. deflandrei												R									
D. dilatus												R									
D. druggii												R				R					
D. exilis	K	S									K	K									
D. cf. *kugleri*		R										R									
D. lautus												R									
D. musicus																R					
D. nephados										R											
D. trinidadensis	K																				
D. variabilis											A										
Perforocalcinella petali																					K
Coronocyclus nitescens	R		R																		
Cricolithus jonesi	A	A		R	R	K	K				R	K								K	
Holodiscolithus macroporus							K													K	
reworking from Paleogene	A	R	S	A	A		A	A	K	R	A	K	K	K		R		R	R	K	
reworking from Cretaceous	K		A	S		R		A		R	K	K	R	R	R	R		R	R	A	K

Legend: R = rare, K = few, A = common, S = abundant

Pecten aduncus Eichw , *Flabellipecten leythayanus* Partsch, *Orbulina universa* D'Orb.

The littoral Lajta-limestone-facies can be traced in the Rákospalota – Kőbánya line on the left side of the Danube and with diminishing thickness from the Mány – Óbarok – Biatorbágy line towards the Tétény plateau on the Buda side of the river.

The Lajta-limestone from the Metro – Diósd – 34. borehole, deepened on the Tétény plateau was barren for nannofossils. The tuffaceous limy marly intercalating the Badenian sequence of the Nyakaskő hill near Bia contained only one reworked species so I could not determine the age of the limestone series.

The nannoplankton of two samples from the Metro – 325. borehole were determined. The drilling is located in the road-cross of the Hungária street and Thököly street in NE Budapest, pentrating the inner basin type sediments. The Badenian sequence is as follows:

9.7 – 23.0 m	alternation of greenish grey, lignitic sand and clay, containing molluscs and plant relics
23.0 44.2 m	greenish grey mollusc bearing clay with clay pebbles, *Cerithium*, *Cardium*, *Turritella*, *Ostrea* and *Pecten* sp.
44.2 – 60.0 m	grey, limy sand and sandstone with Molluscs and at the base, with *Cerithium* sp.

The samples studied from this section. (59.9 m; 39.7 – 44.3 m) contained no index nannofossil. General forms are: *Coccolithus pelagicus*. *Cyclococcolithus floridanus*. *Reticulofenestra pseudoumbilica*, *Helicopontosphaera kamptneri*, *Cricolithus jonesi*. Reworked Eocene and Cretaceous forms were also recorded (Table 6.)

A more complete section was drilled in the borehole Metro – 309, in the Rákóczi-square (East-Budapest)

11.0 – 20.6 m	grey silt
20.6 – 21.8 m	sandy gravel
21.8 – 193.8 m	alternation of light brown-greenish, grey sandy clay and sandy clayey silt, at 92 – 93 m and 190.5 – 109.7 m with small pebbles and at 39 – 42 m and 144.2 – 144.6 m with bentonitic-tuffaceous intercalations
193.8 – 205.0 m	green, bentonitic, tuffaceous clay of fatty appearance and clayey conglomerate consisting of quartz pebbles (terrestric formation)

During detailed foraminifera-study of the rock column, Kernerné has succeeded to demonstrate (personal communication) that beside the bulk of reworked prebadenian forms, only the intervals of 41.5 – 44.3; 78.5 – 81.6; 90.0 – 92.0; 95.4 – 98.3; 107.8 – 111.0 m contain brackish water forms and only in one interval (129.4 – 145.0 m) yielded autochtonous marine foraminifera assemblages, which can be related to Grill's *Spiroplectammina* zone. In 155.8 m one *Helix* specimen occurs according to Nagy J. (pers. comm.).

The nannoplankton investigations support almost completely the results mentioned above. The samples from 194.8 m and 160.4 m contained poor nannoflora. Beside the species listed in the previous borehole, *Cyclococcolithus rotula, C. mirabilis, Syracosphera pulchra* are present. *The marine interlayering, characterized by an approx. twicefold diversity nannoflore, can be assigned to the zone NN 6, based on the presence of Discoaster exilis, D. aulakos, D. variabilis, D. musicus and on the lack of Sphenolithus heteromorphus.* The species *D.* cf. *kugleri* and *D. brouweri* occuring in the uppermost marine sample indicate that this part of the sequence can approach the zone NN 7. The other parts of the rock column yield only a restricted number of species with no stratigraphic value (Table 6.).

One of the three samples (131.3 m) of the borehole Metro H – 40 in the Őrs vezér square (NE Budapest) contained a rich nannoflore, with an extreme abundance of *D. exilis*. This fact indicates, that the sample belongs to the zone NN6 (Martini 1971.). Kókay J. has fixed the age of its foraminifera and mollusc fauna in the Middle Badenian, in Grill's *Spiroplectammina* zone (Table 6.).

In general it can be assumed, that the Badenian in Budapest covers – at least partly the zone NN 6 (which should be precised by further studies of greater number). The *Spiroplectammina* zone similarly to the Mecsek area – coincides with the zone NN 6. Unfortunately, no NN 7 nannoflora was recorded in the uppermost Badenian, here.

Fig. 7. Map of the localities investigated in this paper

4. The general wiew of the Badenian nannofloras in Hungary *(Fig. 7)*

4.1 The nannoplankton as environmental indicator

On their specific diversity and individual numbers, the Badenian nannoplankton assemblages treated in this paper are the richest ones, among those, found in the Tertiary formations of Hungary, younger than Upper Eocene.

The most important controlling factor of the fossilisation of the nannoplankton is the velocity of the water currents in the depositional environment. If this exceeds a limit-value, it can inhibit the deposition of the nannoplankton and the clay particles, having the same dimensions. According to this, the investigated coarse grained sandstones, conglomerates contain no or poor nannoflora. The littoral, coarse grained Lajta-limestone and the Sarmatian limestone represent a different cathegory in this group, since they often have Molluscan moulds proving also diagenetic solution of the calcareous shells of the fossils. It is not surprising in this way, that the Lajta-limestone is almost completely lacking nannofossils. The nannofloras reflect less vigourously the facies-relations, unlike the molluscs or the benthic foraminiferas. The primarily supply information about the salinity and the temperature of the water.

The fresh or brackish water sediments do not contain nannoplankton or with little diversity. In the case of normal salinity deposits, the thermal factors – more correctly the temperature of the upper part of the seawater – becomes predominant, since most of the nannoplankton species live there. *Corresponding to the temperature-maximum we can observe the greatest specific numbers (i.e. the highest diversity) in the Badenian segment of the zone NN 5*

In the examined samples, the relatively eurytherm-euryhaline species, tolerating the more extreme environmental changes and occurring practically in all of the samples with great or relatively great abundance, could be separated quite well from the species appearing in the more pelagic periods of the depositon or at warmer climates. The species with always relatively great individual numbers are: *Coccolithus pelagicus, C. eopelagicus, Cyclococcolithus rotula, C. floridanus, C. jafari, Reticulofenestra pseudoumbilica, R.* cf. *pseudoumbilica, Helicopontosphaera kamptneri, Holodiscolithus macroporus, Rhabdosphaera pannonica, Perforocalcinella fusiformis, Sphenolithus moriformis, Cricolithus jonesi.*

The forms to be listed below are closely attached to the deeper water, pelagic environment, so they appear mostly at the lower Badenian transgression, when these circumstances were prevalent in the territory of our country. This period also coincides with the thermal maximum mentioned above. These species are: *Helicopontosphaera wallichi, Sphenolithus heteromorphus, Coronocyclus nitescens* and the *Discoasters*. From this latter group the most frequent are: *D. variabilis, D. trinidadensis, D. musicus, D. exilis, D. adamanteus,* The *Thoracosphaera* species can be found also in this facies.

4.2. *The nannoplankton as time indicator*

The NN 5 – 6 – 7 Martini nannozones overlap the time interval of the Badenian. The NN5 nannozone index fossils, *Sphenolithus heteromorphus* and *Discoaster exilis* nearly always occur in their proper biofacies in the Badenian sediments of Hungary The extreme abundancy of *Discoaster exilis* (characteristic to the zone NN 6) was observed many times in the Badenian formations of the Mecsek-Mts. and Budapest. Only few specimens of *Discoaster kugleri* indicating the beginning of the zone NN 7 were found. *D. challengeri* s. str., *Triquetrorhabdulus rugosus*, *Scapholithus fossilis* and the different *Scyphosphaera* species are completely missing, however some of them were found in the Badenian of the neighbouring countries (LEHOTAYOVÁ 1970., GHETA in DUMITRICĂ et al. 1975). No characteristic forms of the zone NN 8 or of younger ones were found.

In our local synthese we can have use of those species, that appear to be attached to definite levels of our Badenian sections. According to our studies, the *Helicopontosphaera mediterranea* appears in the middle of the zone NN 4 in the realm of the Pannonian basin (*H.* cf. *sellii* in HORVÁTH and NAGYMAROSY 1978) and although it could be found in the zones NN 6 and also 7, its great abundance is related to the upper part of the zone NN 5. The *Coronocyclus nitescens* is also primarily characteristic of the zones NN 4 and 5.

The *Discoaster brouweri* appears in the top of the zone NN 5, but occurs rather in younger zones, with not very great abundance.

D. dilatus, *D. divaricatus*, *D formosus* are typical of the Zones NN 5 – 6, just like *D. lautus* and *D. adamanteus*.

The *Rhabdosphaera poculi* previously thought to be exclusively an NN 7 zone – indicator, was found however only scarcely – also in the zone NN 5. It seems that the *H. wallichi*, *Cyclococcolithus macintyrei* and the *D. cf. challengeri* (STRADNER and PAPP 1961) are characteristic of the zone NN 7 in Hungary

4.3. *Reworked forms*

Although the determined species coming from older formations are not figured in the Tables, the proportion of the Cretaceous and Paleocene froms is relatively small, compared to the Eocene forms representing the bulk of the reworked specimens. The forms inwashed from the Oligocene and the deeper Miocene formations could not be separated securely, since some of these persisted also in the Badenian.

In the samples of the Mecsek Mountains the reworked nannoplankton is generally very scarce. The NE-Hungarian sections contain an average of 4 – 5 reworked forms by sample, but extremely outstanding values were found as well. These latters are connected to local transgressive periods. In the Metro boreholes in Budapest, the number of the inwashed taxa is very great, it often constitutes one third of the specific number.

5. A brief review of the evolution of the Badenian stage based on nannoplankton investigations

Comparing the Grill assemblage-zones used commonly to subdivide the Badenian to the nannoplankton horizons gained from the recent investigations, the following correlation can be made (in good accordance with the data of Papp 1975, and Rögl et al. 1977):

- the lower and upper Lagenid zone corresponds to the higher part of the zone NN 5
- the *Spiroplectammina* zone corresponds to the zone NN 6
- the *Bulimina – Bolivina* zone corresponds to the zone NN 7.

The boundaries of the standard nannoplankton zones are mostly well recognizable in the Badenian in Hungary as well.

- The NN 4/5 boundary is well indicated by the extinction of *Helicopontosphaera ampliaperta* and with the appearance of *Discoaster exilis* and *D. formosus* in the highest part of the Karpatian.
- At the NN 5/6 boundary, the extinction of the species *Sphenolithus heteromorphus* and the considerable rise in the individual numbers of *D. exilis* is everywhere well observable. The sporadic appearance of *Helicopontosphaera wallichi* is also related to this horizon, but its abundance increases only in the zone NN7.
- The appearance of the species *Discoaster kugleri* at the boundary NN6/7 usually is not detectable in the Central Paratethys. In the present work it was found only in one sample. On the basis of the lack of this species and of *Discoaster challengeri* some researchers suppose, that in the Central Paratethys realm the zone NN 7 would belong to the brackish water Sarmatian. Because of the absence of the *D. kugleri* in Slovakian sections, Lehotayová (in Lehotayová et al. 1978) supposed, that the upper Badenian Kosovian substage also belongs to the zone NN 6. Although the question cannot be answered unambiguously yet, some scattered data (the presence of *D. kugleri* in some sections abroad, the end of the emersion of *D. exilis*, i.e. the end of NN 6, recognized in some profiles) *suggest that the Badenian time interval is covering at least the lower part of the zone NN 7.*

The results of Fuchs and Stradner (1977) based on numerous Austrian and Roumanian samples coincide very well with those of mine with one exception: They put the NN 5/6 boundary inside of Grill's *Spiroplectammina*-zone. (This difference may be due to environmental factors, since Grill's zones are not of absolute stratigraphic value and are strongly facies-dependent.)

Forms indicating younger ages than NN 7 are not known from the Central Paratethys realm.

In the following passage let us see how the two important geological events of the stage Badenian: the volcanic activity and the transgressive-regressive changes developed in time.

5.1. The beginning of the early Badenian volcanic activity is very precisely determined by BÁLDI and KÓKAY (1970) in the lower Lagenid zone in the area of the Börzsöny and Dunazug Mountains. Concording with this statement, the traces of the beginning of the volcanism in the Badenian sections of the North – Central-Mts. coincide almot precisely with the appearance of the Badenian type faunas in every case. The volcanic activity can be indicated by pyroclastic matter (Szokolya, Kismaros, Nógrádszakál) or by reworked pumiceous, tuffaceous interlayerings (Sajó valley). This volcanic paroxysm having taken place in the middle of the zone NN 5 was followed in the Sajó valley by a newer, thick tuff-supply at the end of the chronozone NN 5.

In the section investigated from the Mecsek, thin tuffaceous interlayerings occur at the base, in the middle and at the top of zone NN 5. In the Badenian sequence of Nagylengyel, belonging to the NN 5 zone, tuffaceous laminae were observed continuously throughout the sections.

5.2. The sediments of the lower Badenian transgression lay conformly or unconformly upon the Karpatian or older formations.

In the Northern Cserhát (Nógrádszakál) the Karpatian and the Badenian are uniformly represented by normal salinity sediments with continuous deposition. In the S W Börzsöny (Szokolya, Kismaros, Szob) the continuous marine section of the Karpatian and Badenian is interrupted at the boundary of the two stages by the interlayering of approx. 30 m thick freshwater-brackish water segment. This temporaneous environmental change was probably caused by uplifting, as the consequence of the volcanic activity.

Eastward from these undisrupted, essentially marine rock-columns, in the Sajó valley, the marine Badenian evolves continuously from brackish water Karpatian. More to the west, in the Northern Bakony, there is an erosional unconformity, between the Karpatian and the marine Badenian while more to the north, in the surroundings of Budapest, the postkarpatian denudation was not followed by Lower Badenian sedimentation.

In the Mecsek, the freshwater-brackish water environment was replaced by dominantly marine conditions a little earlier than the Karpatian-Badenian boundary.

The extension of the Lower Badenian sea in Hungary can be imagined as follows:

The marine influx arriving from SSW covered the Mecsek and SW Transdanubia. A large bay extended in the S-Bakony until Várpalota, not reaching Budapest. The other seaway extended from the Zala basin through the Vienna basin, the Little Hungarian Plain and S-Slovakia until the North Central-Mts.

The ranges of the High Bakony, Vértes, Gerecse and Pilis Mountains rose like islands or peninsulas from this sea, which covered almost all of Northern Transdanubia.

The southern origin of the temporal transgression is proved in the sections of the Mecsek, the S-Bakony and the Várpalota basin. The continuous Karpatian Badenian sections of the Börzsöny, Cserhát, S-Slovakia make us suppose another, permanent marine connection which extended over the Great Hungarian Plain until Transylvania and until S-Poland passing round the island-likely emerged N-Carpathes.

The regression at the end of the Lower Badenian was connected with uplift and denudation in some areas (p.ex. in the Bakony) and brought the dominance of fresh and brackish water circumstances in others (Zala basin, Sajó valley). The age of the regression can be fixed shortly before the end of the chronozone NN 5. The marine sedimentation continued without break only in the Sopron and Mecsek Mountains, where the sediments of the zone NN 6 can also be detected, (In the Eastern Mecsek a small partial regression took place at the and of the lower Badenian. In this area the newer transgression can be fixed at the end of the zone NN 5 and the carbonaceous period following it can be assigned to the zone NN 6.)

As a consequence of the middle Badenian regression (NN 6), the Podolian seaway stratching from S-Poland to Transylvania and the Transylvanian basin were temporally cut away from the Paratethys. In the hypersaline lagoons evaporites began to precipitate. This change took place in the Transylvanian basin at the boundary of the chronozones NN 5 and 6 (Dumitrica et al. 1975) and the normal marine conditions were reestablished only in the younger half of the chronozone NN 6.

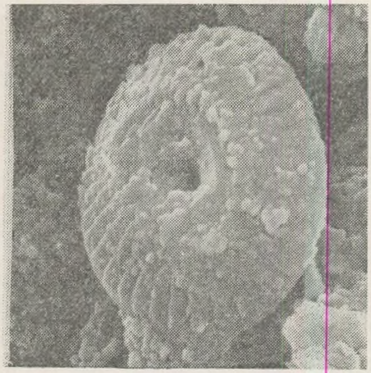
In the time of the halitic precipitation, in the Sopron Mountains and S-Börzsöny in Hungary, the Lajta-limestone was deposited. Further investigations are needed to resolve the problem of the proximity of the Mecsek, where brown coal deposition with humid climate was dominant. The two extremely different climates were only at a distance of 300 – 350 km-s from each other

The beginning of the second Badenian transgression can be placed to the end of the time-interval of the zone NN 6. Up to our knowledge, the SW connection with the Mediterranean was broken. This new transgression could have arrived from SEE. Its marine sediments can be traced from S to the N in the Mecsek (Turritella and Corbula bearing marl) in the Tapolca basin (4 m thick marine limestone in the borehole Szigliget – 1., Kókay 1967) in the vicinity of Budapest, in the Sopron Mountains and in the area of the Vienna basin. The brackish water Upper Badenian sediments in the N-Bakony and in the Várpalota basin follow unconformably the older Badenian formations. The NN 7 zone is represented in the North Central Mountains and in SE-Slovakian by brackish and freshwater sediments as well.

6. List of nannoplankton species mentioned in this paper

Reticulofenestra minuta Roth 1970.
R. pseudoumbilica (Gartner) Gartner 1969.
*R.*cf. *pseudoumbilica* (Gartner) Gartner 1969.
Coccolithus eopelagicus (Bramlette et Riedel) Bramlette et Sullivan 1961.
C. miopelagicus Bukry 1971.
C. pelagicus (Wallich) Schiller 1930.
C. radiatus Kamptner 1955.
Cyclococcolithus cricotus Gartner 1967.

C. jafari (Müller 1974)
C. leptoporus (Murray et Blackmann) Kamptner 1956.
C macintyrei Bukry et Bramlette 1969.
C. mirabilis (Lohmann) Kamptner 1954.
C rotula (Kamptner) Kamptner 1956.
Cyclicargolithus floridanus (Roth et Hay) Bukry 1971.
Thoracosphaera diff. sp. Kamptner 1927.
Rhabdospharea clavigera Murray et Blackmann 1898.
R. pannonica (Báldi – Beke 1960.)
R. poculi (Bóna 1964.)
Discolithina multipora (Kamptner) Martini 1965.
D. sparsiforata (Kamptner 1948.)
Helicopontosphaera ampliaperta (Bramlette et Wilcoxon) Bukry 1970.
H. euphratis (Haq) Martini 1969.
H. intermedia (Martini) Hay et Mohler 1967.
H. kamptneri Hay et Mohler 1967.
H mediterranea Müller 1981. (This species was described as H. cf. sellii Bukry et Bramlette 1969. in Nagymarosy 1980. For detailed references see Báldi – Beke 1982.)
H. wallichi (Lohmann) Boudreaux et Hay 1969.
Syracosphaera pulchra Lohmann 1902.
Coronosphaera mediterranea Gaarder 1974.
Sphenolithus heteromorphus Deflandre 1953.
S. moriformis (Brönnimann et Stradner) Bramlette et Wilcoxon 1967.
Micrantholithus flos Deflandre 1950
M. vesper Deflandre 1954.
Braarudosphaera bigelowi (Gran et Braarud) Deflandre 1947).
B. discula Bramlette et Riedel 1954.
Discoaster adamanteus Bramlette et Wilcoxon 1967. (inclusive *D. obtusus* Gartner és *D. stellulus* Gartner)
D. aulakos Gartner 1967.
D. brouweri Tan Sin Hok 1927.
D. deflandrei Bramlette et Riedel 1954.
D. dilatus Hay 1967.
D. divaricatus Hay 1967.
D. druggii Bramlette et Wilcoxon 1967.
D. exilis Martini et Bramlette 1963.
D. fornosus Martini et Worsley 1971.
D. kugleri Martini et Bramlette 1963.
D. lautus Hay 1967.
D. musicus Stradner 1961.
D. nephados Hay 1967.
D. trinidadensis Hay 1967.
D. variabilis Martini et Bramlette 1963.
Discoaster sp.
Perforocalcinella petali Bóna 1966.
Coronocyclus nitescens (Kamptner) Bramlette et Wilcoxon 1967.
    Cricolithus jonesi Cohen 1965. (Some of the forms described as *C. jonesi* in this paper may be *Coronosphaera mediterranea* Gaarder. Due to the tiny character of this particles, the exact determination of the forms in light microscope is not always possible.)
Holodiscolithus macroporus (Deflandre) Roth 1970.
Lithostromation triangularis Gardet 1955.



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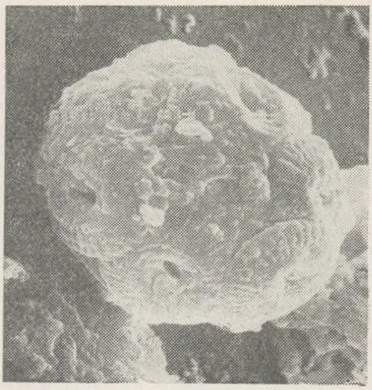

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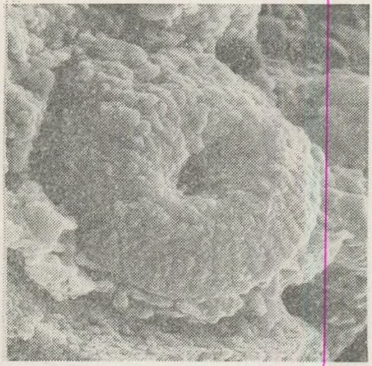

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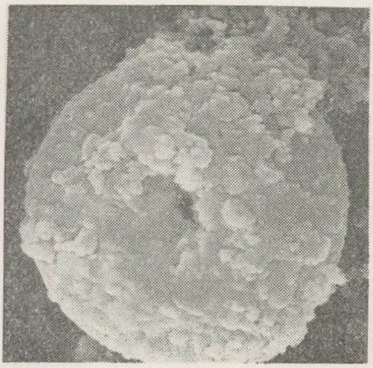

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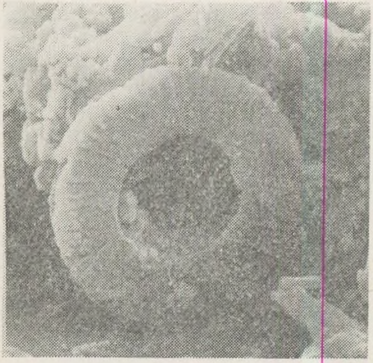


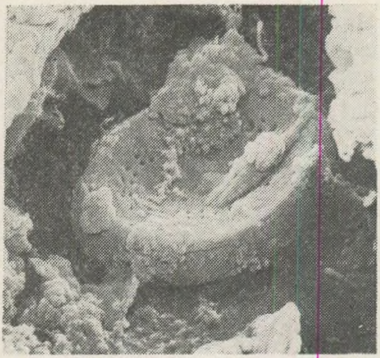
5.

6.

Plate I.
(photos of R. LEHOTAYOVÁ; Tekeres 1., 41 – 42 m)

1 – 3. *Coccolithus palegicus* (WALLICH) SCHILLER, 1. N = 10 000, 2. N = 4000, coccosphaera, 3. N = 9000
4. *Cyclococcolithus leptoporus* (MURRAY et BLACKMANN) KAMPTNER, N = 10 000
5. *Cyclococcolithus rotulus* (KAMPTNER) N = 10 000
6. *Helicopontosphaera kamptneri* HAY et MOHLER, N = 8000

Explanation of plates
Key: n″ = parallel nicols
n+ = crossed nicols
N = magnification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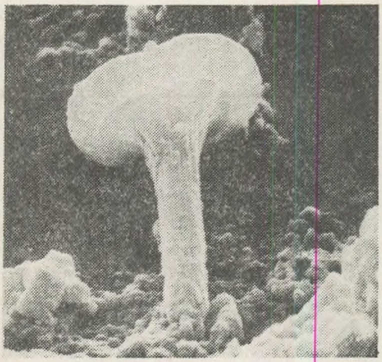
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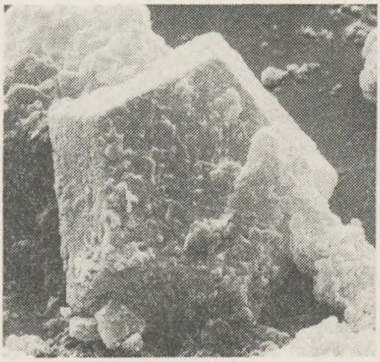
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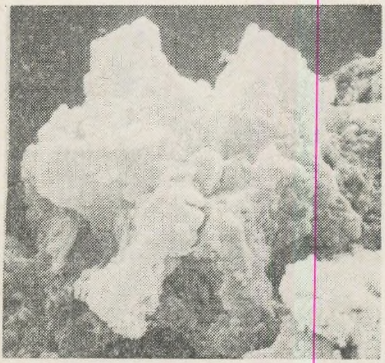
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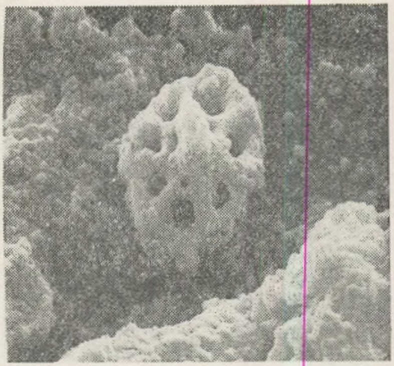
Plate II.
(photos of R. LEHOTAYOVA; Tekeres-2., 41 – 42 m)

1. *Discolithus multiporus* (KAMPTNER) N = 8000
2. *Discolithus sparsiforatus* KAMPTNER, N = 6000
3. *Rhabdosphaera pannonica* (BÁLDI – BEKE), N = 9000
4. *Braarudosphaera bigelowi* (GRAN et BRAARUD) DEFLANDRE, N = 4000
5. *Discoaster variabilis* MARTINI et BRAMLETTE, N = 7000
6. *Cricolithus jonesi* COHEN, N = 20 000



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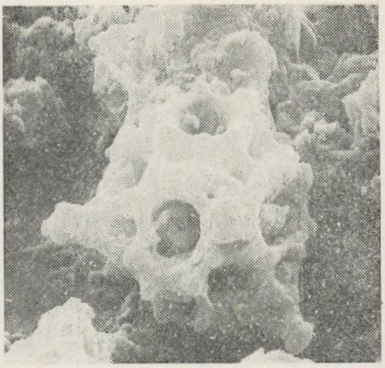

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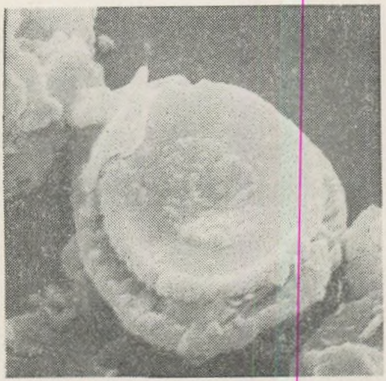

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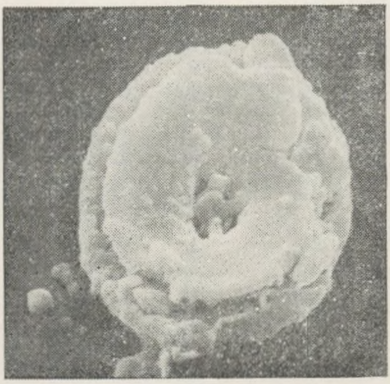

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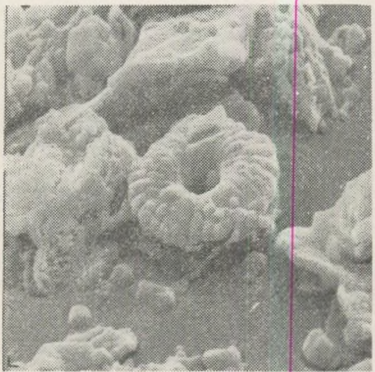

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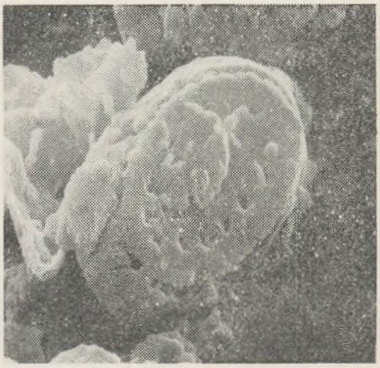

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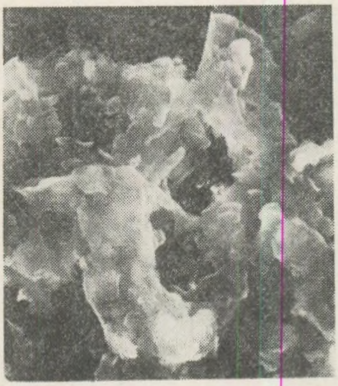
Plate III.
(photos of R. LEHOTAYOVÁ)

1. *Holodiscolithus macroporus* (DEFLANDRE) ROTH, N = 10 000, Tekeres-1, 41 – 42 m
2. *Lithostromation triangularis* GARDET, N = 6000, Tekeres-1, 41 – 42 m
3. *Reticulofenestra* sp., N = 10 000, Sajóvelezd-49, 218 m
4. *Coccolithus pelagicus* (WALLICH) SCHILLER, N = 10 000, Sajóvelezd-49, 218 m
5. *Cyclococcolithus jafari* (MÜLLER), N = 10 000, Sajóvelezd-49, 218 m
6. *Discolithus sparsiforatius* KAMPTNER, N = 10 000, Sajóvelezd-49, 218 m



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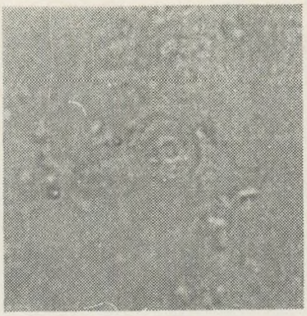

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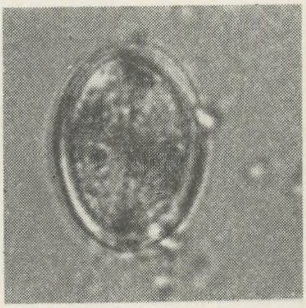

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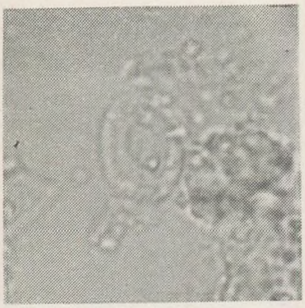
Plate IV

1. *Helicopontosphaera* cf. *sellii* Bukry et Bramlette, N = 2500, Tekeres-1, 52 – 55 m
2. *Cyclococcolithus jafari* (Müller), N = 1900, Tekeres-1, 41 – 42 m
3 – 4. *Rhabdosphaera pannonica* (Báldi – Beke), both N = 1900, 4. n +, Tekeres-1, 96,8 – 98,0 m
5 – 6. *Discolithus sparsiforatus* Kamptner, 5. n”, 6. n +, both, N = 1900, Sajóvelezd-49 390 m



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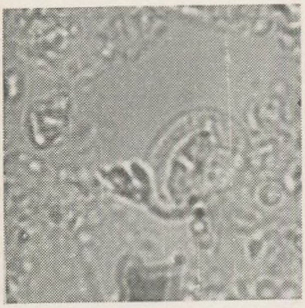

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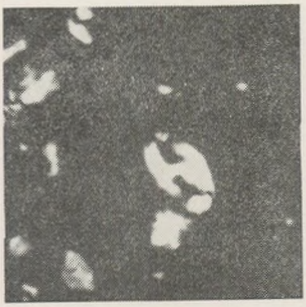

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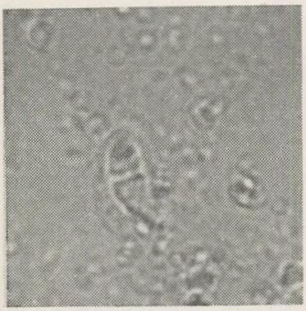

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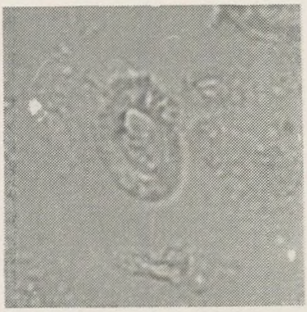

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Plate V.

1 – 2. *Helicopontosphra ampliaperta* (Bramlette et Wilcoxon) Bukry, 2. n+, mindkettő N = 1900, Sajóvelezd-49, 390 m

3 – 6. *Helicopontosphaera* cf. *sellii* Burky et Bramlette 4. n+, all four N = 1900, 3 – 4. Bánhorváti-17, 153 m, 5. Tekeres-1, 262 – 264 m, Szokolya-Md-surface sample

7 – 8. *Helicopontosphaera wallichi* (Lohmann) Bourdeaux et Hay, 8. n+, both N = 1900, Tekeres-1, 26,0 – 285, m

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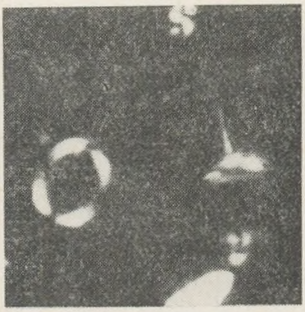

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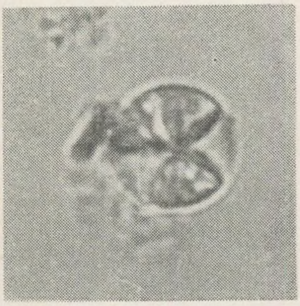

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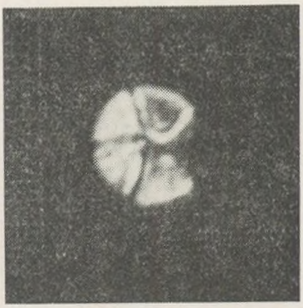

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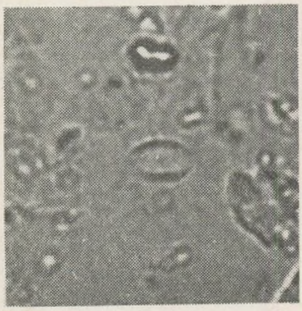

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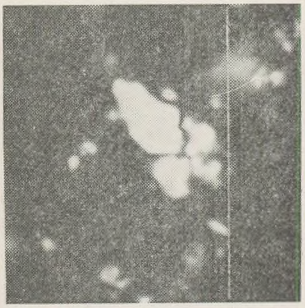
Plate VI.

1 – 2. *Syracosphaera pulchra* Lohmann, 2. n +, N = 1900, Sopron, Kurucdomb
3 – 4. *Braarudosphaera discula* Bramlette et Riedel, 4. n +, both N = 2500, Tekeres-1, 41 – 42 m
5 – 8. *Cricolithus jonesi* Choen, 5 – 6. N = 1900, Tekeres-1, 96,8 – 98,0 m, 6. n +, 7 – 8. N = 2500, Frättingsdorf, 8. n +



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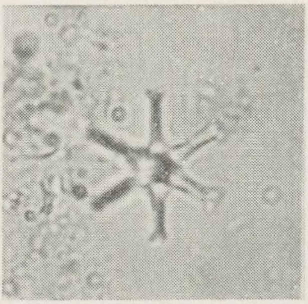

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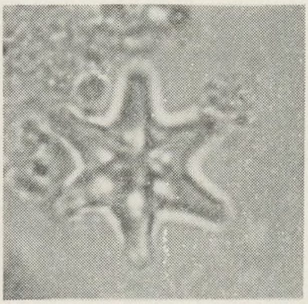

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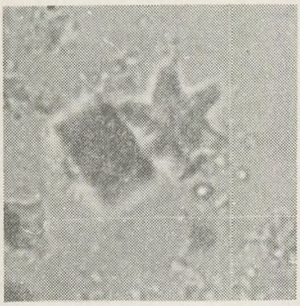

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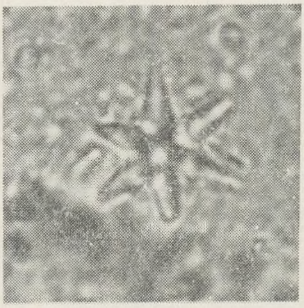

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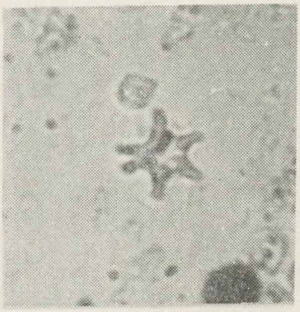

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Plate VII.

1. *Sphenolithus heteromorphus* BRAMLETTE et WILCOXON, n+, N = 2500, 45° to the nicols, Nagylengyel-82, 2259 – 2260 m
2. *Discoaster exilis* MARTINI et BRAMLETTE, N = 1900, Tekeres-1, 52,5 – 54,5 m
3. *Discoaster brouweri* TAM SIM HOK, N = 1900, Tekeres-1, 52,4 – 54,5 m

4 – 5. *Discoaster adamanteus* BRAMLETTE et WILCOXON, 4. N = 2500, Szokolya-2, 114 – 155 m, 5. N = Tekeres-1, 96,8 – 98,0 m

6 – 7. *Discoaster formosus* MARTINI et WORSLEY, 6. N = 2500, Tekeres-1, 227 – 229 m, 7. N = 1900, Nógrádszakál-2, 122 – 123 m

8. *Discoaster kugleri* MARTINI et BRAMLETTE, N = 1900, Tekeres-1, 41 – 42 m

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Abbreviations:

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F. K. = Földtani Közlöny (Bulletin of the Hungarian Geological Society)
In. Rep. DSDP = Initial Report of the Deep Sea Drilling Project
Magyarázó. . = Magyarázó Magyarország 200 000-es földtani térképsorozatához (Explanatory notes to the geological map of Hungary, 1:200 000)
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Proc. VI. th. . . – Proceedings of the VI. th Congress RCMNS Bratislava, 1975.
kézirat = manuscript

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MAIN FEATURES OF THE EVOLUTION OF THE EASTERN PARATETHYS IN THE OLIGOCENE AND LOWER MIOCENE

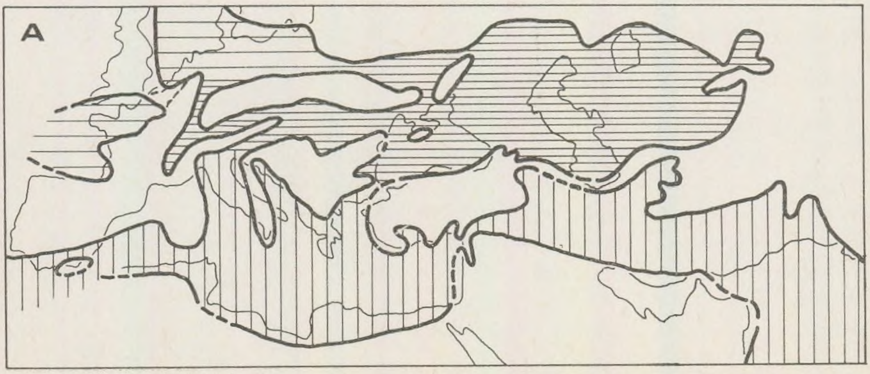
by

A. A. VORONINA and S. V. POPOV

(Recived: 1st March 1984)

The independent basin of the Eastern Paratethys has been formed in the Late Eocene and Early Oligocene by the effect of the Alpine orogenic phase folding and uplifting the chains of the Alps, Dinarids, Caucasus, Elburs and Kopet Dag, and thus separating the northern part of the Tethys from the central basin (fig. 1.). From the beginning of the Oligocene era the Paratethys existed as a partly isolated sedimentary basin (BÁLDI 1980) with individual sedimentation and more or less endemic fauna. The most significant part of this epicontinental basin was the Eastern Paratethys, extending from the Black Sea to the Kopet Dag.

In the Crimea, Mangyshlak, at the Black Sea and on the northern and southern slopes of the Great Caucasus a transition of the Beloglin horizon and its corresponding formations into the Khadum horizont can be observed at the base of the Oligocene. It means, thath the light, clayey-calcareous Beloglin layers change upwards into black, microlaminated, slightly or not calcareous clays of the Khadum. Usually an unconformity and hiatus can be observed in the shallow water sediments at this level, but this boundary is sharp even in the profiles with continous sedimentation. A large-scale reworking of the microfauna (according to L. S. TER – GRIGORYANTZ) and nannoplankton (ANDREEVA – GRIGOROVICH 1981) occurs at this boundary



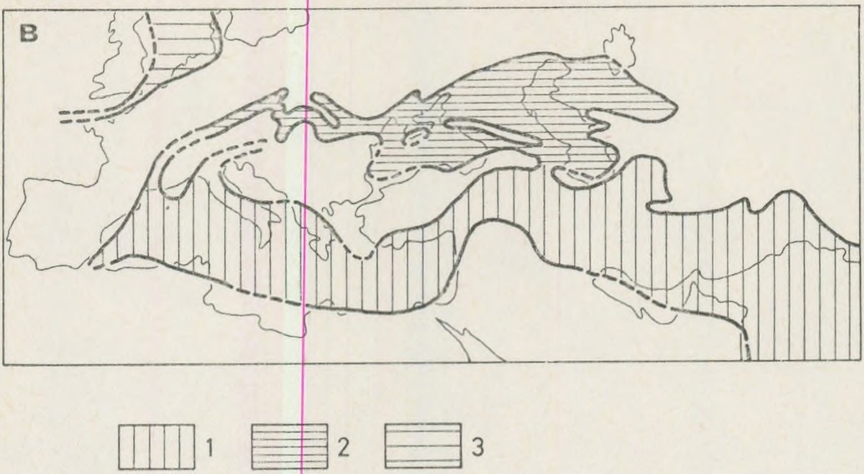


Figure 1. Paleogeographic sketch of the Paratethys and its neighbouring basins 1 – Tethys, 2 – Paratethys, 3 – Atlantic A = Early Oligocene B = Early Miocene

Large-sized forms of the *Globigerina gortanii – Globorotalia centralis* zone together with the benthic foraminifers of the *Bolivina antegressa* zone and with the nannofossils of the *Discoaster barbadiensis* zone (*Sphenolithus pseudoradians* subzone) (Krashenninikov and Musilyov 1975.) can be found in the higher, marly part of the Beloglin horizon of the Caucasian Foredeep. Very rich mollusc assemblages and microfaunas were described from South Ukraina, Transcaucasia and Usturt too.

The deeper, Lower Oligocene part of the Khadum clay contains the planktonic foraminiferas of the *Globigerina tapuriensis* zone and the nannofossils of the *Helicopontosphaera reticulata* zone (Andreeva – Grigorovich 1981) (*Coccolithus subdistichus* subzone, sensu Musilyov 1980), together with mollusc assemblages, similar to the West European Rupelian ones.

A relatively quiet, undisturbed, long period of the evolution of the Eastern Paratethys began in the Lower Oligocene, in which the boundaries of the basin and the sedimentary environments remained rather unchanged. This basin is referred as to Maikopian. Its geological history can be divided into the following periods (Table 1.):

1. Pshechian period (Early Oligocene)

Its name is derived from the Pshechian horizon of the Western Caucasian Foredeep (Korotkov 1935) corresponding to the Lower Khadumian. The stratotype of the horizon can be found on the Vosskovaya mountain (Khadizshensky district). This period is characterized by marine sedimentation, similarly to the whole Paratethys, including also its western part (Pannonian basin). The investigation of the Paratethyan faunas suggests an effective connection toward the Atlantic ocean (see fig. 1.). The Lower Oligocene mollusc faunas having been described from the near Black

Table 1.

Age	East Paratethys	Microfauna	Molluscs	Nannoplanktonic zone	Central Paratethys
Lower Miocene	Tarchanian			NN 5	Karpatian
	Kozachurian VI	*Saccamina zuramakensis*	*Rzehakia socialis* *Cerastoderma ivericum* *Eoprosodacna kartlica* *Congeria subclaviformis* *Melanopsis incrassata*		Ottnangian
	Sakaraulian V	*Neobulimina elongata*	*Leonucula burdigalica* *Glycymeris deshayesi* *Anadara, Glossus, Pinna,* *Megaxinus bellardianus,* *Discors discrepans,* *Fragum kübecki*		Eggenburgian
	Caucasian IV	*Uvigerinella californica*	*Glycymeris lunulata* *Lucinoma borealis* *Laevicardium spondyloides* *Parvicardium heeri* *Arcopsis, Turritella beyrichi, T. venus*	NP 25	Egerian
Upper Oligocene		*Bolivina goudkoffi*			
	Roshnean III		*Cerastoderma prigorovskii* *Lenticorbula helmerseni* *Cordiopsis incrassata*	NP 24	Kiscellian
		Spiroplectammina terekensis, *Virgulinella ex. gr. pertusa*	*Nuculana gracilis* *Glycymeris lunulata* *Similipecten hauchecornei* *Plagiocardium abundans*		
Lower Oligocene	Solknovian II	*Trochammina florifera,* *Pseudogaudryina tripartita*	*Lenticorbula sokolovi,* *L. subtriancula,* *Cerastoderma mutabile* *Nucula comta, Callista beyrichi, Natica*	NP 23	
		Dysopontocypris oligoçaenica	*Ergeniça cimlanica* *Urbnisia lata, Janschinella vinogrodskii, Korobkoviella kiktenkoi,* *Cerastoderma serogosicum*		
	Pshechian I	*Spiroplectammina carinata oligoçenica*	*Nuçulana sulcifera, Astarte kickxi,* *Glycymeris obovata, Pecten arcuatus,* *Ostrea cyatula, Megaxinus batalpaschinicus, Neritina abastumanica,* *Ptyçhopotamides subelegans, Prienella monilifera, Babylonia caronis*	NP 22–21	
		Cribrostromboide deformabilis			
		Subtilina fidelis, Globigerina tapuriensis			
Upper Eocene		*Globigerina gortanii* *Globorotalia centralis* *Bolivina antegressa*		NP 19–20	

Table 1. Stratigraphical division and faunistic features of the Oligocene-Early Miocene formations of the Eastern Paratethys

sea depression, from the Caucasian Foredeep (KOROBKOV 1937), from Transcaucasia (KAZAKHASHVILI 1969), from Usturt and Mangyshlak (MERKLIN 1974) show a composition, similar to the West European Rupelian assemblages. A more hindered connection existed toward the Tethys, though some common mollusc species in the Lower Oligocene strata of South Georgia (part of Paratethys) and Armenia (part of the Tethys) proves the faunal exchange between the the two regions.

The following benthic foraminifers occur at the base of the Pshechian horizon (together with molluscs, nannoplankton and planktonic foraminiferas)· *Subtilina fidelis*, *Cribrostromboides deformabilis* in Stavropol height and *Lenticulina herrmani* assemblages in the maritime region of the near Black sea depression, in Mangyshlak and in the Kopet Dag (TER–GRIGORYANTZ 1980). The higher part of the Pshechian horizon is characterized by the foraminifers of the *Spiroplectammina carinata oligocenica* zone. This foraminifer-rich level is usually well traceable in the Maikopian strata.

The thickness of the Pshechian formations is rather small (30 – 50 m) in the greatest part of the Eastern Paratethys, but their thickness exceeds even 600 meters in the depressions.

2. *Solenovian period (end of Early Oligocene – beginning of Late Oligocene)*

Its name is derived from the Solenovian horizon, which was set up by G. I. POPOV (1959) based on borehole profiles of the area between the Volga and the Don. The Solenovian was the period, when the Paratethys-basin closed first time and a peculiar, endemic fauna developed after a decrease in the salinity. The macrofauna is composed by molluscs, mainly cardiids *(Cerastoderma, Korobkoviella, Merklinicardium)* corbulids *(Lenticorbula, Lentidium)*, rzehakids *(Ergenica, Urbnisia)* and myids *(Janschinella)* (POPOV and TITOVA 1982). The lower part of the Solenovian horizon contains the nannofossils of the local nannoplankton zone *Zygodiscus vialovi*, together with the common species of the standard nannoplankton zone *Sphenolithus predistentus* (NP 23) (ANDREEVA GRIGOROVICH 1981) Also ostracods occur in these layers, their most characteristic form is the *Disopontocypris oligocaenica*. The Solenovian sediments are often referred as to "Ostracoda beds" because of the presence of the large-sized ostracods (Table 2.).

The formations of this period can be divided unambiguously into two parts on the base of lithology and the faunas. The marls and the light. carbonatic clays of the lower part of the Solenovian horizon (Pollinian subhorizon) with their brackish water fauna dispose an excellent marker level in the monotonous, non-carbonatic, hardly fossiliferous bulk of Maikopian strata. The upper part of the Solenovian horizon consists of non-carbonatic, brown, ferriferous, fossil-free clays (Gechinian sub-horizon) However in this level, – only in shallow water sediments – , brackish water species generally occur, and even few euryhaline marine species has been found in Georgia and Ustyurt.

Table 2.

Age	Horizons (regiostage)	South Ukraine	North Caucasus							Georgia	Mangyshlak		North Usturte	
			West, Central			East								
Lower Miocene	TARCHANIAN	tarchanian	tarchanian			tarchanian				tarchanian				tarchanian
	KOZAHURIAN VI	majachkovskaya	maikopskaya serie		ritsevskaya	maikopskaya serie			zuramakentskaya	kozahurskaya				,,Rzehakia'' beds
	SAKARAULIAN V	chernobaecskaya			olginskaya				sulakskaya	sakaraulskaya				
	CAUCASIAN IV	gornostaevskaya			karadzhalginskaya				assinskaya	uplistsichskaya				
Upper Oligocene					zelenchukskaya									
					septarievaya				septarievaya			kashkaratinskaya		baigubekskaya
					alkunskaya				alkunskaya		karagiinskaya	upper		
	ROSHNEAN III	askanijskaya			batalpashinskaya				miatlino-mucidakalskaya			middle		
				chadumskaya	upper Morozkinskaya subsuite		chadumskaya	upper	roshnenskaya			Virgulinella horison		karatomakskaya
	SOLENOVIAN II	serogozskaya			lower Morozkinskaya subsuite				gechinskaya	Corbula beds		lower	solenovian h.	manaisorskaya
Lower Oligocene		molochanskaya			polbinskaya			m.	Ostracoda beds	Urbnisia beds		Ostracoda beds kendzhalinskaya		Ostracoda beds
	PSHECHIAN I	nikopolskaya			pshechskaya				lower	lower chadum		kujulusskaya		asteairykskaya
		rubanovskaya (kyzyldzharskaya)										usunbasskaya		
Upper Eocene	BELOGLINIAN	beloglinskaya	beloglinskaya			beloglinskaya				Bolivina beds		adaevskaya		cheganskaya

Table 2. The sequence of the Maikopian formations in the different regions of the Eastern Paratethys

Interpreting the data above it seems, that the connection with the world sea became, at least partim, reestablished from the second part of the Solenovian periode. Sharp stratification of water masses and increased H_2S development, due to the influence of the normal salinity water into the brackish water basin. The effect of this phenomenon is shown in the composition of the sediments (high concentration of not demolished organic material, jarosite, pyrite) and in the absence or impoverishment of the faunas. This effect also makes more difficult to draw chronostratigraphic boundaries in the Oligocene and Miocene.

In this period, as in earlier periods, no sharp separation of West and East Paratethys existed. The brackish water layers of this period are well traceable in the whole dimension of the Paratethys, from the Caspian lake until Rumania (Moisescu 1978) and Hungary (Báldi 1980.). In Hungary, this level corresponds to the "*Cardium*" *lipoldi* and *Ergenica cimlanica* bearing layers and to the upper part of the Tard Clay.

The thickness of the lower sub-horizon of the Solenovian horizon usually does not exceed 10 – 15 meters, though in deeper depressions it ranges until 150 meters. The thickness of the upper sub-horizon is 50 70 meters.

3. *Roshnean period (Late Oligocene)*

The name derives from the Roshnean horizon of the Eastern Caucasian Foredeep (Somov 1970), its stratotype is at the barrage of the rivers Roshna and Gekhi.

The connection between the Paratethys and the world sea reestablished completely in this period. The sea water flooded again the basin of the Paratethys. The direction of the marine connection might be a northwestern one. The greater part of the molluscs show an North-Atlantic affinity. Their composition even of the most eastern Ustyurtian Bay of the Paratethys, corresponds in a 2/3 ratio to the common species of the Chattian of Western Europe (Merklin 1974).

Rich assemblages of the *Spiroplectammina carinata* and *Virgulinella* ex. gr. *pertusa* benthic foraminifera zones and *Sphenolithus distentus* (NP 24) nannoplankton zone occur in the lower part of the Roshnenian sediments (Popov et al. 1983), while its upper part contains only very impoverished mollusc and foraminifer assemblages. This duality is due to the decrease of the salinity in the northern coastal region and the normal salinity in the central part of the basin, where it is demonstrated by the normal marine fish fauna. The *Rhombodinium longimanum* and *Wetzeliella clathrata* dinoflagellate assemblages (Andreeva – Grigorovich) are characteristic throughout the whole series.

The Roshnenian strata can be well correlated with the Kiscell Clay in Hungary. The thickness of the Roshnenian strata is usully 250 350 meters rarely 1000 meters.

4. *Caucasian period (end of Late Oligocene? -beginning of Early Miocene)*

This term was proposed by A. K. BOGDANOVICH and M. F. NOSOVSKY as regional stage (see NEVESSKAYA et al. 1975), its stratotype is localized in the valley of the Kuban river, near to Cherkessk.

At the beginning of this period the marine environments existed continously as it is shown by the rich benthic foraminifera assemblage of the *Bolivina goudkoffi* zone. The direction of the marine connections of the Paratethys changed and Tethys-type faunas began to immigrate from the south. This procedure is proven by mollusc faunas having been described from West Georgia (near to the town Tkvarcheli).

In the upper part of the Caucasian strata a rapid impoverishment of the microfauna has been noticed (*Uvigerinella californica* zone), which may be due to the decrease in the salinity of the sea water (BOGDANOVICH 1974).

The age of the Caucasian complex is disputable: while the benthic foraminifera and mollusc assemblages are interpreted to be Miocene, the nannofossils of the *Sphenolithus distentus* (NP 24) and *Sphenolithus ciperoensis* (NP 25) zones and the dinoflagellates of the *Wetzelliella gochtii* and *Rhombodinium longimanum* zones correspond to the Chattian of Western Europe (POPOV et al. 1983). The extreme rarity of fossils in the Caucasian sediments makes the correlation complicated with the formations outside of the stratotype area.

The thickness of the Caucasian rocks is 150 – 300 meters in the Caucasian Foredeep.

The Caucasian corresponds to the Egerian in the Western Paratethys. The later one is much better characterized by mollusc faunas, therefore the change in their composition is much more detectable through time. Using the compositional changes (BÁLDI 1973), we can also measure the growing influence of the Tethys.

5 *Sakaraulian period (Early Miocene)*

The term has bean set up on the base of the "Sakaraulian horizon" introduced by L. S. DAVITASHVILI (1933.). Its stratotype is in Metekhi, Central Georgia.

Analyzing the rich, warm water dwelling mollusc faunas of the Sakaraulian (KHARATISHVILI 1952) a wide connection can be proved with the world sea southward. The Paratethys – indirectly – was connected with the Indo – Persian region that time, as it is supported by the marine Burdigalian sediments extending as far as Turkey and Iran. No really characteristics mollusc fauna is known outside Georgia, and thus the Sakaraulian is characterized mainly by benthic foraminifera (*Neobulimina elongata* zone).

Making a comparison between the mollusc faunas of the Central European Eggenburgian and the Sakaraulian, not only their synchronity can be proved, but also paleobiographical differences can be noticed: the Sakaraulian mollusc faunas contain some tropical elements.

The thickness of the Sakaraulian is 150 – 200 meters on the stratotype area.

6. Kozachurian period (Early Miocene)

The term has been set up on the base of "Kozachurian horizon" (Davitashvili 1933). Its stratotype is located at the town Caspi, its hypostratotype in Metekhi (Central Georgia).

The Paratethys became a separated. brackish water basin again dwelt by peculiar fauna. The Kozachurian mollusc faunas are only in Georgia discovered. The species belong either to endemic genera *(Rzehakia, Eoprosodacna, Limnopappia)*, or to typical brackish water genera *(Melanopsis, Congeria)* The Kozachurian sediments outside Georgia are characterized only with specific, very impoverished benthic foraminifers *(Saccamina zurmakensis)* and molluscs *(Rzehakia)*.

Not concerning its basically separated character, the dimensions of the Kozachurian basin system are not explored yet, its delimitation has not been carried out yet. The *Rzehakia*-bearing beds overlay the older rocks transgressively in the Transcaspian region.

The connection toward the Western Paratethys might have been episodic that time, as it is shown by some common brackish water species (*Eoprosodacna* in the Upper Ottanngian and *Limnoppapia* in the Kozachurian, Popov et Voronina 1983).

The thickness of the Kozachurian sediments is 100 – 150 meters in the stratotype area.

The long and individual history of the Maikopian sea, ranging from the beginning of the Oligocene until the end Early Miocene finished in the Kozachurian. A regression occurred at the end of the Kozachurian, and the Tarchanian sediments overlay the Maikopian usually unconformly. Continous sedimentation was observed in the deeper depressions of the basin, where a gradual change of the sedimentary environments occurs: noncarbonatic, jarositic, chocolate-brown clays alternate with carbonatic Tarchanian sediments, containing many benthic and planktonic fossils.

Summarizing, at least six important periods of the history of the Eastern Paratethyan Maikopian basin can be distinguished. However it is possible, that the Roshnenian and Caucasian periods are not homogenous, and must be divided into two-two parts respectively The Miocene horizons, similar to the Oligocene ones described above are concerned to be distinct regional stages. It is clear, that the same method must be applicated in the establishing an Oligocene regional stage system. Nevertheless the extension of these stages on the whole Paratethys is rather difficult because of their weakly characterized faunas.

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A PLIENSBACHIAN – LOWER CRETACEOUS PROFILE AT ZOBÁKPUSZTA (MECSEK MTS., HUNGARY)

by

I. FŐZY, CS. LANTAI, K. SCHLEMMER

(Recived: 1st March, 1984)

Abstract

Jurassic sedimentary and Lower Cretaceous volcanic formations were studied in a new road cut between Zobák-puszta and Kisújbánya, in the Eastern Mecsek Mountains. Fossils, microfacies and sedimentary characters were investigated in the several hundred meters long row of outcrops ranging from Pliensbachian through all stages to Tithonian. Fragments of volcanic rocks proving Late Jurassic volcanic activity have been found in Callovian – Oxfordian strata. A new occurrence of pillow diabase in the Lower Cretaceous volcanic and volcano-sedimentary sequence in the surroundings of Zobák-puszta is described. A new geological map was made in 1 : 10.000 scale. Results of the investigations are summarized in a composite stratigraphic column.

Introduction

A new forest road has been built some years ago between Zobák-puszta and Kisújbánya. Geological mapping was carried out by us on 4 km^2 between this road and Takanyó valley (Fig. 1). The road, running in nearly dip direction. exposes Upper Liassic, Dogger, Malm and Lower Cretaceous beds in an undisturbed sequence in excellent outcrops. This new road cut has not been studied before.

Earlier studies on this sequence in the Mecsek Mts. are: Böckh J (1880 – 81), Hoffmann K. (1876), Vadász E. (1935), Kovács L. (1950), Földi M. (1966), Hetényi R. (1964, 1967), Bilik I. (1966), Nagy I. (1966), Nagy E. – Nagy I. (1969), Wein Gy. (1968, 1974).

Each formation is described by field characteristics and by the results of laboratory examinations. The results are summarized on a geological map (Fig. 2) and in a composite stratigraphical column (Fig. 3).

Stratigraphy

Pliensbachian

Yellow to gray, fine to medium grained, bedded sandstone, containing 30 – 40 cm thick marly intercalations. Quartz grains of the sandstone are angular and show undulating extinction in thin sections. The matrix and several globe-like fossils (radiolarians?) are intensively silicified. In absence of any fossils of stratigraphic importance and lack of megafossils the Pliensbachian age of the beds is based on earlier papers (Wein. 1968). Thickness: 70 m.

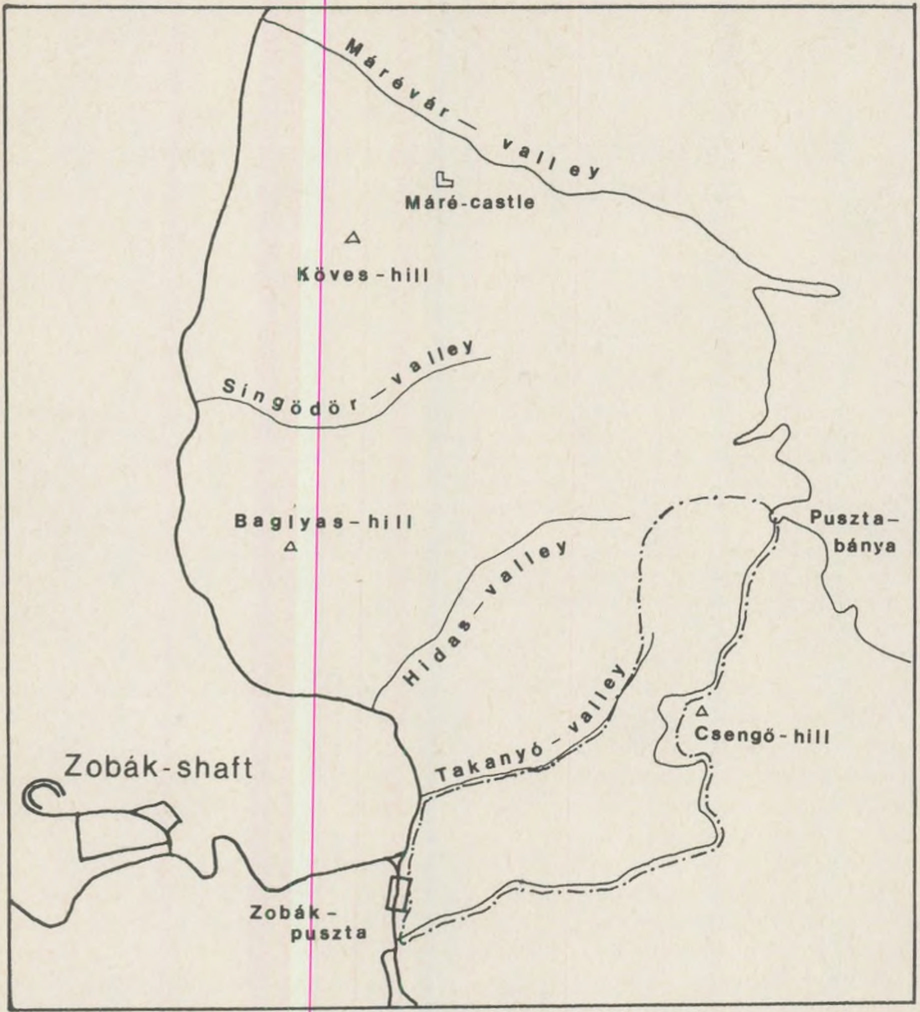

Fig. 1. Topographic sketch indicating the area of geological mapping

Toarcian

Gray, compact, occasionally spotted, laminated clayey marl in continuation with the underlying sandstone. Its age is indicated by a *Pleydellia* earlier papers (WEIN, 1968) range this formation into the Toarcian as well. Microscopic texture: wackestone with *Bositra,* radiolarians and sponge spicules. The terrigenous quartz grains are angular and display undulating extinction. Thickness: 80 m.

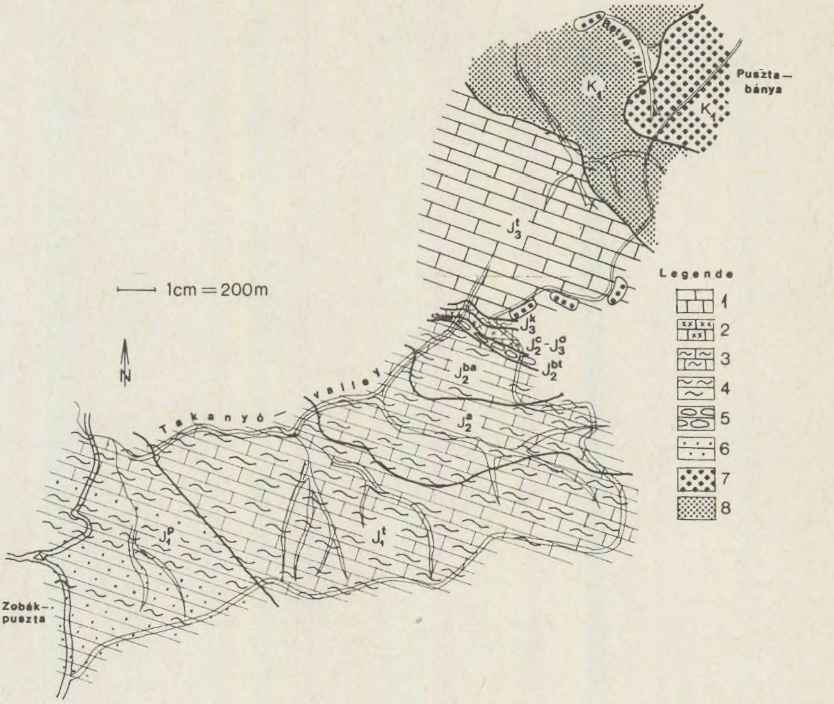

Fig. 2. Geological map of the Zobákpuszta – Pusztabánya area

1 = limestone
2 = cherty limestone
3 = calcareous marl
4 = marl
5 = nodular limestone
6 = sandstone
7 = volcanogenic sediments
8 = diabase

J_1^p = Pliensbachien
J_1^t = Toarsian
J_2^a = Aalenian
J_2^{ba} = Bajocian

J_2^c-J_3^o = Callovian-Oxfordian
J_3^k = Kimmeridgian
J_3^t = Tithonian
K_1 = Lower Cretaceous

Aalenian

Gray, spotted, bituminous, partly slightly silty calcareous marl, having some dm thick massive beds alternating with laminitic ones. Megafossils: frequent *Pleioceras* (Pl. 1. fig. 5. *Lytoceras*, *Canavarella*, belemnite rostra, *Bositra* and carbonaceous plant remains. The spotty character is due to extensive bioturbation. *Zoophycos* type trace fossils can be found, too (Pl. 5. fig. 2.). Bioturbation can be observed in thin sections as well (Pl. 2. fig. 1.): the original packstone texture has been transformed into oriented wackestone texture in the burrows. Characteristic microfauna: *Bositra* shells, sponge spicules, radiolarians, echinoderm fragments, foraminifers. Thickness: 70 m.

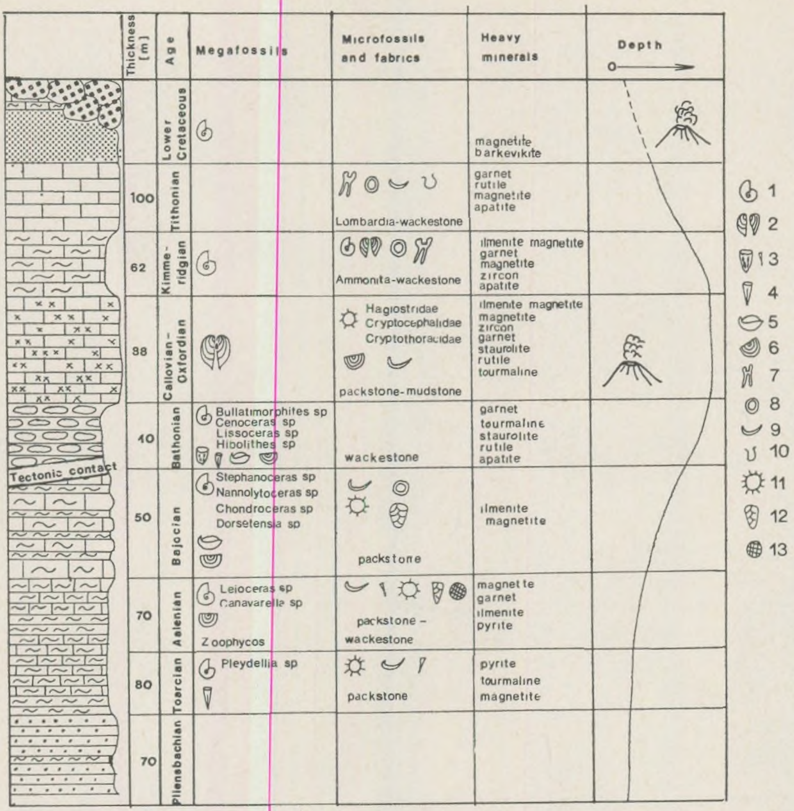

Fig. 3. Stratigraphical column indicating fossil content, microfacies, heavy minerals, postulated depth of sedimentation and volcanic activity

1 = Ammonites
2 = Aptychus
3 = Sponges and sponge spicules
4 = Belemnites
5 = Brachiopoda
6 = *Bositra*
7 = *Lombardia*
8 = *Calcisphaera*
9 = other mollusc fragments
10 = *Calpionella*
11 = Radiolaria
12 = Foraminifera
13 = Echinoderm fragments

Bajocian

Greyish yellow, massive, 40 – 50 cm thick calcareous marl beds alternate with platy, 20 – 30 cm thick clay or clayey marl beds. This formation contains a rich ammonite fauna: *Stephanoceras* sp. indicating Bajocian age

(Pl. 1. fig. 1). *Adabofoloceras* sp.. *Nannolytoceras* sp. (Pl. 1. fig. 3), *Phylloceras* sp., *Holcophylloceras* sp., *Calliphylloceras* sp., *Dorsetensia* sp., *Chondroceras* sp. (Pl. fig. 4). *Normannites* sp. Besides there are many belemnite rostra, carbonaceous plant remains, *Bositra* shells, some *Inoceramus* and a brachiopod: *Monsardithyris* cf. *ventricosa*. Microscopic texture is Bositra – Calcisphaera – Radiolaria-packstone. Thickness: 50 m.

Pliensbachian to Bajocian heavy mineral spectra are nearly alike, 2 – 4% in the 0.1 – 0.2 mm fraction. These contain staurolite, sillimanite, zircon, tourmaline, rutile, magnetite and hornblende.

Bathonian

Middle Bajocian beds of the outcrop are covered by characteristic red nodular calcareous marl beds of Bathonian age. In Middle Jurassic sequences in the neighbourhood the Upper Bajocian – Lower Bathonian series (clayey, sandy marl, greenish yellow clayey marl with rich fauna) is about 100 m thick. In absence of this part of the Dogger formations we think that tectonic movements can be named as causes of this apparent hiatus in this exposure. The road bend, where this part lies, is situated at the mouth of a small valley, probably indicating the position of this fault.

Red or white calcareous clay, conteining calcareous marl nodules, 2 – 5 cm in diameter: this is the most common picture of the Bathonian strata. Megafauna is very rich, but fragmentary. The Bathonian stage is indicated by the following ammonites: *Bullatimorphites* sp., *Holcophylloceras zignodianum*, *Holcophylloceras* sp., *Ptychophylloceras* sp., *Cenoceras* sp., *Lissoceras* sp., *Asphynctites* (?) sp. (Pl. 1. fig. 2.), *Hibolites* sp. Besides a rich sponge fauna has been collected (Pl. 2. figs. 3 – 5.) Microscopic texture is a *Bositra*-aptychus wackestone. Some "*Protoglobigerina*" sp. also occurs in thin sections. Thickness 10 m.

Callovian Oxfordian

Well-bedded limestone made of thin beds, calcareous marl, silicified limestone. Laminated clay beds of some cm thickness are intercalated in the 10 20 cm thick, more calcareous beds. There are grey, red or yellow chert lenses. Besides aptychus and Belemnites fragments and some small crinoid calix remnants no other megafossils have been found, consequently the two stages could not be separated. A detailed microfaunal investigation may solve this problem. As this sequence does not show any hiatus presence of both stages is supposed in the cherts.

Microscopic texture is Radiolaria-packstone (Pl. 3. fig. 1.). The radiolarians belong to the Hagiastridae, Cryptocephalidae and Cryptothoracidae families. A rhyncholith (cephalopod masticatory organ) was found in one of the thin sections (Pl. 3. fig. 2.).

This sequence contained a palm-size rock sample which includes a spot 3 4 cm in diameter, of greenish colour and porphyritic texture. The limestone displays concentric jointing around it. A binocular microscope revealed frequent opaque minerals (magnetite, ilmenite) and felspars transformed to clay minerals; both can be cleary separated from the decomposed matrix. This fragment is considered as a mafic lapilli (fragment) of volcanic origin (Pl. 4. fig. 1.). Trace element composition of these strata shows a characteristic increase in Ti (from 600 g/t to 2000 g/t), Ni (from 10 g/t to 35 g/t) and Co (from 10 g/t to 16 g/t), which may be due to the same volcanic activity.

Thickness of the Callovian – Oxfordian strata: 88 m.

The Bathonian and Callovian – Oxfordian sediments show the most rich assemblage of heavy minerals: staurolite, sillimanite, zircon, tourmaline, rutile, magnetite, hornblende, garnet, apatite, epidote, disthene, biotite, corundum. They form 1 – 2% of the 0.1 – 0.2 mm grain size fraction.

Kimmeridgian

Five to ten cm thick, red, nodular calcareous marl beds alternate with thin, broken, calcareous – clayey beds in the lower part of the sequence. Upwards the ratio of clayey – marly intercalations increases and the sequence turns into a clayey one with calcareous nodules in layers. The beds are slightly folded. Megafossils are scarce and of poor preservation. Microscopic texture is ammonite-wackestone. Biogenic components are mostly juvenile ammonite shells and aptychi (Pl. 4. fig. 2.). Thickness: 65 m.

Tithonian

Grey to white, yellowish, massive limestone, with intraclasts in some parts. Sometimes contains platy, grey chert bands. The rock is brittle, fragmented and slightly folded in some places. Microscopic texture: Lombardia-wackestone, with much calcisphaera, calpionellids and mollusc shell fragments (Pl. 5. fig. 1.). The formation is strongly disturbed and fragmented by the Lower Cretaceous volcanic activity (Nagy I., 1967), consequently there are large, strongly weathered diabase bodies of several tens of metres in diameter among the exposures of the limestone. Estimated thickness: 100 m.

The relative quantity of heavy minerals is the smallest in the Kimmeridgian and Tithonian limestone: generally 0.5 – 1% consisting of garnets, apatite, rutile, zircon and magnetite.

Lower Cretaceous

There is a sequence consisting of Lower Cretaceous diabase, tuffites, volcanogenic sediments and calcareous marl above the Tithonian limestone. The lowermost volcanogenic sandstone alternates with yellow, benthonite-like clay beds of conchoidal fracture. This high-felspar sandstone – arkose – contains a considerable quantity of heavy minerals in 0.1 – 0.2 mm grain size fraction (barkevikite, magnetite, ilmenite). Quartz is a minor constitute only. Both the sandstone and the clay contain considerable quantity of mixed, smectite structure montmorillonite; the clay is nearly pure montmorillonite.

The volcanogenic sediments are overlain by diabase and tuffite. The latter is poorly stratified, fragmented, dark brown with green spots and is strongly weathered. Either the sedimentary (clayey or sandy) or the volcanogenic components dominate. Thickness of beds is 5 – 10 cm. One specimen of indeterminable ammonite has been found, too.

There are several diabase occurrences on the mapped area. In Betyárherhes there is a new form of diabase occurrences: pillow diabase (Pl. 2. fig. 2.). The 50 – 150 cm diameter pillows bear an autochthonous hyaloclastite cover of yellowish colour It is mainly montmorillonite by X-ray data. Also the inside of the pillows is very weathered, so the composition has been determined by X-ray method. There were characteristic plagioclase and pyroxene peaks in the samples from the centre. Outwards first the plagioclase, then the pyroxene peaks disappeared, but the ratio of montmorillonite gradually increased. The texture of a less weathered diabase in thick beds is porphyritic, intersertal, bearing amygdaloidal structures. The phenocrysts are: olivine (weathered into montmorillonite, iddingsite or chlorite and serpentine) and fresh, euhedral Ti-augite. The matrix is formed by plagioclase, augite and opaque minerals. The plagioclease is basic labradorite Glass of the matrix turned into nontronite and amygdaloidal holes are also filled by nontronite.

Several exposures of the diabase could be studied in the forestry road cut. This rock is highly weathered into clay minerals, it is dark brown and breaks into small fragments. It transects the Tithonian limestone at several points as several ten meters wide bodies.

Within the Lower Cretaceous sequence the topmost stratigraphic position in the investigated area is occupied by a gray, massive calcareous marl with green spots. To determine its exact age the investigation of a greater area is necessary. Its beds are 10 – 30 cm thick, but it is platy in some places. It contains limonitic concretions and carbonaceous plant remains. Microscopic texture is wackestone. There are straight and oval fossil-like components in the unoriented texture but these are indeterminable due to poor preservation.

Paleogeography and volcanism

The Upper Liassic, Dogger and Malm formations form a nearly continuous sequence (except the absence of Upper Bajocian – Lower Bathonian beds due to tectonic disturbances). Slight folding has been formed in the Malm strata by subsequent tectonism.

The Upper Liassic sandstone has been deposited in a nearshore environment. The basin attained greater depths from the end of the Liassic. as shown by the decrease of the grain size of sediments. Heavy bioturbation and rich microfauna of the spotted Aalenian calcareous marl indicate a quiet, shallow marine environment. The many angular quartz grains indicate a closeness of the shore. Upwards in the sequence the ratio of planktonic organisms increase and of the benthonic decrease. The radiolarians become the most important elements of the microfauna. The probably greatest depth of the Jurassic sea was reached in the Callovian – Oxfordian, when cherty beds were deposited. The heavily weathered volcanic fragment was found in these beds and it indicates syndepositional volcanic activity. (Thick tuffite beds have been known already in the Liassic carbonaceous beds of the Mecsek Mountains (NAGY E. – NAGY I., 1969). Also, relicts of tuffites have been described by PATAKY et al. (1982) in the Toarcian of the Szén-völgy at Ófalu). Higher stages of the Jurassic also contain traces of volcanic activity, mostly tuffitic explosions: E. VADÁSZ and L. GYOVAI collected samples from Márévár Valley, which are stored in the collection of Geological Department, Eötvös University, but their observations have been never published. PANTÓ G. et al. (1955) considered tuffitic explosions as proven already from the Tithonian onwards. All these data indicate Jurassic volcanism in the Mecsek Mountains.

The intraclasts in the Tithonian limestone indicate deposition in high-energy environment. As the calpionellids are characteristic for open marine environments, it is considered that strong botton currents resedimented the less consolidated carbonate mud.

Heavy mineral content of 13 Jurassic samples indicate the following) (data from PATAKY et al., 1982 and BÁLINT, et al., 1983 were also used). Heavy mineral asemblages in older (Pliensbachian – Bajocian) rocks indicate a source made of mostly metamorphic rocks. During Bathonian – Callovian Oxfordian erosion of a more variable territory began, which contained magmatic rocks as well. The smallest heavy mineral assemblage, which is also the less variable can be found in the Kimmeridgian and Tithonian formations. This may be due to an increase in the shore distance and sedimentation occurred in the most open sea. Due to lack of specific minerals we cannot determine if magmatic or metamorphic rocks were eroded.

The sequence overlying the Tithonian limestone consists of Lower Cretaceous diabase, tuffite and partly volcanogenic sediments. Pillow structure of the diabase indicates submarine eruptions. High montmorillonite content of volcanogenic clay and sandstone proves autochthonous. submarine weathering. The presence of barkevikite as a heavy mineral in them indicates transport from distant areas as well, as this mineral cannot be found in diabases of the investigated area. BÁLINT et al. (1983) described this alkaline amphibole from a diabase between Hidasi Valley and Takanyó Valley and SZILÁGYI (1979) also described it from the diabase dykes at Komló.

Early Cretaceous magma broke across consolidated Upper Jurassic sediments and transported smaller parts with itself. This is the cause of the formation of this sequence which looks like as alternating of volcanics and sediments at the first glance.

The investigations sketched in this paper are not finished as yet, but may serve as a base for a detailed work.

Many thanks are due to Prof. B. GÉCZY and A. GALÁCZ for the determination of ammonites; to A. VÖRÖS for the determination of brachiopods; to P. DE WEWER for Radiolaria determinations; to J. ANDÓ, L. BOGNÁR and CS. SZABÓ for their extensive help in mineralogical and petrographical investigations.

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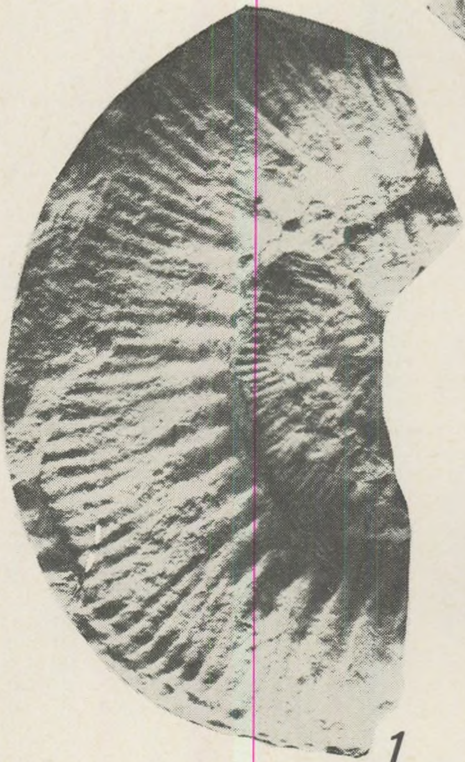

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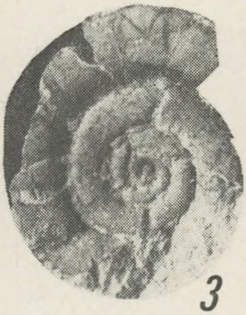

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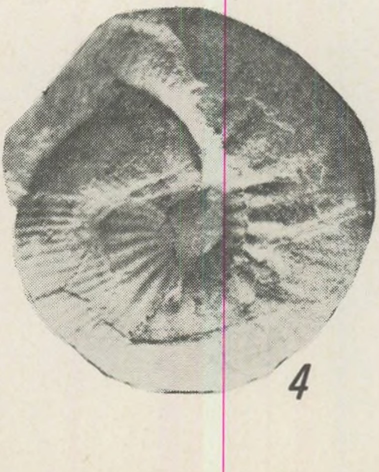

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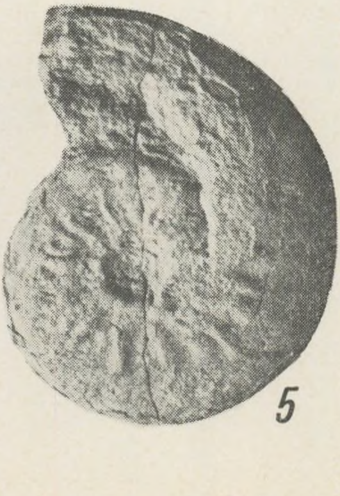

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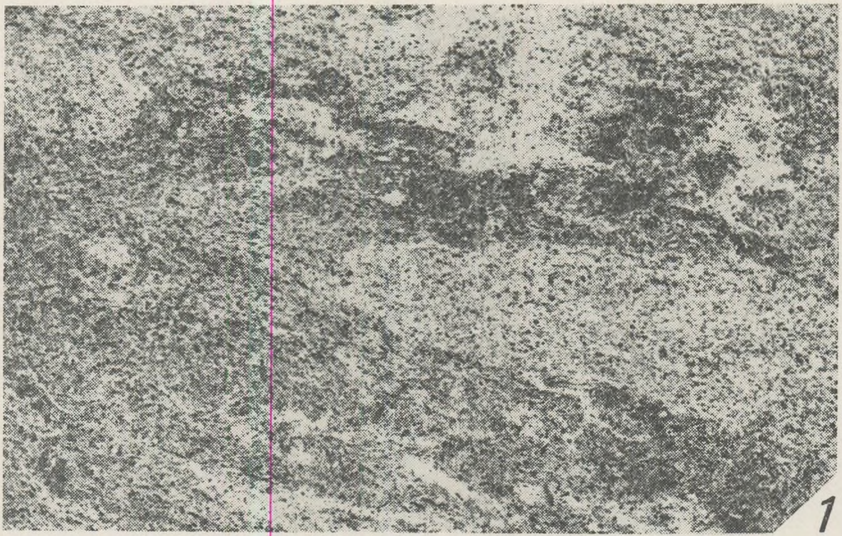
PLATE 1

Figure. 1. Stephanoceras sp. x 1 Bajocian
Fig. 2. Asphynctites? sp. x 1,2 Bathonian
Fig. 3. Nannolytoceras sp. x 0,8 Bajocian
Fig. 4. Chondrorceas sp. x 1,2 Bajocian
Fig. 5. Leioceras sp. x 1 Aalenian



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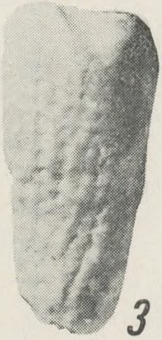

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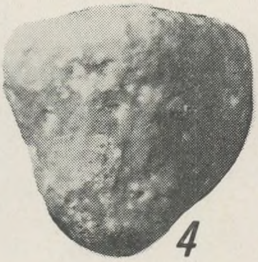

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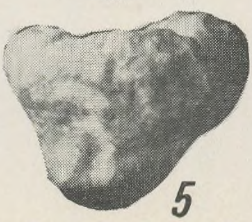

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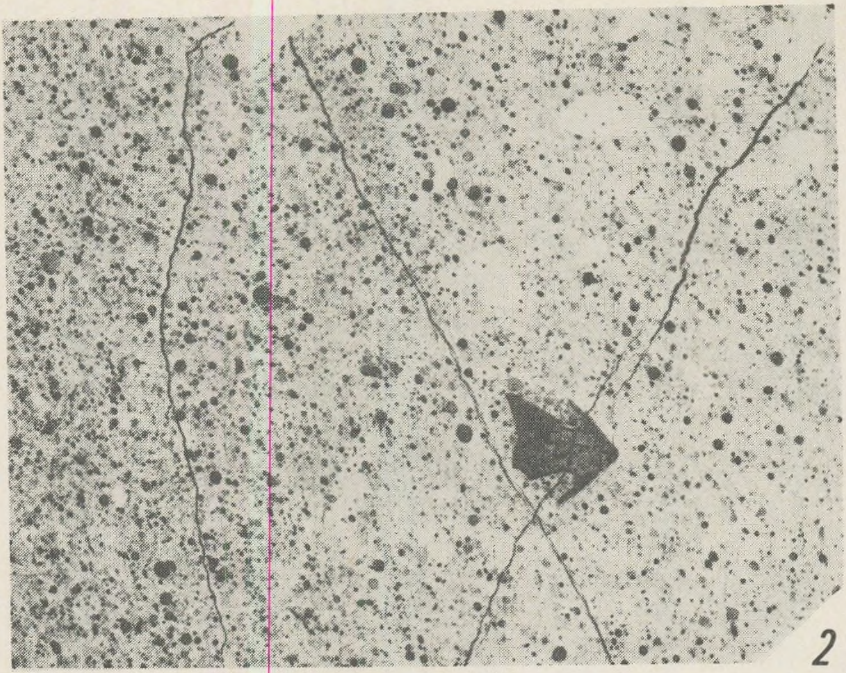
PLATE 2

Fig. 1. Bioturbation in the Aalenian calcareous marl. x 3,6 (negative print)
Fig. 2. Pillows of Lower Cretaceous diabase in Betyár ravine
Figs. 3 – 5. Sponges from Bathonian beds. x 1



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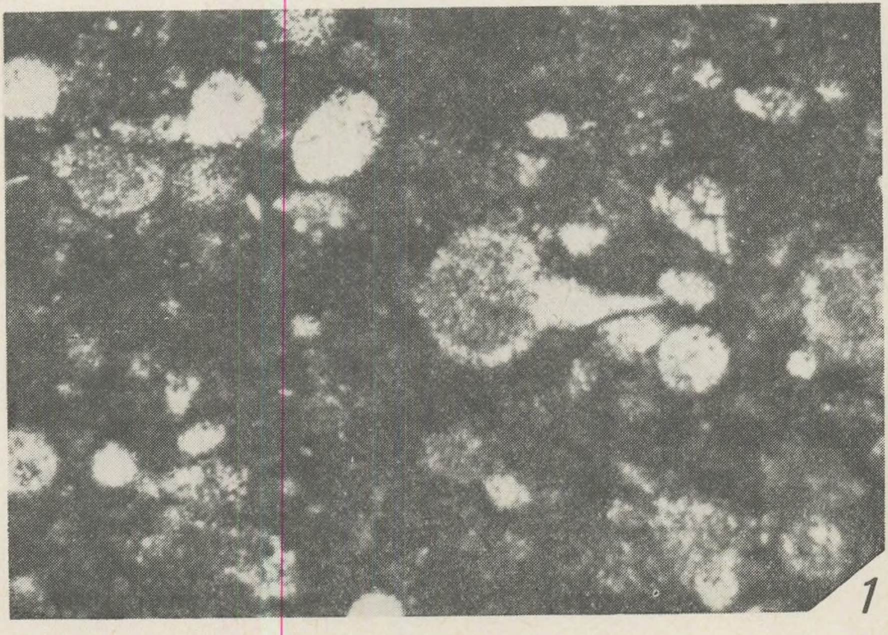

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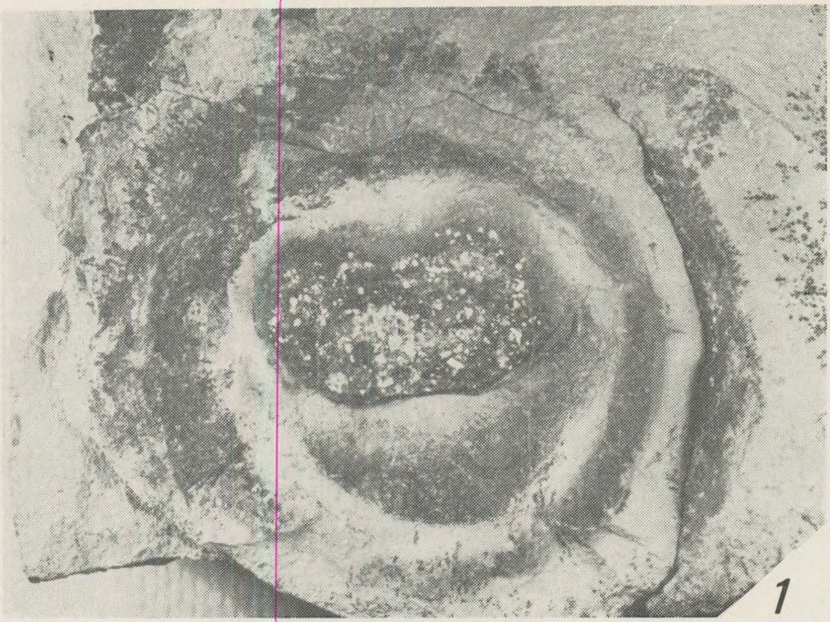
PLATE 3

Fig.1. Radiolaria packstone. x 62,5 Callovian – Oxfordian
Fig. 2. Rhyncholite x 8 Callovian – Oxfordian (negative print)



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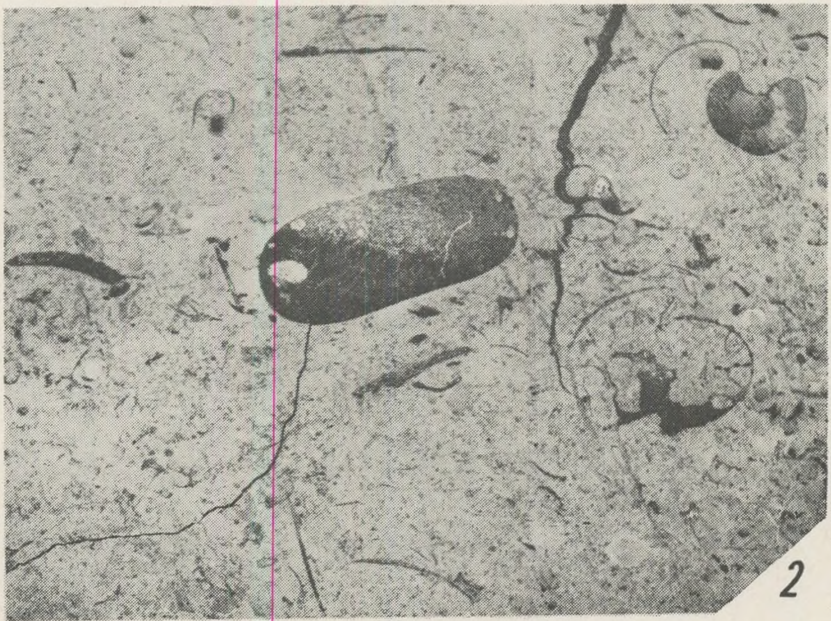

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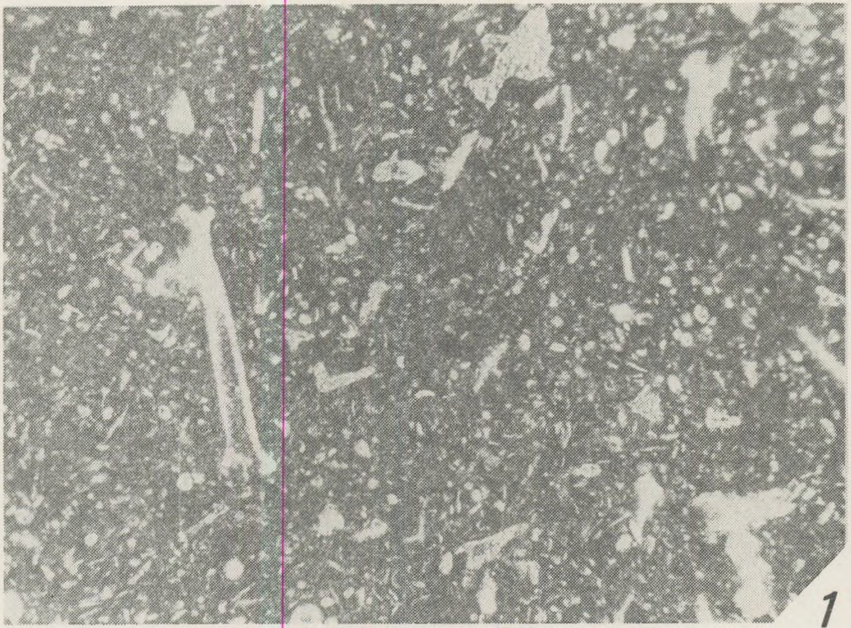
PLATE 4

Fig. 1. Fragment of volcanic rock in the Callovian – Oxfordian cherty limestone x 1
Fig. 2. Ammonites wackestone x 7,2 Kimmeridgian (negative print)



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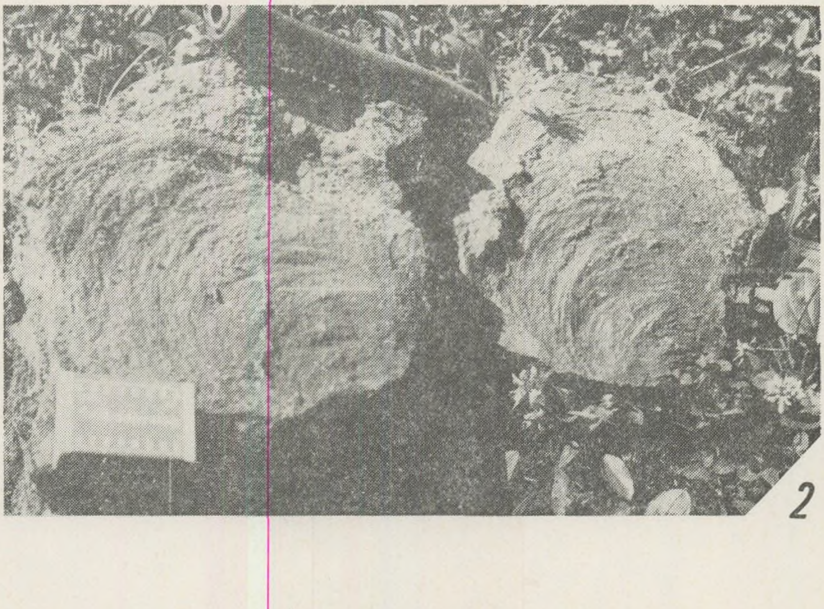

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PLATE 5

Fig. 1. Lombardia wackestone x 62,5 Tithonian
Fig. 2. *Zoophycos* x 0,15 Aalenian

COMPARATIVE STUDY ON THE MOLLUSC FAUNA OF TWO LOWER-MIOCENE CONGLOMERATES IN THE EASTERN MÁTRA (N-HUNGARY)

by

I. FŐZY and SZ. LEÉL – ŐSSY

(Received: 1st March 1984)

Summary

The subject of the present paper is the description of two localities of Lower-Miocene age (Eggenburgian) in the Eastern Mátra Mts.

In the Ilona-völgy, a sequence of 17 m thickness is built up of fine micaceous sand and sandstone. In its lower and upper parts 1 m thick conglomerate layers are intercalating, which contain rich mollusc fauna. The more than 1000 specimens collected from these conglomerate layers belong to 70 species. So our site has supplied the richest fauna of Eggenburgian age in Hungary known till now. On the basis of the composition of the fauna, of recent observations as well as of the examination of the enclosing rocks, it is supposed that the one-time community lived in a warm, shallow water of normal salinity.

A comparison is made between fossil and gravel materials of this outcrop and a conglomerate of the same age found in the side of the Darnó-hill, 11 km to NE from our site. We have not found common species in these two exposures, and the material, size and sphericity of the pebbles is considerably different.

Structural interesting of the study is the fact, that the two localities are situated on the opposite sides of the Darnó tectonic line.

The geographical position and sequence in the exposure of the Ilona-valley

The exposure can be found 5 km to the south from Parádfürdő, 200 m beneath the waterfall of the Ilona-valley (Fig. 1.). The brook here cuts into a gravelly, sandy complex of Lower-Miocene age.

The lower 5 m part of the exposure was discussed by ROZLOZSNIK (1939) and BÁLDI (1983).

The second layer upwards from below, is exceedingly rich in molluscs.

Exploring other fossiliferous layers, we widened the earlier exposure to a thickness of 17 m. The section now investigable made possible not only the thorough collection of the fossil material, but it can be considered as a representative exposure of the "glauconitic sadnstone" now described as Ilona-valley Member of the Pétervására Sandstone Formation, known from more sites in the Eastern Mátra Mts. (see the Fig. 2.).

The sequence is quite monotonous; harder beds intercalate into the gray, micaceous, friable sand. Though certain layers have a coarse-clastic appearence and conglomeratic feature, the major part of the section consists of sand with a grain diameter of 1 – 2 mm. The clayey, micaceous, fine-sandy intercalations become more frequent upwards. Thin coaly claybands are found throughout the section. On the top the sedimentary rocks are in contact with a cracked but only slightly weathered andesite dyke.

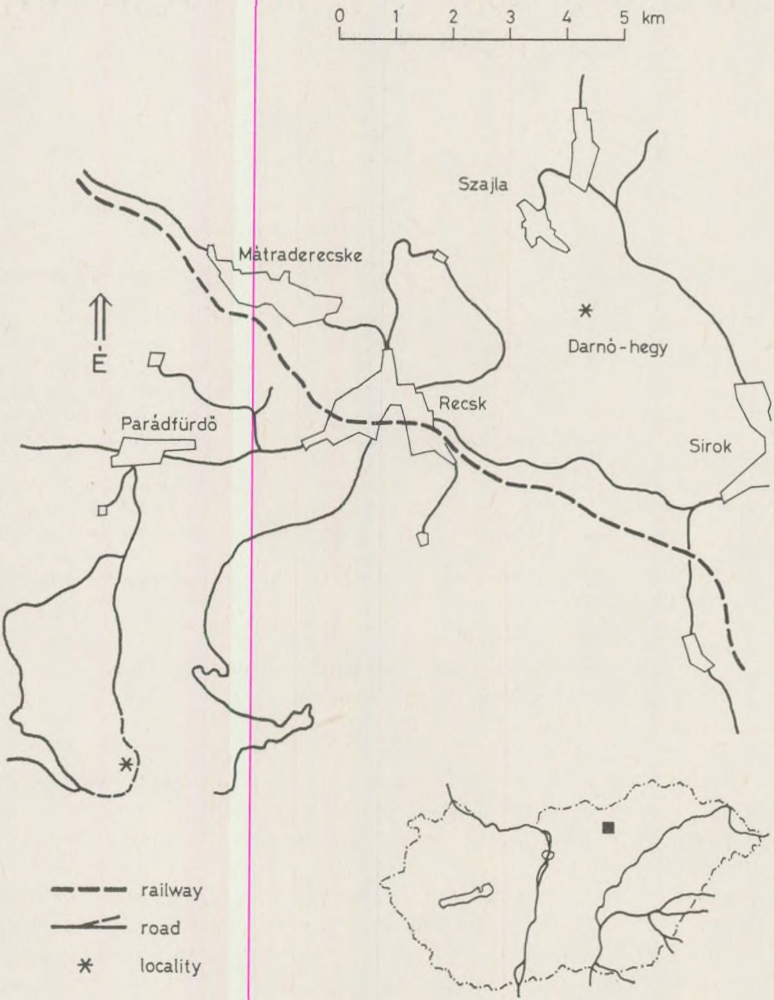


Fig. 1. Topographic sketch of the Eastern Mátra Mts. Localities are indicated by an asterisk.

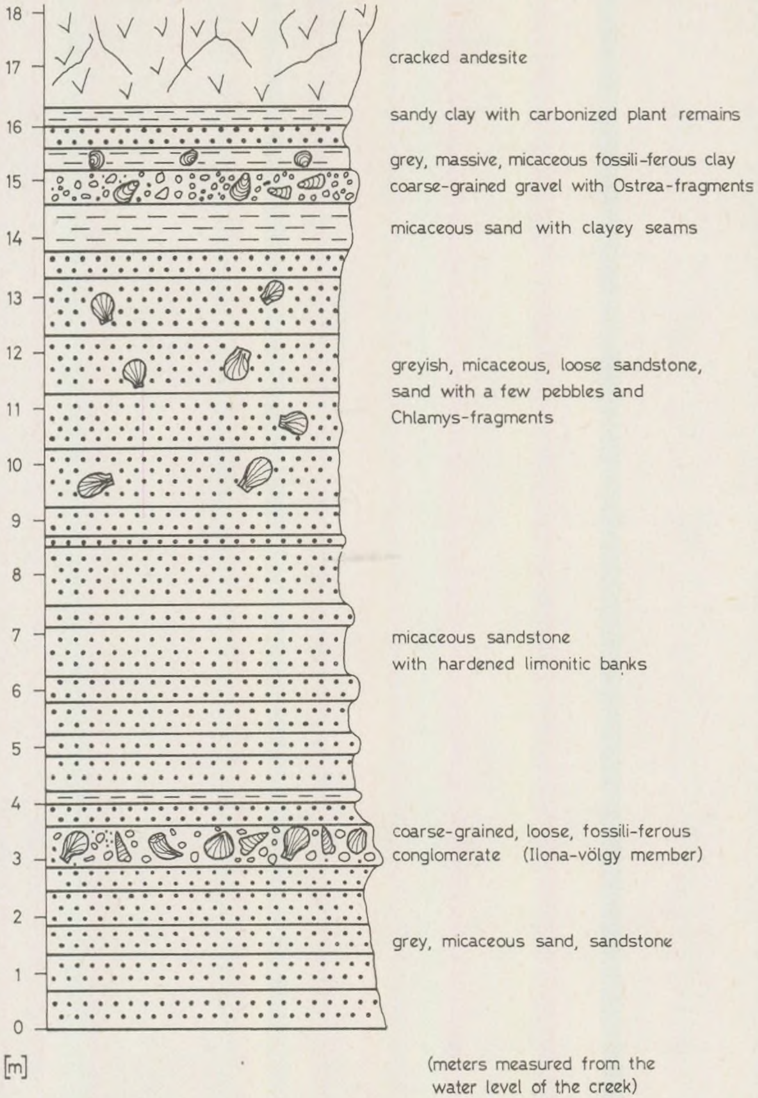


Fig. 2. Profile of the Pétervására Sandstone Formation in the Ilona-valley

Characterization of the conglomerate containing mollusc fauna

The previously mentioned conglomerate with the rich fauna contains abraded, well-rounded pebbles. This badly sorted clastic layer (which consists of sand grains and gravels of some mm to some cm) is cemented by a limonitic matrix. 70% of the pebbles are black, gray and white quartzite. The quantity of sandstone, aleurite and clay gravels is subordinate. From this layer the fossils could easily be released, especially from those parts which are exposed to weathering.

The main part of the fauna is formed by bivalves and gastropods, but we found number of corals solitary as well as hermatypic ones, Dentalium and bryozoans as incrustants. The fragments of balani and shark-teeth were found in small quantity.

While Rozlozsnik (1939) mentioned only a few taxa, Báldi (1983) described about 40 species from here. The more than 1000 specimens we collected, could be ranged into 70 species. So the exposure gave the richest and at the same time a very well preserved fauna of Eggenburgian age in Hungary (Table 1. and 2.).

Table. 1. List of fossils from Ilona-völgy profile 3,0 – 3/m

BIVALVIA

Scutum bellardii (Michelotti, 1847)
X *Ostrea* sp.
Anadara moltensis (Mayer, 1868)
Glycymeris inflata (Brocchi, 1814)
X *Glycymeris fichteli* (Deshayes, 1852) Pl. 1, fig. 1
X *Chlamys scabrella* (Lamarck, 1819) Pl. 1, fig. 2
X *Pecten hornensis* Deperet et Roman, 1902
Anomia sp.
Dentilucina borealis anteproducta Sacco, 1901 Pl. 1, fig 3
Plastomiltha multilamellata (Deshayes, 1830)
Discors discrepans (Basterot, 1825)
X *Cardiocardita zelebori* (Hörnes, 1846) Pl. 1, fig. 4
Laevicardium norvegicum (Spengler, 1790)
X *Laevicardium* div. sp.
X *Macoma* cf. *elliptica* (Brocchi, 1814)
Tellina serrata Renier, 1804
Callista lilacionides Schaffer, 1910 Pl. 1, fig. 6
Gastrochaena dubia (Pennant, 1777) Pl. 1, fig. 5
Ventricola cf. *multilamellata* (Lamarck, 1818)
Venus haidingeri Hörnes, 1861 Pl. 1, fig. 7
Dosina exoleta (Linné, 1758) Pl. 2, fig. 1

GASTROPODA

Patella anceps Michelotti, 1847
Patella sp.
Trochus sp. Pl. 2, Figs. 4 – 5
X *Astrea carinata* (Borson, 1821)
X *Astrea speciosa* (Michelotti, 1847)

X *Bolma meynardi* (MICHELOTTI, 1847) Pl. 2, fig. 6
Bolma castrocarensis (FORESTI, 1876)
X *Diloma amadei* (BRONGNIART, 1823) Pl. 2. figs. 7 – 8
Calliostoma granulatus (BORN, 1778)
Solarium sp. Pl. 3, figs. 1 – 2
Turritella triplicatus (BROCCHI, 1814)
X *Turritella desmarestiana* BASTEROT, 1825
Turritella trerbralis subgradata SACCO, 1893
X *Protoma cathedralis* (BRONGNIART, 1823) Pl. 3, fig. 2
Acrilla amoena (PHILIPPI, 1843)
X *Natica millepunctata* LAMARCK, 1822
Natica sp.
Rimella decussata (BASTEROT, 1842)
X *Trona loibersdorfensis* SCHILDER, 1932
Zonaria flavicula (LAMARCK, 1810)
X *Ficus condita* (BRONGNIART, 1823) Pl. 3, fig. 4
Echinophoria sp. Pl. 3, fig. 5
Oniscia cithara (BROCCHI, 1814)
Murex trinodosus BELLARDI, 1873
Murex erinaceus LINNÉ, 1766
Nassa conglobata BROCCHI, 1814
Nassa sp.
X *Ancilla glandiformis* (LAMARCK, 1810)
Ancilla sp.
Olivella sp.
Tudicla rusticula (BASTEROT, 1825)
Sveltia cf. *varicosa* BROCCHI, 1814
X *Clavatula semimarginata* (LAMARCK, 1822) Pl. 3, fig. 6
Clavatula intermedia miopercostata SACCO, 1904
Clavatula reevei BELLARDI, 1904
X *Leptoconus allioni* (MICHELOTTI, 1847) Pl. 3, fig. 7
Lithoconus antiquus (LAMARCK, 1810)
Lithoconus parvicaudatus SACCO, 1893
Conus sp.

SCAPHOPODA

X *Dentalium* sp.

ASSOCIATED FAUNAL ELEMENTS

Ammonia beccarii (LINNÉ, 1758) (was determined by M. Horváth) solitary corals Pl. 3, fig. 8.
worm tubes
Balanus sp.
Bryozoa sp.
Carcharodon megalodon (AGASSIZ, 1843)

NANNOFLORAL ELEMENTS
(were determined by A. NAGYMAROSY)

Reticulofenestra hesslandii (HAQ, 1966)
Coccolithus pelagicus (WALLICH, 1898)
Helicopontosphaera mediterranea (MÜLLER, 1982
Cyclicargolithus floridanus (ROTH et HAY, 1967)
Sphenolithus morifornis (BRÖNNIMANN et STRADNER, 1960)

X Taxa indicated by an asterisk have been described by BÁLDI (1983)

Table. 2. List of fossils from Ilona-völgy, profile 14,6 – 15,3 m

BIVALVIA

Cardium sp.
Macoma cf. *elliptica* (BROCCHI, 1814)
Pitaria (Macrocallista) erycinoides (LAMARCK, 1823) Pl. 2, fig. 2

FORAMINIFERIDA

(was determined by M. HORVÁTH)
Ammonia beccarii (LINNÉ, 1758)

NANNOFLORAL ELEMENT

(was determined by A. NAGYMAROSY)
Reticulofenestra hesslandii (CHQ, 1966)

About the composition of the fauna

It can be seen from Fig. 3. that more than half of the individuals of this mollusc fauna of otherwise great diversity, belongs to 3 species: *Chlamys scabrella*, *Clavatula semimarginata*. and *Natica millepunctata*.

Beside this three taxa, the 34 percent of the collected specimens belong to the following taxa; *Conus allioni*. *Ficus condita*. *Gibbula semirotunda*, *Protoma cathedralis*, *Calliostoma granulatus*, *Tellina serrata*, *Glycymeris* div sp.

The remaining 16 percents of the specimens is quite uniformly distributed among the remaining 45 species. This distribution of the taxa is similar to that of recent as well as fossil marine faunas of normal salinity (TATISHVILI and BAGDASARIAN 1968).

Although the shells are imbedded without orientation in the enclosing rocks, the gastropods, which are decorated richly with therns, and the presence of double-valved Tellinae and *Glycymeris* indicate that most of these animals buried in their original place of living and were not exposed to long transportation.

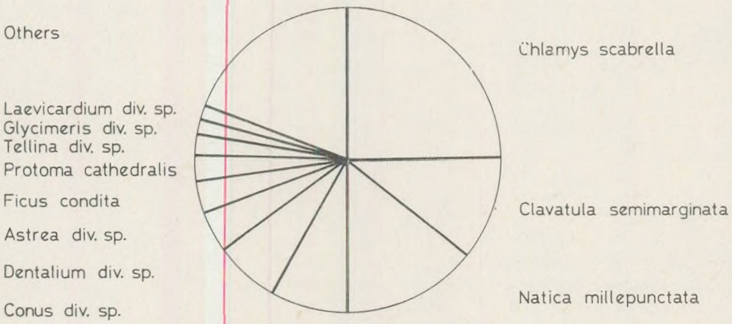


Fig. 3. Composition of the Ilona-völgy fauna.

Ecological interpretation of the fauna

By using the actuo-ecological data of literature concerning the collected material we have reconstructed the one-time enviroment.

In the epibenthos the most frequent taxa are *Chlamys*, Naticids and *Conus*, from among the taxons with shallow burrower way of life *Glycymeris* were found in greatest number. The characteristic elements of the infauna were Tellinas and Dentaliums. The most important carnivores were *Clavatula*, *Natica* and *Conus*, The ratio of Gibbulas grazed on *Diatoma* living on algas is significant (6%), but *Calliostoma* also was relatively frequent.

The organic material of the intercalating calcareous claybands has originated from the remains of the one-time sea-weeds and algal-mats.

The normal salinity of the sea-water is proved also by the presence of *Conus*, *Gibbula*, *Chlamys* and corals. These genera as well as the *Ficus* refers to warm and shallow sea-water.

The rerat frequency of these genera indicates that the sea-water was well-agitated, clear and rich in oxygene. On the basis of the vertical range of certain genera the most probable depth of water was about 10 – 15 m, around the wave-base.

The Eggenburgian age of the fauna is proved by the occurrence of *Pecten hornensis*, *Cardiocardita zelebori*, *Bolma meynardi taurinensis*, *Turritella desmarestina*. .etc.

Short description of the exposure of the Darnó-hill

The Darnó Conglomerate can be studied on the surface 11 km NE from the exposure in the Ilona-valley, in the hillside of the Kis-hill which is a northern member of the Darnó-hill (Fig. 1.). (Kiss 1958, Báldi 1983). It has natural exposures which can be studied generally in the creek.

The rock has a bedded appearance without a fine lamination. dipping with 40° to NNE.

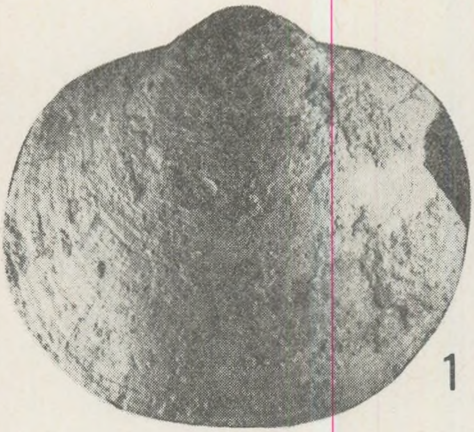
The gravel material of the conglomerate is not sorted: the size of the pebbles range from some mms to 10 cm. In certain beds pebbles of some mm size are more frequent, but the alternation of finer and coarser fractions does not show a tendency to a continuous increase or decrease of size.

The surfaces of most of the pebbles are polished, this indicates episodic atmospheric exposures.

The major part of the pebbles (about 80%) consists of quartzite of different colours. and of red radiolarite. A minor amount is limestone, aleurolite and diabase.

Table. 3. List of fossils from Darnó-hegy

- *Chlamys gigas* (Schlotheim, 1813)
- *Chlamys brussoni* (De Serres, 1829)
- *Chlamys darnoensis* Cs. Meznerics, 1960 Pl. 2, fig. 3
- *Chlamys multistriata* Poli, 1791
- *Pecten* div. sp.
- *Terebratula hoernesi* Suess, 1886
- *Balanus* sp.
- Bryozoa sp.
- *Ostrea* sp.
- *Anomina ephippium* Linné, 1758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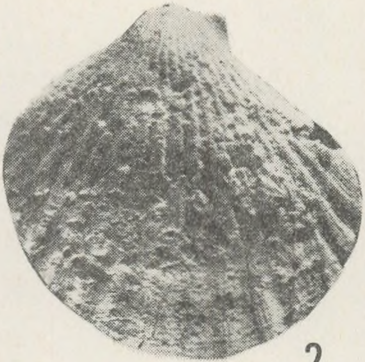
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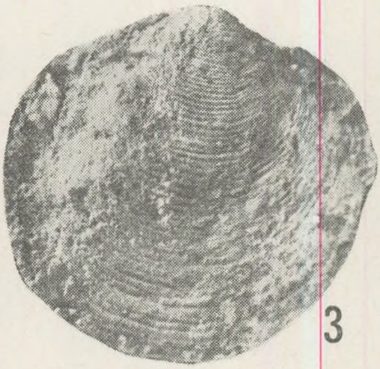
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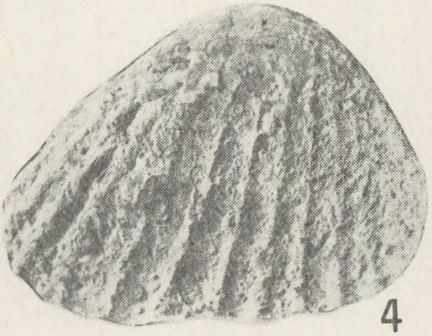
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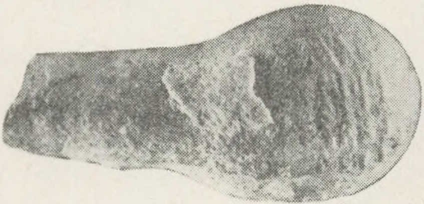
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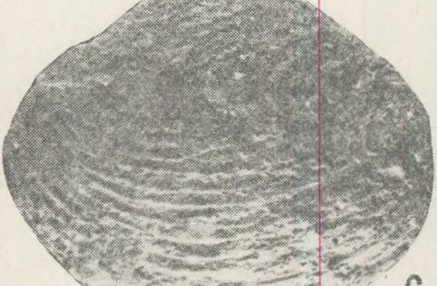
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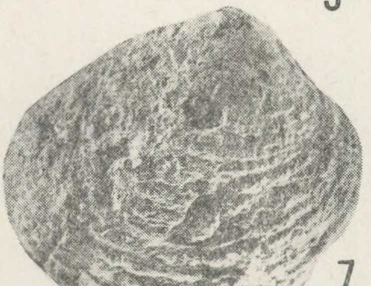
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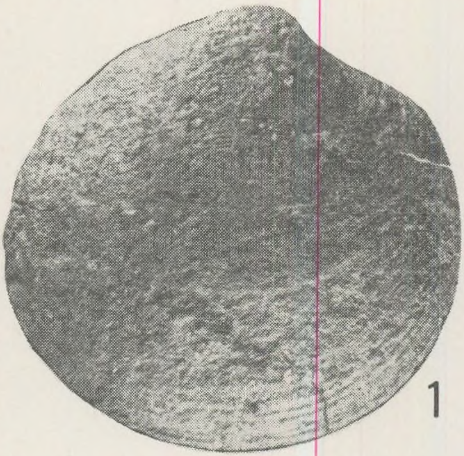
PLATE 1.

	enlargement
1, *Glycymeris fichteli*	0,7x
2, *Chlamys scabrella*	1,2x
3, *Dentilucina borealis anteproducta*	3,0x
4, *Cardiocardita zelebori*	1,3x
5, *Gastrochaena dubia*	3,0x
6, *Callista lilacinoides*	1,2x
7, *Venus haidingeri*	1,2x

Photo: L. KLINDA – I. FŐZY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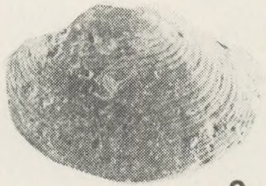
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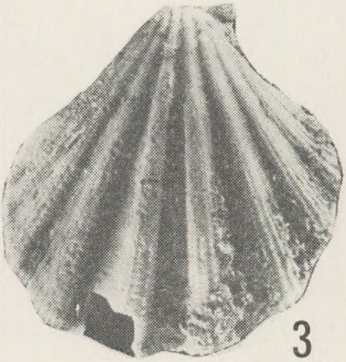
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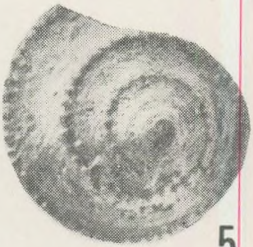
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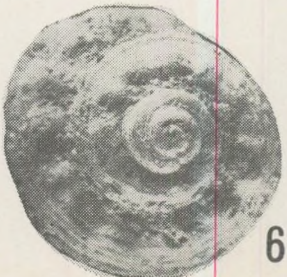
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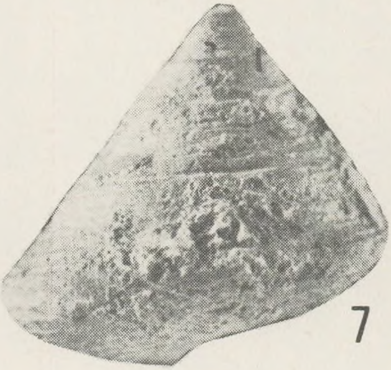
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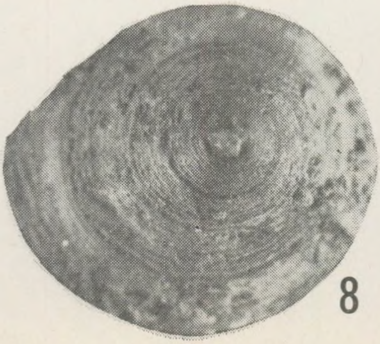
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PLATE 2.

	enlargement
1, *Dosina exoleta*	1,4x
2, *Pitaria (Macrocallista) erycinoides*	1,2x
3, *Chlamys darnoensis*	1,2x
4, *Trochus* sp.	2,0x
5, *Trochus* sp.	2,0x
6, *Bolma meynardi*	2,5x
7, *Diloma amadei*	3,0x
8, *Diloma amadei*	3,0x

Photo: L. Klinda – I. Főzy


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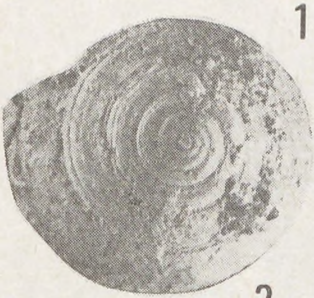
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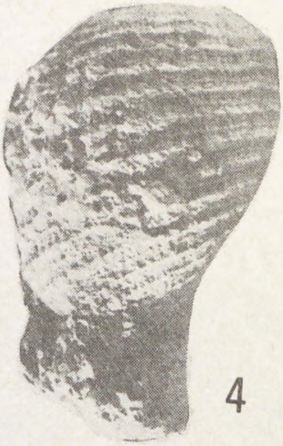
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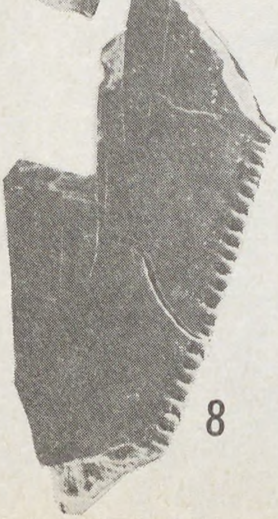
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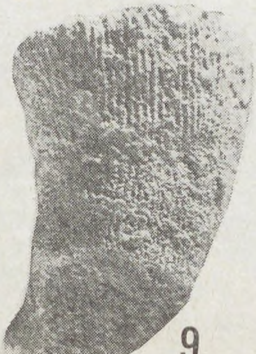
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PLATE 3.

	enlargement
1, *Solarium sp.*	2,0x
2, *Solarium* sp.	2,0x
3, *Protoma cathedralis*	1,4x
4, *Ficus condita*	2,0x
5, *Echinophoria* sp.	1,7x
6, *Clavatula semimarginata*	1,2x
7, *Leptoconus allioni*	1,4x
8, *Carcharodon megalodon*	2,0x
9, Solitary coral	2,0x

Photo: L. Klinda – I. Főzy

Characterization of the fauna of Darnó-hill

The fossil material of the Darnó Conglomerate is poorer and has worse preservation than the Ilona-valley conglomerate. Appreciable fauna was found only in one of the exposures.

We have not found any new species beside the ones mentioned by previous authors (KISS 1958, CS. MEZNERICS 1959). We found and identified 10 species (Table 3.).

In the central part of the faunal exposure a Ditrupa-bearing level can be found (BÁLDI, 1983), We have not found any specimens with aragonite shell. This can be due to diagenetic dissolution.

The normal salinity of the one-time sea is indicated by the *Chlamys* and Pectens; the thick shelled forms *(Ostrea, Anomia)* and fragments of *Balanus* indicate strongly agitated very shallow sea-water.

The Eggenburgian age of the fauna is proved by the occurrence of *Chlamys gigas*.

Comparison between the fossil- and gravel-material of the two exposures

By comparing the exposures in the Ilona-valley and Darnó-hill we can state, that their facies are similar and their age is nearly the same.

We have not found common species in the two exposures (in the Darnó-hill aragonitic shells can not be found) the material, sorting and roundness of the gravels are also different.

This can be partly due to the longer transporting route (distance) of the gravel material of the Ilona-valley, and partly to the different region of ablation.

Since the zone of the Darnó-line is located between the two exposures, the above paleontological – petrological observations may yield data for the reconstruction of the post-Oligocene movements along Darnó-line.

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THE ACTUAL PROBLEMS OF BIOSTRATIGRAPHY: THE MAIN TYPES OF BIOZONES

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(Received: 1st May 1984)

Abstract

At the time of the rapid and manifold progress of stratigraphy, it is justified to emphasize its time-centricity. This time-centricity is emphasized in different ways and grades by the various (e.g. the International, the American, French and Hungarian) stratigraphic guides. The practice of biostratigraphy is closely related to the current theories on evolution. The validity of biozones is relative, and their use is justified as far as their relation to abstract standard chronozones remains unclear.

In the spring of 1971 in its colloquium, the Palaeontological-Stratigraphic Committee of the Hungarian Geological Society discussed the methods of stratigraphic correlation and classification (see Őslénytani Viták vol. 17., vol 19.) The meeting vas followed by the edition of the Directives for the Stratigraphic Classification and Nomenclature (FÜLÖP et al. 1975), by the fully reworked second edition of the Hungarian volume of the Lexique Statigraphique International (FÜLÖP et al. 1978), then by the publication of the lithostratigraphic units of Hungary in the form of tables (FÜLÖP et al. 1983). All of the works cited dealt with the theoretic problems of the biostratigraphy or involved the newest results of the Hungarian stratigraphy.

Because of the rapid, multidirectional development of the international stratigraphy, we have to restudy the position, subjects and nomenclature of the biostratigraphy with putting emphasis on the applications in practice. For the estimation of the viewpoints and results, four basic stratigraphic publications played important role. These are:

- The Directives of the Hung. Strat. Committee (FÜLÖP et al. 1975)
- International Strat. Guide (HEDBERG 1976)
- Principles de la Stratigraphie (POMEROL et al. 1980)
- North American Stratigraphic Codex (1983)

It was M. KÁZMÉR who draw my attention on the Codex for which I'm indebted to him.

The International Stratigraphic Nomenclature Committee, organized in 1952, differentiated the litho- bio- and chronostratigraphy before the birth of plate tectonics, i.e. before the big revolution in geosciences. On the one hand the plate-tectonic concept gave new tasks and impulses to old scientific branches practiced in a traditional way (e.g. systematics, phylogeny, palaeogeography, palaeobiogeography), on the other, it gave birth to new sciences (e.g. palaeomagnetic research).

The widening horizon of the geosciences had its effects on the stratigraphic practice as well. This fact appears very significantly in the Codex, which defines 12 stratigraphic categories instead of the three old ones:

lithostratigraphy
lithodemy
biostratigraphy
pedostratigraphy
allostratigraphy
chronostratigraphy
polarity-chronostratigraphy
geochronology
diachrony
geochronometry.

It is true however, that the last four ones are deprived of all material characteristics, they are pure time categories. On the other side, the enumeration of the different stratigraphic branches can still be continued: the Principles deals with:

seismostratigraphy
rhythmostratigraphy
climatostratigraphy
tectonostratigraphy
oceanostratigraphy
isotope-stratigraphy

in different chapters. These science-branches have their own nomenclature, methodology, and category-systems. That is the cause that stratigraphic and biologic nomenclature differ so much. The taxonomic system of biology is based on only one principle (the priority) and only one categoric system (cl, ordo, fam, gen, sp.). The priority itself has been valid from centuries on. In the Plantae regnum it is the first edition of LINNE's Species Plantarum (1753), in the Animal kingdom it is the tenth edition of his Systema Naturae (1758) which is regarded as a basic work. The systematic categories are related to bacteria as well as to mammals, to species living now, as well as to extinct ones. Even more, these categories can also be applied to artificially classified groups (e.g. trace fossils. organ-genera). In spite of its high variability and long history, the biology can be classified much more easily and surveyably than stratigraphy with ist multi-lateral category-network. We must admit, that this fact did not do good for the unity of stratigraphy. That is why it is extremely important to emphasize that the stratigraphy's branches – in spite of their different methodology – have one thing in common, which is their being concentrated on time, *chronocentric*. That is the essential difference between stratigraphy and faciology!

The structure of the Principles can make someone think of, but is not surprising. The ten-author book deals first with the geological significance of time. This chapter is followed by the one dealing with the stratigraphic units and boundaries, which is mainly based on the Guide. The correlational problems are taken after the desription of phýsical, sedimentological, geochemical, palaeontological, tectonical and oceanological methods of sedimentology.

Perhaps one could criticise from a didactical point of view that the faciology, the most evident means of geological orientation is placed in the last chapter dealing with palaeogeographic questions. But the essential is the emphasis put on the outstanding importance of time.

Time has a complex meaning in stratigraphy. Quite characteristically, the Principes speaks of the fossilisation of the time. That expression will hardly please the undrilled ears.

Anyway, varied documents of stratigraphy can be applied in different amounts to express the notions of succession, synchronity (correlation) duration and limitation.

Succession is not identical to superposition. The notion of succession expresses the sense of time much more than that of superposition, concerning mainly space. A whole series of geological events succeeding each other can be reflected in the same breakable material unit. Rock and fossil are an evident unity – but they are the result of a complex series of phenomena, which took place in time. The embedding, transformation, reworking, secondary embedding are themselves a succession, which can be deciphered from the state.

In a palaeontologist's point of view, biostratigraphy is applied palaeontology, but it is in its whole totality Taxonomic determination is a preliminary condition of interpretation, just like the taphonomic, palaeoecologic, palaeobiogeographic and evolutional aspects of the material. That is one of the reasons, the Guide deals with the biostratigraphic problems of reworked and "infiltrated" fossils separately.

Palaeoecology and palaeobiology play an important role in stating the synchronity Correlation, based on fossils which had been collected from different places have a crucial place in biostratigraphy

That is probably the cause why the Codex emphasizes the outstanding importance of fossils. The irreversibility of evolution is the bases of correlation, which cannot be imagined in an ecological vacuum. The evolution has always an ecological and geographic aspect. These meanings can hardly be wholly understood in biostratigraphy, but they can be approached.

As for the relative precision of correlation, I think two data are sufficient for an argument. The Lower Jurassic Toarcian stage corresponds to 8 million years. Based on ammonites, this stage can be subdivided into 27 horizons, each corresponding to an average 330 thousand year interval, This lapse of time is a minor value considering the historic geological scale since the chronometric determination of the much younger Egerian stage, based on glauconite-age determinations showed an oscillation of 10 million years (1973 – 76) (see also Principles, p. 61).

That is perhaps the determination of time-span, which is the most distant from the palaeontological methodology. The geologist – having followed the path of W. SMITH from 1796 on – ranged long ago formations in rock-columns, stated the synchronity and succession without knowing anything about whether they had investigated the results of 10, 100 or 1000 million year long processes.

Finally, as far as the problem of the limitation is concerned it is one of the most debated problems of palaeontology and historic geology The concepts of stability, gradual change, repetition, and catastrophy had each their outstanding schools for a 100 years. In biostratigraphy, the boundary has different orders according to its belonging to zones, stages or systems. The estimation and definition of these boundaries needs the collaboration of all the branches of the stratigraphy.

The question is, how the new Codex reflects the biostratigraphy, being chronocentric. Anyway it is thought-provoking, that it underlines first the rock-building role of fossils, which gives the occasion of realizing and defining material unities. After that it puts emphasis on the irreversibility of evolution and on the environment-indicating roles of fossils. This order of rank can be criticized, since it does not reflect the connection of bio-and chronostratigraphy quite well. Biostratigraphy can be regarded successful only when is serves as a reliable base for the more abstract chronostratigraphic framework. The Codex separates excessively the bio- and chronostratigraphic frameworks. It is right in considering the biozone the fundamental unit of the biostratigraphy; the biozone is naturally attached to the chronozone. As the chronozone has not got a global value, it can be understood, that the Guide regards the stage as the fundamental unit of chronostratigraphy. It is on the other hand surprising, that the Codex defines the system as the basic unit of chronostratigraphy! It is fortunately very rare, that the multitude of stratigraphic methods can only determine that the rock-body is only e.g. a Tertiary one. The base is generally below, and the system is on it.

The biozones can be classified in different types. The Guide lists four of them, the Codex separates three main types. The Directives did not group its seven zone-types. Hereafter are the types of the Guide and those of the Codex.

Guide	Codex
assemblage zone	assemblage zone
taxon range zone	interval zone
acme zone	abundance zone
intermediate zone	

According to the Guide the assemblage zone is a cenozone corresponding to natural assemblages. However, the fossils derived from a single layer can constitute different assemblage-zones, without the once cenologic connection between these organisms being proven. The nannoplankton, the benthic and planktonic organisms can well be index forms without cenologic connections. The Codex has a more cautious definition. The sufficient condition of the assemblage zone is the presence of three or more characteristic taxa. The assemblage zone sensu stricto is fully independent of the time-span of the observed groups. This zone can be suitable for the determination of "synchronity" of the layers of different territories, without clearing up the position of boundaries. In the other group of the assemblage zones (OPPEL or coincidence range zone) the criteria are the appearance or extinction of two taxa in the same time. This can easily be carried out in an outcrop, but the correlation has different roles. A problem arises, when a coappearance or coextinction observed in one locality is not justified by newer observations. That can easily happen considering the processes of migration, "allopatric" evolution, etc. In such a case the OPPEL zone must be regarded as an assemblage zone, or it becomes an interval zone after the naming species.

The name taxon range zone is not very lucky. The "range" is principally designing a notion of space. The Guide signalled, that the range can be translated to foreign languages only with great difficulties. The Principles tried to translate it as "zone d'extension", HÖLDER et al. (1972) put it as "Verbreitungszone" According to German authors the latter expression does not reflect totally the vertical character of the occurrence. It can well be that these inconveniences forced the editors of the Codex to change the word, "range" to "interval". Certainly, the interval has a more pronounced meaning of time than the range. Its translation to Hungarian is quite difficult since in the Directives, just as in the Guide, the interval zone is a unity independent from the range zone. The Codex defines the interval zone by the apparition and extinction of one or two taxa, which can include the whole, documented vertical occurrence of a taxon, or the strata characterised by the appearance of one and the extinction of another, or the layers lacking fossils but situated between two occurrences of taxa. In this manner, the interval zone of the Directives and that of the Guide is a variation of the Codex interval zone (intrazone) That innovation is doubtful, since intrazones lacking fauna can exist among assemblage zones as well. Another and even more debatable thing is the fact, that the Codex regards the apparition and extinction as equal The radiation of the new group having synapomorph characters is a much quicker evolutional process than the extinction dragging on in time and space. The relict faunas and floras are the best proof of it. Thus that is a well justified practice of biostratigraphers dealing with Jurassic ammonites, that they only consider the apparition-dates.

The independence of the abundance-zone can be criticised from an evolutionary and frequency-measuring point of view. According to the Codex, this zone is based on the relative frequency-rates of one or more taxa and corresponds to the highest abundance, that is to the acme-zone. The idea of acme reflects a wrong vitalistic comprehension, according to which every taxon has – just as in ontogenesis – its birth-, its acme- and its fading-periods (BOGSCH 1968). The evolution is a much more complex process, and the abundance can be in many cases explained by local ecologic or rather taphonomic factors. It depends on the point of view or on the means of investigaton, that in the given material unity those are the macro-micro- or nannofossils, which are considered being abundant. The abundance-zone – if its differentiation is useful at all – should be regarded as a special variety of the interval zone or of the assemblage zone.

It is out of doubt, that it is the variation of the interval zone, based on the apparition of one taxon, that comply best with the "requirements" of the once index-fossil.

The question is: what is the material basis of the interval-zone, from an evolutionary aspect? According to the traditional concept, the speciation is a long during, gradual transformation, i.e. a phyletic speciation. As the changes are continuous there is no sharp boundary between the "chronospecies". Should the fossil-documentation be continuous, the species succeeding each other could not be separated. In this case. every biozone based on low category levels would be artificial, since we separated the species artificially. As species formation has not got precise dates, the limits of the species and those of the zone would be determined by the beginning of fossilisation possibilities or by the subjective opinion of the systematiser considering the apparition of some new characters. After the widespread extension of the plate-tectonic concept, from 1972 on, researchers have begun to doubt in the gradual species-evolution model. The speciation model named "punctual equilibrum" considers quick species-forming stages and longer "stasis" periods, characterised by a morphological stability The other, cladistic model for evolution explains species formation by repeating splitting, when, as the original description states, from the old species being extinct in the moment of cladogenesis arise two newer ones: the one wearing the ancestral characters being the plesiomorph and the species having the new characters being the apomorph one. The palaeontologists prefer rather the punctuated equilibrum model, while the neontologists believe rather in the cladistic model.

Anyway both widespread and strongly debated models have their common biostratigraphic consequence: the biostratigraphic boundary based on the apparition of a species in a natural one.

Apart from the biostratigraphic significance of the processes related to speciation, the possibility arises that the macroevolutionary changes can be related to stratigraphic categories. That is a quite pleasing idea. since the quick formation of taxa belonging to higher systematic categories presumes a hierarchic change of order. Putting this idea into practice the species and subspecies would indicate horizons and subzones, the genus-family-level taxa would characterize zones or substages. It is a possibility, which has only rare applications in stratigraphy.

Changing now from theory to practice, it is worth remembering Arkell's (1956) triple requirement for stratigraphic classification: this emphasizes the need for compromises with the priority, tradition (suitability) and usage. The Davoei chronozone is a very good example because on the one hand it is a classical one, on the other it can be very well studied in Hungary by its rich ammonite fauna.

The Lower Jurassic Pliensbachian stage was defined by Oppel in 1856 with the following zonation·

Amm. spinatus zone
A. margaritatus zone
A. davoei zone
A. ibex zone
A. jamesoni zone

The Davoei zone was later subdivided into three subzones.

Fingulinum subzone
Capricornus subzone
Maculatum subzone

In Yorkshire seven, in Burgundy eight horizons could be defined in the zone. The Burgundian horizons are as follows (see Dommergues et al. 1984):

Fingulinum horizon
Davoei
Capricornus γ
Capricornus β
Capricornus α
Lataecosta
Maculatum
Fimbriatum.

It is surprising, that the zonal index species Prodactylioceras davoei (Sowerby 1822) is only restricted to the base of the Fingulinum subzone. It is a material unit there and only there. In the interval of the whole chronozone, it is merely an abstract symbol.

In Hungary, in the Bakony Mountains the Davoei zone can be studied in 8 sections at favourable outcrop-conditions. The sampling was effectuated under the supervision of the former director of the Hungarian Geological Institute. Dr. J Konda, over large surfaces, and with great precisity The fauna was studied in the Palaeontological Department of the Budapest University. The investigated localities with the time of sampling are as follows:

Bakonycsernye	1954 – 75
Lókút	1961 – 62
Büdöskút	1964 – 65
Kericser	1965
Kávástető	1971
Bocskorhegy	1971 – 73
Hamuháza	1974

11615 ammonite specimens were sampled from the studied sections listed above. The fauna is of Mediterranean caracter 47.2% of the specimens belong to the family Phylloceratidae, 18.0% of them to the Juraphyllitiade, and 5.5% to the Lytoceratidae. *Prodactylioceras davoei* is represented by only 5 specimens (0.0004%) (Géczy 1982).

It seemed to be useful to choose two species indicating the biozone from the relatively more frequent Hildoceratidae (*Protogrammoceras costicillatum* Fucini 1900) and Dactylioceratidae (*Prodactylioceras italicum*) (Meneghini et Fucini 1900) (Géczy (1976). The result of the revision of the Hamuháza section (see Dommergues et al., 1983) enable us to suppose that the *P. costicillatum* can be found in the whole Davoei zone, while the last representants of the *P. italicum* go up to the lowermost Domerian (Stokesi zone). In Hamuháza, the *P davoei* itself is only present in the Davoei horizon!

In the Mediterranean realm, the *P costicillatum* and the *P italicum* are widespread and frequent species. The *P. davoei*, on the contrary, has not been found in Italy up till now. Thus the first two biozones filling the whole time-interval of the Davoei chronozone can be used to identify it. Meanwhile that would not be reasonable to change the name of the Davoei zone because the priority and the tradition underlined by Arkell are justifying without doubt the preservation of the name created by Oppel.

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MICROFACIES PATTERN OF THE UPPER EOCENE LIMESTONES AT BUDAPEST, HUNGARY

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(Received: 1st March 1984)

Abstract

Microfacies types of the Upper Eocene nummulitic limestone and bryozoan marl are described, based upon detailed investigations of 9 surface and subsurface sections. The environments assigned to the microfacies types range from the algal-coated conglomerate of a rocky coast through shallow marine biogenic sands, coral-algal patch reefs, *Discocyclina* accumulations and Bryozoa meadows to hemipelagic calcareous *Globigerina* marl. Relationships among lithologic character, fossil content and postulated water depth are displayed in a synoptic facies diagram.

Introduction

The Priabonian (Upper Eocene) nummulitic limestone and bryozoan marl has been investigated in 9 sections west of the Danube river, in and around Budapest (Fig. 1). The rich microfaunal content and presence of algal flora, and the fairly good preservation of fossils have been known from the papers of HANTKEN (1884) and MONOSTORI (1965). However, no detailed microfacies investigations has been made as yet, except that of VARGA (1980) and VARGA in BÁLDI et al. (1980), for the Alcsútdoboz 3, Sóskút – 1 and Óbuda – 2 boreholes.

The Upper Eocene limestone (and some calcareous marl) beds of four boreholes and of five surface outcrops have been investigated:

Alcsútdoboz – 3
Sóskút – 1
Óbuda – 2
Nagykovácsi – 64
Budaörs, Úthegy quarry
Budapest, Martinovics-hegy, northern quarry
Budapest, Fenyőgyöngye quarry
Budapest, Mátyáshegy, western quarry
Üröm, Rókahegy, quarry N° 5.

The observed carbonate microfacies types were arranged in a sequence to form a hypothetical facies model. At the end the process of the Late Eocene transgression in the Buda Mts. is outlined.

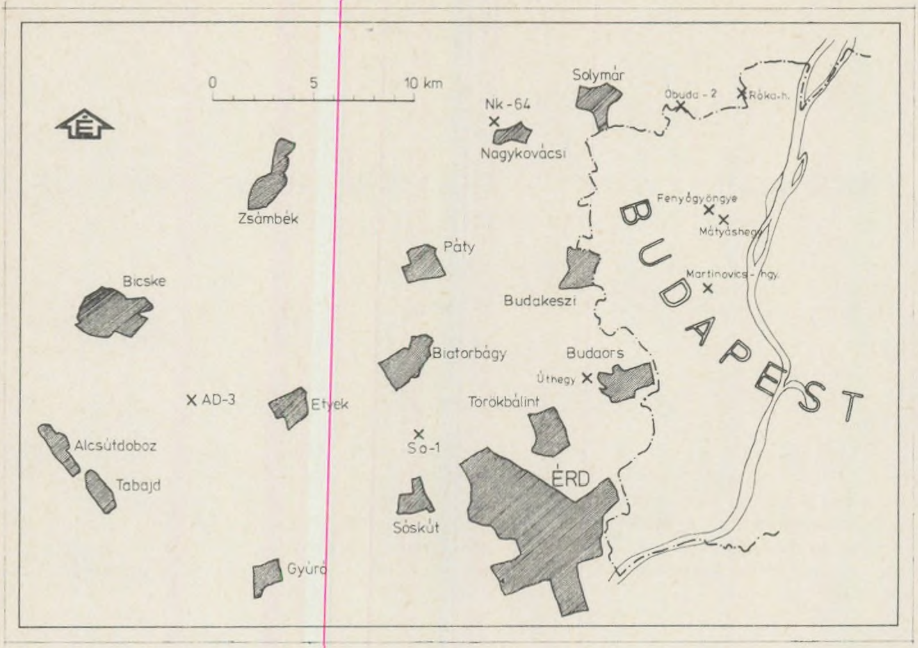


Fig. 1. Localities of Upper Eocene limestone sections around Budapest

Stratigraphy

In the surroundings of Budapest Upper Eocene formations cover mostly Triassic Dachstein Limestone or small spots of Middle Eocene sandstone and marl. The Late Eocene transgression deposited thick basal conglomerate then limestone with *Nummulites fabianii* and discocyclinids. It is followed by neritic bryozoan limestone and marl, then by a pelagic *Globigerina* marl (Buda Marl). The latter extends up to the Oligocene (HORVÁTH M., 1983, pers. comm.)

Methods

Surface and subsurface sections of at least 10 m in length were selected for sampling in intervals from 0,5 to 2,0 m. Altogether 174 samples and 297 thin sections were examined. Features visible on weathered, freshly cracked and polished rock surfaces were considered, too.

Texture of the rock (EMBRY and KLOVAN, 1972), diversity, dominance and percentage of biogenic components determined by semi-quantitative comparison charts (FLÜGEL, 1982), presence of rare but important components (e.g. extraclasts), and in some cases sorting and roundness of components and cement types were considered in the determination of microfacies types. These were interpreted as fossil environments and a facies model was established for the Upper Eocene carbonate rocks in Buda Mts.

Microfacies types

The descriptions contain the following data:
- number and denomination,
  short description;
- fossil content listed in decreasing abundance;
- localities;
- environmental interpretation.

MF – 1A. extraclast-rudstone in alga-grainstone matrix (dolomite-conglomerate in alga-grainstone matrix)

Well-rounded dolomite pebbles with grain support. The matrix contains fragments of encrusting corallinacean algae, cemented by clear, blocky sparite. Some pebbles bear algal crusts.

Fossils. mostly undeterminable Melobesioideae, a few small *Nummulites*, *Asterigerina*?, Miliolina, *Chapmanina*, echinoderm fragments, Crustacea fragments.

Locality· Alcsútdoboz – 3 borehole: 790,0 – 790,2 m.

Interpretation: submarine conglomerate fan of a rocky shore made of dolomite. Extreme environmental conditions within the zone of intense wave action.

MF – 1B: extraclast-rudstone in alga-foraminifera-grain/packstone matrix

Ghosts of rounded dolomite or limestone pebbles, recrystallized into clear sparite or filled by micritic internal sediment. The pebbles bear a thin micritic crust of microbial origin. The matrix is alga-foraminifera grainstone. The sparry cement was partly recrystallized from micrite (pseudosparite).

Fossils: much Melobesioideae; some *Terquemella*?, *Nummulites*, *Eorupertia*, *Gypsina*, porcelaneous Foraminifera, *Actinacis*-type corals, bivalve and echinoid fragments and traces of boring activity

Localities: Nagykovácsi – 64 borehole: 53.5 m, Budapest. Martinovics-hegy, northern quarry.

Interpretation: submarine conglomerate fan of a rocky coast. Less intense wave action than in MF – 1A. Micrite crusts indicate less than 10 m water depth.

MF – 2: alga-foraminifera-grain/packstone

Fragments of red algae and various benthonic foraminifers in pseudosparite-sparite. Compaction cracks of fossils are filled by sparite. Micrite-filled foraminifers and bryozoans with geopetal infill. One sample (Sóskút – 1: 912.6 m) is characterized by a first generation of fibrous cement and a second generation of clear blocky cement, while some intergranular voids are filled by vadose micrite.

Fossils: indeterminable Melobesioideae, *Lithoporella*, *Ethelia*, Corallina; *Nummulites*, *Asterigerina*, *Acervulina*, *Gypsina*, *Eorupertia*, various smaller foraminifers, *Hydractinia* (a hydrozoan), Actinacis-type coral, Gastropoda, Bryozoa, *Ditrupa* and echinoid fragments.

Localities: Sóskút – 1: 912.6 m; Óbuda 2: 148.6; Nagykovácsi 64. 49.0 – 50.7 m and 52.8 m.

Interpretation: calcareous sand, deposited in well-agitated water of several metres depth. Some parts have risen to subaerial conditions, suffering vadose cementation.

MF – 3: Nummulites-packstone

Dominant (40%) *Nummulites* shells with stylolitic contacts in micritic matrix, containing badly preserved calcareous red algae and other hyaline smaller Foraminifera.

Fossils: Melobesioideae, *Nummulites*, hyaline and porcelanous smaller Foraminifera, Bryozoa, echinoderm fragments.

Locality: Sóskút – 1 borehole: 909.9 m.

Interpretation: *Nummulites* sand deposite below wave based, with some redeposited rhodoliths. It may be a poorly developed equivalent of the Nummulites-bank of ARNI (1965).

MF – 4: alga-echinoidea-foraminifera-packstone

Overpacked biomicrite with frequent stylolitic grain contacts. Badly preserved red algae and echinoderm fragments.

Fossils: dominating indeterminable Melobesioideae and echinoid fragments. Small Bryozoa fragments, *Corallina*, *Lithoporella*, *Nummulites*, smaller Foraminifera, *Asterigerina*, *Gypsina*, *Discocyclina*, *Eorupertia*, *Heterostegina*.

Locality. Óbuda – 2 borehole: 145.0 m.

Interpretation: Medium diversity fossil assemblage deposited below wave base. Considerable compaction resulted in almost total absence of micritic matrix and overpacking of components.

MF – 5. alga-foraminifera-bryozoa-pack/grainstone

Mostly Melobesioideae in a partly winnowed micritic matrix. Pores are filled by sparite. Several algal species encrust each other as it can be deduced from different cell sizes within an oncoid. Corallinacean algal layers cover bryozoans, encrusting foraminifers (*Gypsina* and *Fabiania*) and the squamariacean alga *Ethelia*. Larger Foraminifera (discocyclinids and *Nummulites*) occur frequently, together with recrystallized corals and bryozoans. Components are badly sorted but microstylolitic grain contacts occur. There is no orientation of plate-like components in the samples. The encrusting organisms are well-preserved and bind a considerable part of the matrix.

Fossils· calcareous algae are dominant: *Lithophyllum*, *Hemiphyllum* or *Paraphyllum*, *Ethelia*, *Lithoporella;* smaller *Nummulites* are frequent: *N vascus; Actinocyclina*, *Exagonocyclina; Asterigerina*, *Eorupertia*, *Placopsilina?*, *Fabiania*, *Alveolina*, *Pyrgo* and other Miliolina, smaller foraminifers, Hydractinia, a calcareous sponge, ACTINACIS-type coral, *Ditrupa*, Bryozoa, Echinoidea-fragments, calcisphaera.

Localities. Alcsútdoboz – 3 borehole: 787.0 788.3 m; Sóskút 1 borehole 907.6 m, Budapest, Fenyőgyöngye quarry· 0.0 – 3.5 m and 10.0 – 13.0 m, Óbuda 2 borehole: 127.8 m and 139.4 m, Nagykovácsi – 64 borehole: 45.4 47.8 m.

Interpretation: well -oxygenated, moderately agitated, favorable environment below wave base. The delicate fossils are autochthonous but original bedding has been eliminated by bioturbation. Partly bound by thin layers of encrusting organisms. Part of the coral and algal fragments originated from the area of MF – 6A (patch reefs).

MF – 6A. algal-coral-bind/bafflestone in bioclastic wacke/packstone matrix

Micrite-dominated rock with biogenic components up to 30% Moreover, the matrix contains small, unidentifiable bioclasts. Encrusting red algae form dichotomous branches or thin crusts binding the micritic matrix. Corals were recrystallized in several steps, resulting in spar-filled voids with ghosts of septa. Some of them are encrusted by algae and sessile foraminifers. Corallinacean and squamariacean algae form oncoids with enclosed micritic layers and foraminifers.

Fossils: Melobesioideae, Scleractinia, *Discocyclina*, Bryozoa, Echinoidea fragments, *Lithoporella*, *Hemiphyllum* or *Paraphyllum*, *Ethelia*, *Mesophyllum?*, *Asterocyclina*, *Exagonocyclina*, *Operculina*, *Heterostegina*, *Asterigerina*, *Eorupertia*, *Nummulites*, *Gypsina*, *Sphaerogypsina*, *Pyrgo*, *Quinqueloculina*, *Haddonia?*, smaller benthonic and planktonic Foraminifera Gastropoda, Bivalvia, *Serpula*.

Localities Budaörs, Úthegy quarry. 0.2 – 3.0 m and 3.2 8.0 m, Budapest, Fenyőgyöngye quarry: 4.0 – 9.5 m, Óbuda – 2 borehole: 103.0 m.

Interpretation. calm, well-oxygenated environment below wave base. The branching corals attenuated water motion near the sediment surface, so micritic mud was deposited and bound by red algae. The various foraminifers lived among and on the corals but a considerable part of these is possibly redeposited from nearby environments. The 5 m thick bed at Fenyőgyöngye with corals in micritic mud can be interpreted as a coral-algal mud-mound. Fragments of MF – 6A can be recognized in the area of MF – 5. where the mud-mounds were situated as small topographic highs. The extensive development of early diagenetic features indicate slow sedimentation rate.

MF – 6B. algal-coral-bind/bafflestone in extraclast-bioclast-packstone matrix

Similar to MF – 6A but contains quartz sand grains up to 15%.

Fossils: Melobesioideae, corals, *Lithoporella*, *Pyrgo* and other Miliolina, *Discocyclina*, *Ethelia*, planktonic Foraminifera, Echinoidea fragments, Gastropoda.

Locality: Budaörs, Úthegy quarry· 3.0 – 3.2 m.

Interpretation: same as of MF – 6A. The high quartz content indicates the renewal of carbonate sedimentation after the deposition of a 0.1 m thick, terrigenous sandy marl layer.

MF – 7: echinoidea-alga-bryozoa-grainstone

Bioclastic sandstone made of rounded echinoid fragments, a few algal oncoids, much algal and bryozoan fragments. The clear sparite cement is mostly part of the syntaxial rims of echinoid fragments. Many fossils contain micrite infill.

Fossils: Melobesioideae, Echinoidea, Bryozoa, *Nummulites*, *Sphaerogypsina*, Miliolina, Textulariina, *Discocyclina*, *Gypsina*, *Ditrupa*.

Localities: Alcsútdoboz – 3 borehole: 765.5 – 777.4 m; Óbuda – 2 borehole: 146.5 m.

Interpretation: polymictic calcareous sand deposited in agitated water. The grains were washed together from several places. The moving sand prevented the settlement of a diversified fauna like in MF – 6A.

MF – 8: nummulites-floatstone in echinoidea-packstone matrix

Some relatively large *Nummulites* shells "float" in micritic mud containing echinoid fragments up to 50%. The *Nummulites* shells are filled by micrite. A kind of textural inversion can be observed: small, but relatively well-sorted echinoid fragments are packed together in micritic matrix.

Fossils: Echinoidea, *Nummulites*, *Operculina*, Miliolina, Rotaliina.

Locality: Budapest, Martinovics-hegy, northern quarry· 22.9 – 21.9 m.

Interpretation: echinoidea-sand transported to a muddy sedimentation area. The *Nummulites* shells are autochthonous.

MF – 9A: Discocyclina-floatstone in alga-discocyclina-echinoidea-grain/packstone

Variable composition characterized by the dominance of Discocyclina. Most of them are intact but the thin edges of swollen specimens are frequently broken. The corallinacean fragments are well-rounded and smaller than 0.5 mm in diameter. Much of these are micritized and cannot be distinguished from peloids. Thin algal crusts (bindstone) and oncoids occur, too. Echinoid fragments are surrounded by thick syntaxial cement rim enclosing neighbouring components as inclusions. Orientation of *Discocyclina* specimens indicate bedding.

Fossils: Melobesioideae, *Discocyclina*, Echinoidea, *Corallina*, *Lithoporella*, *Ethelia*, *Exagonocyclina*, Bryozoa, smaller vagile and sessile Foraminifera and calcite-shelled Bivalvia.

Locality: Nagykovácsi – 64 borehole: 39.4 – 43.3 m.

Interpretation: This sediment was deposited seaward from environments represented by Nummulites and corals, near the base of the wave agitated zone.

MF – 9B. Discocyclina-rudstone in Discocyclina-packstone matrix

Similar to MF – 9A, but with lesser diversity of fossils. The rudstone matrix contains mostly Discocyclina with some other larger Foraminifera and considerably smaller quantity of echinoid fragments and red algae, than in MF – 9A. Stylolitic grain contacts are common.

Fossils: *Discocyclina*, Melobesioideae, Corallinoideae, *Nummulites, Asterigerina, Operculina, Heterostegina*, smaller Foraminifera, Bryozoa, Echinoidea.

Locality: Budapest, Mátyáshegy, western quarry: 0.0 5.0 m.

Interpretation: similar to MF – 9C. Optimal conditions for Discocyclina due to washing out of micritic mud resulted in the outplacing of most other organisms. It is possible that the area of this microfacies was a small topographic high of some tenth of a metre.

MF – 9C: Discocyclina-floatstone in alga-discocyclina-bryozoa-echinoidea-packstone matrix

Large, subparallel Discocyclinas with stylolitic contacts, sometimes penetrating each other. Equal amount of red algae, small Discocyclina and Bryozoa form the matrix of the floatstone.

Fossils: *Discocyclina*, Melobesioidea, Bryozoa, Echinoidea, Corallinoideae, *Operculina, Heterostegina, Asterigerina, Nummulites, Sphaerogypsina*, smaller hyaline and porcelanous Foraminifera, sessile agglutinated Foraminifera, *Ditrupa*.

Localities: Budapest, Martinovics-hegy, northern quarry: 19.7 – 13.5 m; Budapest, Fenyőgyöngye quarry: 13.5 – 15.0 m; Budapest, Mátyáshegy, western quarry: 5.5 – 16.0 m.

Interpretation: the large *Discocyclina* specimens lived in situ; the intensity of water agitation is characterized by the components of the matrix of the floatstone. Sedimentation occurred below wave base (20 to 50 m depth). Great sedimentation rate is shown by sparite fill of foraminifer chambers. It was joined by a relatively slow diagenetic process causing mutual penetration of components during compaction.

MF – 10. bryozoa-alga-extraclast-foraminifera-grainstone

Large, double-layered bryozoa crusts "floating" in polymictic bioclastic matrix. Place of dissolved aragonitic fossils shown by inclusion ghosts in blocky spar matrix. Slightly rounded quartz grains.

Fossils: Bryozoa, Melobesioideae, *Nummulites, Asterigerina*, Miliolina, calcitic and aragonitic Bivalvia, *Actinacis*-type coral, *Haliotus?*

Locality: Nagykovácsi – 64 borehole: 52.0 m.

Interpretation. Polymictic association washed together to the area of double-layered Bryozoa. Extraclasts indicate terrigenous influx. The encrusting red algae indicate undisturbed sedimentation at their place of origin. Probably the sparite-filled Bryozoa are autochthonous. Lower part of photic zone, near the deposition zone of calcareous bryozoan marl.

MF – 11A: bryozoa-grainstone

Well-sorted association of branching and globular bryozoans with micrite and/or sparite infill. Stylolitic grain contacts are common.

Fossils: Bryozoa, Echinoidea, Melobesioideae, smaller Foraminifera, Globigerinidae.

Localities. Alcsútdoboz 3 borehole: 779.4 m; Sóskút – 1 borehole: 897.0 m.

Interpretation: "bryozoan-bush" deposited in streaming water near the lower boundary of the photic zone. First appearance of planktonic Foraminifera indicates the closeness of hemipelagic environments.

MF – 11B: bryozoa-packstone

Oriented, branching, double-layered or globular bryozoans with micritic or sparitic fill, partly encrusted by thick micritic layer. The syntaxial cement rim of echinoids encloses bryozoans.

Fossils: Bryozoa (80%), *Lithoporella*, Globigerinidae, smaller benthonic Foraminifera, *Discocyclina*, *Sphaerogypsina*, *Asterigerina*, *Ditrupa*,

Localities: Alcsútdoboz – 3 borehole: 784.0 m; Sóskút – 1 borehole: 902.0 m; Budapest, Martinovics-hegy, northern quarry: 8.0 m.

Interpretation: bryozoa-meadow in well-oxygenated water near the lower boundary of the photic zone. Relatively fast sedimentation prevented the full micritic infill of the bryozoan zooecia.

MF – 11C: Bryozoa-floatstone in bryozoa-wacke/packstone matrix

Thin-walled, double-layered bryozoan fragments with micrite or sparite fill. Orientation of flat *Asterocyclina* indicates bedding. Some microstylolitic grain contacts occur.

Fossils: Bryozoa, Melobesioideae, *Asterocyclina*, *Heterostegina*, Globigerinidae, Coscinophragmatinae, Miliolina, calcitized sponge spicules, calcisphaera, Echinoidea.

Locality: Budapest, Mátyás-hegy, western quarry: 16.5 – 20.5 m.

Interpretation: calmer environment than that of MF – 11A and MF – 11B; indicated by very thin-walled bryozoans and thin Asterocyclina of large diameter. Strong pelagic influence is indicated by Globigerinidae.

MF – 12: bryozoa-foraminifera-mollusca-packstone

Badly preserved, small, biogenic fragments in micritic matrix. Parallel position of the dominating bryozoans indicates bedding.

Fossils: fragments of branching Bryozoa, smaller, hyaline and porcelaneous Foraminifera, thin-shelled Mollusca, Globigerinidae, Echinoidea, Melobesioideae, calcitized sponge spicules.

Locality: Alcsútdoboz – 3 borehole: 755.0 – 758.5 m.

Interpretation: echinoidea and red algae indicate redeposition from shallow marine environments, while Globigerinidae indicate pelagic influence. Presence of thin-walled Bryozoa, thin mollusc fragments and sponge spicules correspond to the proximity of pelagic environment. This sediment was deposited below photic zone, where biogenic carbonate production was attenuated due to lack of light and consequently percentage of terrigenous material increased.

This microfacies type – together with MF – 11A, MF – 11B and MF – 11C – from the so-called bryozoan marl of the Buda Mts.

MF – 13. Globigerina-wackestone

Whole and fragmented Globigerinidae, some other smaller foraminifers and thin-shelled, subparallel mollusc fragments floating in homogenous, clayey micrite.

Fossils· Globigerinidae, Bivalvia, red algae, sponge spicules, Echinoidea spines.

Locality: Alcsútdoboz – 3 borehole: 747.0 – 750.0 m.

Interpretation: globigerina marl (= Buda Marl), deposited in bathyal environment of the upper flanks of the continental slope. Small fragments of red algae and echinoid spines indicate slight resedimentation.

MF – 14A: echinoidea-alga-foraminifera-packstone

Well-sorted, rounded, echinoidea-, red algal and foraminifer fragments in equal quantity. Vagile and sessile benthic foraminifers, the latter include a considerable quantity of *Gypsina*. Less than 10% extraclasts: chert, quartz, dolomite, all in micrite-microsparite matrix. Inhomogeneous texture: indistinct spots one with third of original grain size, with much bryozoans and microsparitic matrix.

Fossils: Echinoidea, micritized red algea, *Corallina*, *Nummulites*, *Gypsina*, *Chapmanina*, *Eofabiania?*, hyaline smaller Foraminifera, Bryozoa, *Ditrupa*, Crustacea.

Locality: Üröm, Rókahegy, quarry no. 5. 0.0 – 26.0 m

Interpretation. see MF – 14B.

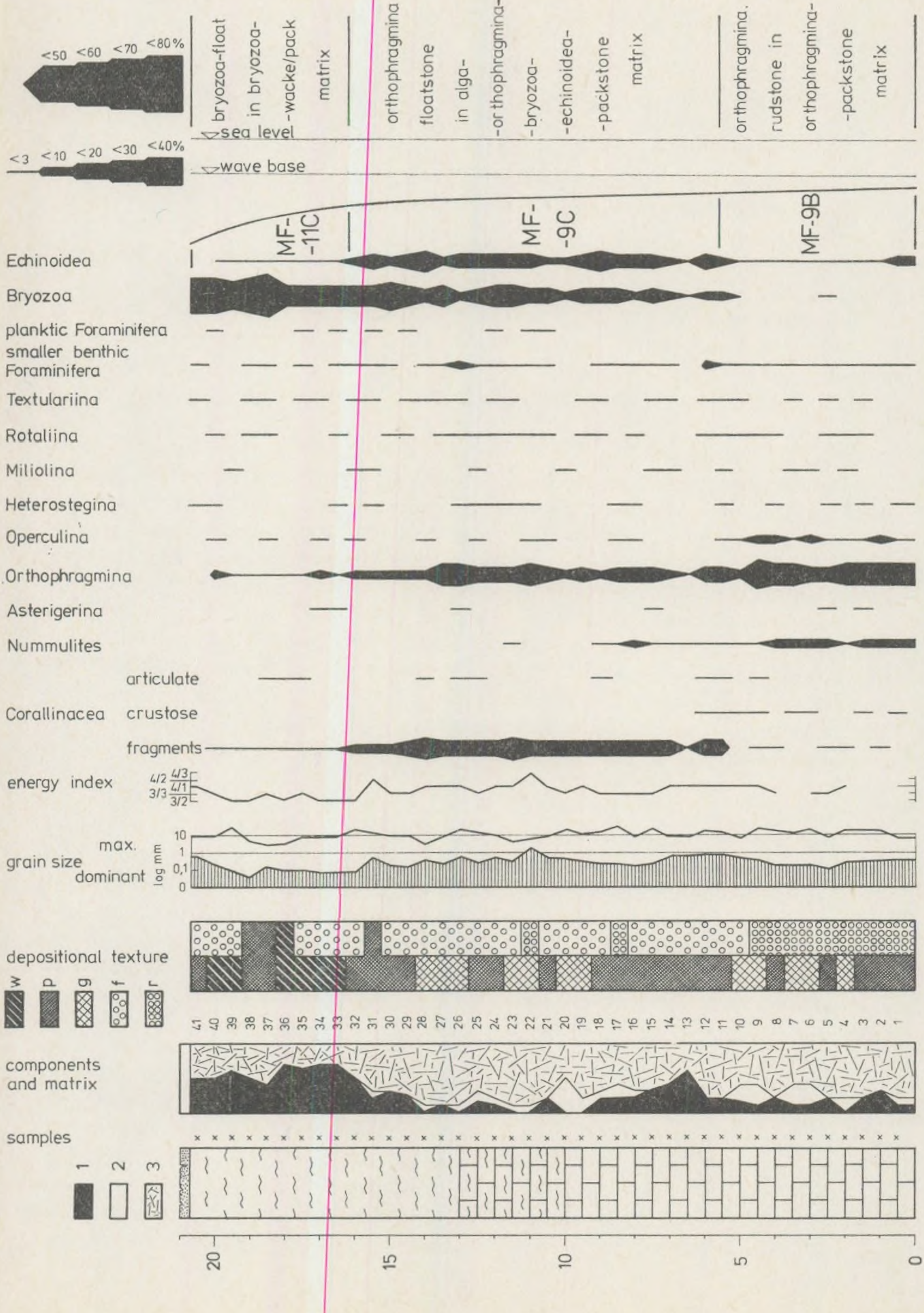
MF – 14B: extraclast-alga-foraminifera-pack/grainstone

Medium to badly sorted components in inhomogeneous matrix. Much extraclast (different kinds of cherts, quartz) but less echinoids than in MF – 14A. The encrusting foraminifer *Gypsina* froms tube-like bodies of not more than 1 cm in length and 3 – 4 mm in diameter, or it encrusts bivalve fragments.

Fossils: red algae, *Gypsina*, *Nummulites*, *Fabiania*, *Chapmanina*, calcisphaera, hyaline and porcelaneous Foraminifera, Bryozoa, Echinoidea, Crustacea.

Locality: Üröm, Rókahegy, quarry no. 5: 27.5 – 31.0 m.

Interpretation: the most conspicuous components are the *Gypsina* tubes: these are remnants of the foraminifer which encrusted the stems of sea grasses. After the death and decay of the plant the central hollow was filled by the surrounding sediment. The sorting and composition indicates an environment within the wave agitated zone. The sea grass meadows slowed the water motion near the bottom so micrite couldn't be winnowed out. The presence of sea grasses indicate a well-oxygenated environment in the upper part of the euphotic zone.



<50 <60 <70 <80%
<3 <10 <20 <30 <40%
sea level
wave base
bryozoa-float in bryozoa- -wacke/pack matrix
orthophragmina floatstone in alga- -orthophragmina- -bryozoa- -echinoidea- -packstone matrix
orthophragmina. rudstone in orthophragmina- -packstone matrix
MF- -11C
MF- -9C
MF-9B
Echinoidea
Bryozoa
planktic Foraminifera
smaller benthic Foraminifera
Textulariina
Rotaliina
Miliolina
Heterostegina
Operculina
Orthophragmina
Asterigerina
Nummulites
articulate
Corallinacea
crustose
fragments
energy index
4/2
3/3
4/3
4/1
3/2
max.
grain size
dominant
log mm
10
1
0,1
0
depositional texture
w p g f r
41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
components and matrix
samples
1 2 3
20
15
10
5
0

Microfacies sequence of Mátyáshegy, western quarry

The microfacies diagram of Mátyáshegy quarry (Fig. 2.) is an excellent example of microfacies delimitation. There are two changes of rock type (from limestone to calcareous marl to marl) in the lithologic column on the left side. Neither the matrix-constituent composition, nor the percentage of fossils follow the lithologic changes observed in the field by the naked eye. The microfacies types has been delimited on the presence or absence of corallinacean algal fragments, disappearance of *Nummulites* and *Operculina*, decrease of *Discocyclina (= Orthophragmina)* and appearance of Bryozoa and echinoid fragments.

The microfacies diagram shows a constant, gradual change of environments below wave base, due to slow, even sinking of the basin.

Microfacies pattern

The following criteria were considered for the interpretation of depositional depth for each microfacies. Large quantity of coarse, terrigenous debris (dolomite clasts and pebbles) was regarded as abrasion conglomerate. Chert fragments indicated nearshore environment, too, as cherty dolomite formed the postulated shore. Type of matrix (micrite or sparite) indicates agitation of water. Sparite was precipitated in interstitial spaces from where lime mud has been washed out. This occurred mostly in depths less than 20 m, i.e. in the zone of wave agitation. Deep-water currents can produce microfacies types similar to shallow water ones but these are of limited lateral extent. Ratio of components and matrix may be an important feature e.g. mud-supported texture indicates that disaggregation of biogenic components dominates over accumulation. This is characteristic for less favourable in this case for deep neritic – environments. Dominant grain size is characteristic for water agitation, but the maximal one refers to the size of autochthonous organisms only.

One or two specimens of some fossil groups (calcareous red algae, *Discocyclina*, Bryozoa, Echionidea) can be found in almost all facies types, but their enrichment is an important facies indicator

Disappearance of red algae is due to bad photic conditions these facies types (containing large amounts of bryozoans) were assigned to the deeper shelf (100–200 metres).

◀ *Fig. 2.* Microfacies diagram of Mátyáshegy, western quarry. The lithological boundaries (left side) does not show any coincidence with change in fossil content (middle).

1 = micrite
2 = sparite
3 = bioclasts

w = wackestone
p = packstone
g = grainstone
f = floatstone
r = rudstone

The comprehensive Fig. 3. shows the microfacies pattern: matrix and texture, percentage of most important fossils and postulated water depth are included for each microfacies types. The sequence was established following the increase in water depth, increase of shore distance indicated by the decrease of extraclastic content and ecological needs and/or tolerance of fossils. Probably, this pattern contains subjective elements, mostly in the arrangement of facies types deposited at wave base.

Unfortunately, MF–14A and MF–14B couldn't be included in the facies pattern as the stratigraphic position of the Rókahegy quarry no. 5. is uncertain. Possibly it is a calcareous heteropic facies of bryozoan marl but this hypothesis needs further verification.

The following depositional environments can be postulated in the Buda Mts. and its surroundings during Late Eocene time:

- Submarine debris fan of a rocky coast (MF–1A, –1B and –2);
- Protected lagoon with open circulation of normal saline, well-oxygenated, less agitated water. Diversified fossil communities lived in this environment, where biological production exceeded disaggregation but lime mud wasn't washed out (MF–2, –3, –4 and –5.)
- Shoal of sand-size particles washed together, partly with subaerial, vadose cementation. It was deposited far from the shore as it doesn't contain any terrigenous components (MF–7).
- Coral-algal patch reef below wave base. The branching corals attenuated water currents so micrite mud was deposited and bound by encrusting red algae (MF–6A, –6B).
- Outer part of the shallow shelf: *Discocyclina* lived here in large quantity, below wave base. The lumachella-like beds are autochthonous, since the thin foraminifers couldn't bear significant transportation
- MF–8, –9A, –9B, –9C).
- Deeper shelf dominated by bryozoans. MF–10 contains some fragments of corallinacean red algae but the deeper environments are devoid of them. The grainstone texture developed locally following the winnowing effect of deep-water currents. In this depth of 50 to 100 metres the biogenic carbonate production was inhibited and, consequently, the ratio of terrigenous clay minerals increased (MF–10, –11A, –11B, –11C).
- Shelf margin and beyond: hemipelagic environment from one hundred to several hundred metres. Characteristic microfacies is the *Globigerina*-wackestone (MF–13). Following the further decrease of carbonate content the terrigenous material became dominant: this is the Buda Marl.

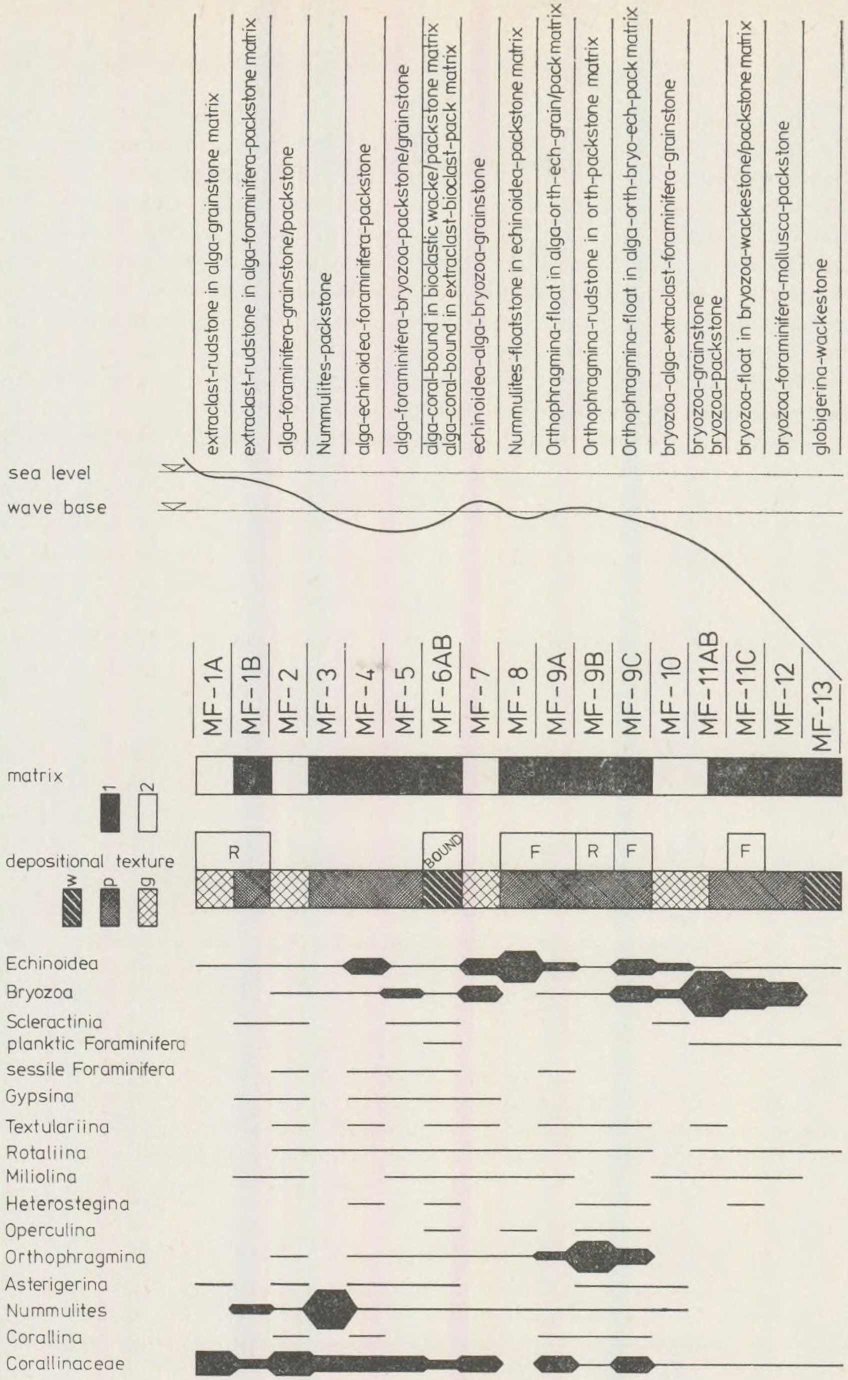


Fig. 3. Microfacies pattern of the Upper Eocene carbonate rocks at Budapest. The curved line indicates change in sedimentation depth between neighbouring microfacies types.

w = wackestone
p = packstone
g = grainstone

1 = micrite
2 = sparite

Conclusions

Overview of the Upper Eocene formations in and around Buda Mts. showed a general sinking of the basin, manifested in different facies in different tectonic blocks. The transgressive sequence started with a conglomerate of Triassic dolomite, limestone and chert pebbles and debris. It was followed by the deposition of algal limestone showing a variable range of microfacies. By the deepening of the sea the role of carbonate sedimentation decreased and limestone was replaced by bryozoan marl and then by Buda Marl with globigerinids.

This hypothetical sequence of events was constituted from the observations made in 9 sections. The transgressive sequence of microfacies types is conspicuous in every section but some facies may be absent or may return. No simple correlation could be established among the sections during this work. This behavior of facies types indicates differential motion of tectonic blocks during Late Eocene time. (A first draft of this hypothesis was made by DUDICH (1959), recognizing gradual Priabonian transgression on the Buda Mts.

Acknowledgements

Professor J. FÜLÖP initiated this work and provided financial support. P. VARGA put the samples of Alcsútdoboz – 3, Sóskút – 1 and Óbuda – 2 boreholes and his unpublished data at my disposal and gave me significant help in the field and in the *Nummulites* determinations. M. MONOSTORI presented me with his sample collection of the Mátyáshegy, western quarry Professor T BÁLDI, M. HORVÁTH, and P. MÜLLER helped with valuable advices. CS. PÉRÓ, P . VINCZE, L. CSONTOS and L. FÉLEGYHÁZY assisted me in the field. L. CSONTOS translated some French papers.

Their help is greatly acknowledged herein.

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STUDIES ON THE LOWER CRETACEOUS CEPHALOPOD-BEARING BEDS OF THE "MARBLE-QUARRY" AT ZIRC (TRANSDANUBIAN CENTRAL RANGE)

by

E. MISZLIVECZ

(Received: 1st April 1984)

Data on marine Barremian rocks in the Transdanubian Central Range have been known only in the last decades. According to previous studies the Barremian was regarded as an interval of emersion and bauxite deposition in Hungary (see VADÁSZ 1960). This concept proved false with finding Barremian marine macrofauna first in the area of Zirc (WEIN, 1934; NOSZKY, 1934).

Geological setting

The so-called "Old Marble-quarry" is situated northwest of Zirc, in the abbey-forest on the Pintér-hegy (Fig. 1). The quarry was named after

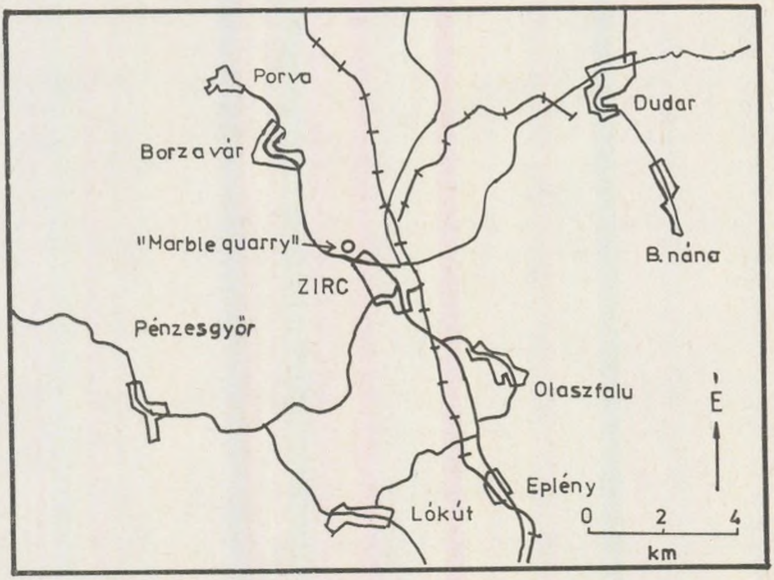

Fig. 1. Location chart of „Marble quarry"

the here quarried thick-bedded pink Tithonian limestone, the "Zirc marble" A detailed description and study on the outcrop is given by Fülöp (1964).

The quarry exposes mostly the pink, yellowish-white or light-grey, banked or thick-bedded Tithonian limestone of variable grain-size and nodularly weathering bedding planes. The limestone contains yellowish-brown chert nodules and rare Calpionellids in the microfauna.

The Tithonian limestone is paracomformably overlain by the Barremian cephalopod-bearing limestone of c. 50 cm. thickness. This is a brownish, pinkish limestone containing fine sand grains and very rich macrofauna, mainly ammonites. Other elements are sponges, corals, bivalves and gastropods, brachiopods, crinoids and echinoids. This cephalopod-bearing limestone is a member of the Borzavár Limestone Formation (Valanginian, Hauterivian, Barremian; Császár 1980). The overlying formation is the similarly paracomformable Aptian grey crinoidal limestone, i.e. the typical Tata Limestone Formation.

Thin-section studies

The microfauna of the Tithonian and Barremian limestones are markedly different. The thin-sections of the underlying limestone indicate the Middle and the uppermost Tithonian. This is a biomicrite indicating a rather quite deposition. Benthonic foraminifers occur in strikingly great abundance, with calcareous Nodosariidae and agglutinated Textulariidae. The characteristic Tithonian facies with rich calpionellids does not occur The pelletal texture with the associated poor planktonic association suggests shallow-water sedimentation.

The thin-section of the Barremian limestone show biomicritic matrix with echinoderm skeletal fragments, foraminifers and radiolarians. Benthonic *(Lenticulina, Epistomina)*, as well as planktonic foraminifers *(Hedbergella)* occur, with the dominance of the latters. This suggests, that the shallow-water facies was in connection with open-sea areas. This is supported by the result of nannoplankton studies of M. Beke (1981. pers. comm). Further studies may result in the indentifying the plaktonic zones.This would make possible a correlation between zonal index planktonic forms and the zonal index ammonites, thus resulting a complex stratigraphic reference.

Ecological evaluation of the fauna

An evaluation of the non-ammonite fauna was carried out by quantitative methods.

Taxonomic studies

The systematic treatment of the ammonites follows that in the Treatise (Arkell, 1957), with the exception of genus *Crioceratites*, which is discussed after the scheme of Immel (1978).

714 of the studied 1003 cephalopod specimens belong into the following genera.

	specimen number	percentage (%)
Lytoceras	89	12
Protetragonites	119	17
Crioceratites	138	19
Protacrioceras	1	0.14
Anahamulina	3	0.42
Hamulina	39	5
Ptychoceras	26	4
Neolissoceras	10	1
Barremites	97	14
Valdedorsella	51	7
Nicklesia	2	0.28
Belemnites	96	13
Duvalia	3	0.42
Rugaptychus	40	6

The other, nearly 200 specimens are mainly fragments which were regarded as indeterminable.

Within the genus *Lytoceras* 37 specimens belong into the species *L. subfimbriatum* (Plate I).

Detailed studies were carried out on genus *Crioceratites*, which resulted in some specific determinations.

In the former literature usually younger specimens are figured. These, according to Immel, can be easily mixed, being of low variability. On the other hand the adult whorls show different sculpture, and this makes problems, too. Groups of species can be outlined with close connections, in many cases with similar specific characters. Usually the very characteristic features (i.e. the presence or lack of tubercules, number of ribs) are missing by wearing or bad preservation. *Crioceratites duvali*, *C emerici* and *C nolani* (Pls. II, III) are typical species in this respect, being easily mixed on the basis of fragmentary specimens. The three species are distinguished by the number of intervening ribs. This is lowest (1 – 7) in *C. emerici*, intermediate (2 – 17) in *C. nolani* and highest (5 – 20) in *C. duvali*. *C. nolani* and *C emerici* share the feature of having tubercule rows externally, laterally and umbilically. *C. duvali* has a single, external tubercule row. The tubercules are situated on the main ribs, suffering primarily by wearing, so the presence of tubercules is hard to identify

The degree of crioceratid uncoiling can be determined only in the most complete specimens, which makes possible calculating the ratio of the "dorsal" and "ventral umbilical diameter". In the formula

$$\frac{\text{dorsal umbilical diameter}}{\text{ventral umbilical diameter}}$$

the dorsal umbilical diameter means the umbilical width between the dorsal sides, while the ventral umbilical diameter refers to the diameter between the ventral sides (Fig. 2). When the whorls touch each other, the ratio is 1; values lower than 1 reflect involute coiling,and values higher than 1 (and this is the case in *Crioceratites*) suggest uncoiling with whorls not attached to each other. On the basis of measurements made on the *Crioceratites* species, the uncoiling ratio is 1.12. This is close to 1, i.e. the evolute whorl touching. Conclusively, the *Crioceratites* specimens are slightly uncoiled.

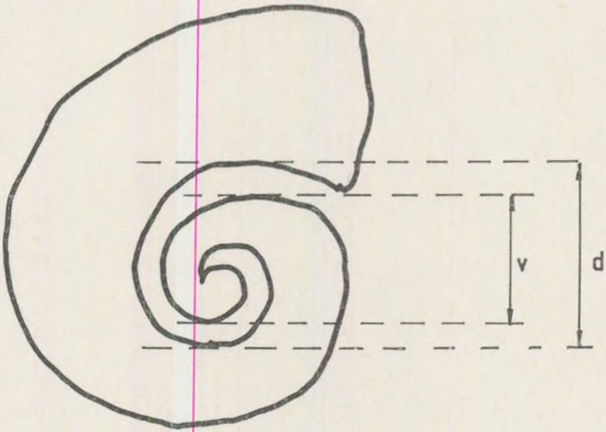

Fig. 2. Dorsal (d) and ventral (v) umbilical diameters

Stratigraphic evaluation of the fauna

On the basis of the faunal list of FÜLÖP (1964) and the recently studied elements of the fauna, it is suggested that the range of the cephalopod species found in the Marble quarry of Zirc is of Lower Barremian. The listed *Crioceras emerici* characterises the Nicklesia pulchella Zone, i.e. the basal Barremian in the stratotype (ROGER 1980, p. 110). Two specimens congeneric with the zonal index were also collected. The presence of *Hamulina* species suggests also the Lower Barremian.

On the other hand, some species, e.g. *Barremites hemiptychus*, occur in the Silesites seranonis Zone of the stratotype, which in turn belongs to the Upper Barremian. Being an old-collected fauna, further studies are needed to decide whether the associated occurrence of Lower and Upper Barremian species was a result of condensation or faunal mixing.

The detailed studies on the fauna made possible the comparison of some Hungarian Barremian occurrences. The work may serve as a basis of a future monographing of the fauna.

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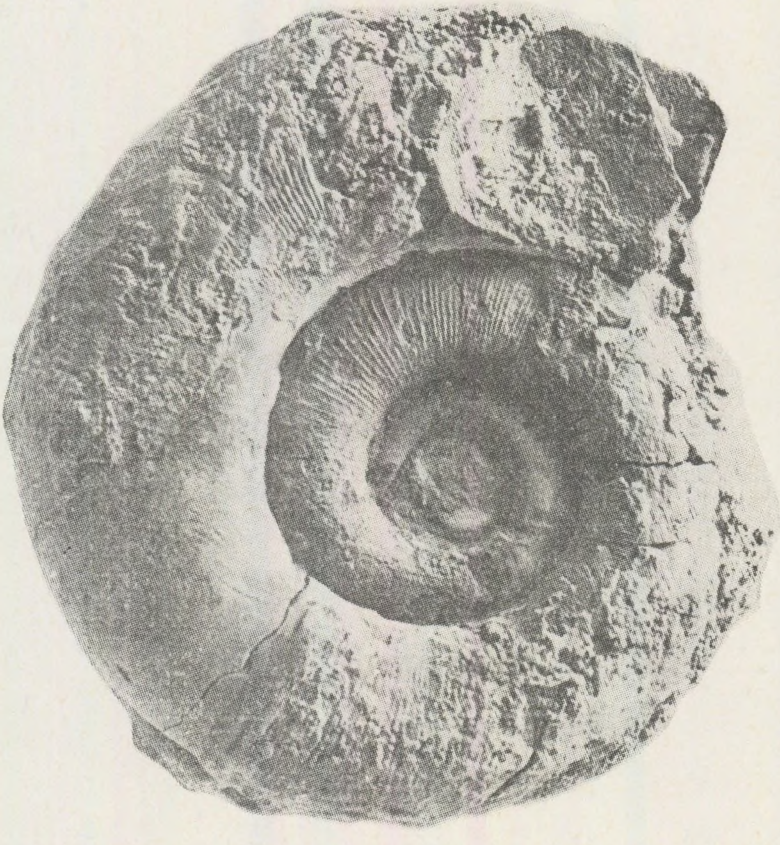

PLATE I

Fig. 1. Lytoceras subfimbriatum (d'ORBIGNY) 1x

PLATE II

Fig. 1. Crioceratites cf. *nolani* (Kilian) 1x

PLATE III

Fig. 1. Crioceratites cf. *emerici* (KILIAN) 1x
Fig. 2. Crioceratites cf. *duvali* (KILIAN) 0.6x

OSTRACODS OF EOCENE/OLIGOCENE BOUNDARY PROFILES IN HUNGARY

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(Accepted: 1st December, 1983)

Abstract

Descriptions of ostracod faunae of Hungarian Eocene/Oligocene boundary profiles are given in this paper. Besides several forms indeterminable to the species level 5 new species or subspecies are described: *Cardobairdia? spinifera* n. sp., *Cytheromorpha subalpina dorsodepressa* n. ssp., *Schuleridea rauraciformis* n. sp., *Loxoconcha carinata tardense* n. ssp., *Argilloecia quasiramphasta* n. sp.

Sixty-two known species are described as well: *Cytherella dentifera* Méhes, *Cytherella compressa* (von Münster), *Cytherella* aff. *méhesi* Brestenská, *Cytherella pestiensis* (Méhes), *Cytherella (Cytherelloidea)* cf. *hieroglyphica* (Bosquet), *Cardobairdia hungarica* Monostori, *Bairdia cf. brevis* Lienenklaus, *Bairdia rupelica* Monostori, *Bythocypris* cf. *arcuata* (Münster), *Paijenborchella (Eopaijenborchella) sturovensis* Brestenská, *Eucytheridea reticulata* Goerlich, *Cytheridea mülleri* (von Münster), *Cytheridea mülleri truncatula* Goerlich, *Cytheridea pernota* Oertli, *Cyamocytheridea punctatella* (Bosquet), *Hemicyprideis helvetica* (Lienenklaus), *Miocyprideis rara* (Goerlich), *Schuleridea dorsoarcuata* (Méhes), *Cuneocythere marginata anterodepressa* Monostori, *Cuneocythere marginata marginata* (Bosquet), *Cuneocythere truncata* Lienenklaus, *?Pontocythere denticulata* (Lienenklaus), *Pontocythere truncata* (Lienenklaus), *Krithe pernoides* (Bornemann), *?Turmaekrithe fragilis* Pietrzeniuk, *Agrenocythere bensoni* Pokorný, *Costa* cf. *hermi* Witt, *Hazelina indigena* Moos, *Trachyleberidea* cf. *posteroarcuata* (Lienenklaus), *Pterygocythereis retinodosa* Oertli, *Henryhowella asperrima* (Reuss), *Leguminocythereis* ex gr. *sorneana* Oertli, *Murrayina? gibberula* (Reuss), *?Megahemicythere oertlii* Witt, *Pokornyella* ex gr. *limbata* (Bosquet), *Pokornyella* ex gr. *moyesi* Ducasse, *Hermanites* cf. *laticarinatus* (Lienenklaus), *Quadracythere* cf. *macropora* (Bosquet), *Quadracythere* cf. *vahrenkampi* Moos, *Bosquetina zalanyii* Brestenská, *Bosquetna* cf. *reticulata* Scheremeta, *Occultocythereis rupelica* Monostori, *Occultocythereis* ex gr. *mutabilis* Triebel, *Cytheretta posticalis* Triebel, *Cytheretta* cf. *tenuistriata* (Reuss), *Loxoconcha delemontensis hungarica* Monostori, *Loxoconcha favata* Kuiper, *Loxoconcha* ex gr. *subovata* (von Münster), *Eucytherura dentata* Lienenklaus, *Semicytherura* ex gr. *gracilis* Lienenklaus, *Cytheropteron brevalata* Lienenklaus, *Cytheropteron emmeneggeri* Scherer, *Uroleberis odessensis* Scheremeta, *Uroleberis striatopunctata* (Ducasse), *Monoceratina* ? cf. *striata* Deltel, *Macrocypris* cf. *cylindracea* (Bornemann), *Abissocypris palaviensis* Pokorný, *Paracypris* aff. *aerodynamica* Oertli, *Paracypris* cf. *propinqua* Triebel, *Paracypris ? rupelica* Monostori, *Phlyctenophora oligocaenica* (Zalányi), *Candona ? recta* Lienenklaus.

Introduction

A Hungarian Working Group of IGCP Project 174 investigates the position of the Eocene/Oligocene boundary in Hungary, investigates geological events around the Eocene/Oligocene boundary and the problem of the Kiscellian Stage. The statistical investigation of ostracod faunas collected bed by bed is closely linked to this project. The results of this work are summarized in this paper

Recently an article has been published on the Lower Oligocene (Kiscellian) ostracods of Hungary (MONOSTORI, 1982) All taxa discussed in that paper has got a short review of special characters of the new populations only, besides the statistical evaluation. A detailed description is given on all species not discussed in MONOSTORI (1982).

As stated above, ostracod faunas of Priabonian and Kiscellian formations has been treated. A very rich Upper Oligocene (Egerian) has been also recovered from the Alcsútdoboz – 3 borehole, giving a unique possibility to study the effect of all Oligocene events on the formation of ostracod faunas in one section. A detailed investigation of this key section has been made, too. Priabonian, Kiscellian and Egerian species are treated together in the systematic chapter as several of them are transient ones. Examination methods has been described in a recent volume of the author (MONOSTORI, 1984).

Geological part

Priabonian

The only formation of Hungary with an ostracod fauna is the Buda Marl Formation as yet. It extends from the surroundings of Budapest to Eger (Northern Hungary) at the top of the Priabonian, a smaller part being already Kiscellian. The ostracod fauna was extracted from the loose marl and clayey marl beds. For a detailed lithological and faunistical description see BÁLDI et al. (1983).

Kiscellian

The extent of the Tard Clay Formation is similar to that of the Buda Marl Formation. Both the Tard Formation and the Kiscell Clay Formation contain ostracod faunas. The faunas of the Tard Formation are characteristic for the upper part of the formation. The Hárshegy Sandstone Formation investigated in the profiles of the project did not yield ostracods. The fauna of this formation from other localities is described in MONOSTORI (1982).

Detailed lithological and faunistical descriptions of the Kiscellian formations are given in BÁLDI (1976), BÁLDI et al. (1976), BÁLDI (1980), KORPÁS (1981), BÁLDI et al. (1983).

Egerian

The rich ostracod fauna of several Egerian formations has not been investigated since Méhes (1941).

Detailed lithological and faunistical descriptions of the Egerian formations are given in Báldi and Seneš (1975), Báldi (1976, 1980), Kopás (1981).

The Mány Sand Formation and the Kiscell Clay Formation yielded ostracod faunas during the present investigations.

Profiles

Three key profiles yielded the greatest part of the examined ostracod material.

Alcsútdoboz – 3 borehole

Below Neogene (Carpathian) strata Upper Oligocene (Egerian) beds (Mány Sand Formation and Kiscell Clay Formation with ostracods), then the Kiscellian part of the Kiscell Clay Formation, the Hárshegy Sandstone Formation without ostracods, the Tard Clay Formation and the Buda Marl Formation containing the Eocene/Oligocene boundary have been found. A rich ostracod fauna is contained in the loose marl and clayey marl beds of the Buda Marl Formation between 737.0 – 752.5 m.

A poor ostracod fauna has been found in the clayey marl beds of the Kiscell Clay Formation between 442.0 – 504.0 m.

A rich, characteristic Egerian ostracod fauna has been found in the Alcsútdoboz – 3 borehole between 120.0 – 413.0 m. (Mány Sand Formation).

Cserépváralja – 1 borehole

The Kiscell Clay formation, the Tard Clay Formation and the Buda Marl formation have been found.

A rich ostracod fauna hes been recovered from the Buda Marl Formation between 407.4 – 435.8 m.

A poor fauna has been found in the lowermost part of the Tard Clay Formation between 382.5 – 402.2 m. In the middle part there was fauna in one bed only between 336.8 – 337.0 m.

The Kiscell Clay Formation contains some beds with faunae between 211.0 – 286.0 m.

Kiscell – 1 borehole

The Tard Clay Formation and the Buda Marl Formation have been found in the borehole.

A rich ostracod fauna has been recovered from the 89.5 – 108.3 m interval.

The lowermost part of the Tard Clay Formation (89.5 and 83.4 m samples) contains fauna. In the middle part (51.6 and 62.5 m samples) ostracod-rich beds were found.

Small profiles:

Budapest, Pusztaszeri út, outcrop

The outcropt shows the Priabonian strata of the Buda Marl Formation. Nearly all beds contain rich fauna.

Budapest, Ibolya utca, quarry

Rich ostracod fauna in beds of uncertain litho-and chronostratigraphic position.

Budapest, SSOT – 1, – 2, – 4, – 6 boreholes

Engineering geological boreholes with ostracod faunas from the Buda Marl Formation.

Budapest, Zugliget, outcrop

Several horizons of the Tard Clay Formation contain ostracods.

Eger, Kiseged, outcrop

Rich ostracod fauna on the Tard Clay Formation. The outcrop shows a profile from the Priabonian nummulitic limestone to the Kiscell Clay.

Noszvaj, Síkfőkút, quarry

Uppermost Priabonian + Lowermost Kiscellian profile. It yielded some poor faunal samples below and above the Eocene/Oligocene boundary. Biostratigraphical and ecological interpretation of the investigated ostracod faunas will be published elsewhere.

Systematic descriptions

Subclass Ostracoda LATREILLE, 1806
  Order Myodocopida SARS, 1866
    Suborder Myodocopa SARS, 1866
      Family Cypridinidae BAIRD, 1850
        Subfamily Cypridininae BAIRD, 1850
          Genus *Cypridina* MILNE – EDWARDS. 1840

Cypridina? sp.

Remarks

1.3 mm long valve resembling this genus, of very poor preservation.

Occurrence

Budapest, SZOT – 6 borehole 11.0 m

Order Podocopida G. W. MÜLLER, 1984
  Suborder Platycopa SARS, 1866
    Family Cytherellidae SARS, 1866
      Genus *Cytherella* JONES, 1849
        Subgenus *Cytherella* JONES, 1849

Remarks

Forms included in this genus show considerable morphological variations, so the correct and reliable determination of species needs statistical biometric investigations. The results will show what characters could be considered as belonging to one or the other species and within what limitations. This investigation, due to its considerable extent, will be the subject of a separate study, using all *Cytherella* material in Hungary.

Cytherella dentifera MÉHES, 1941
Pl. 1, fig. 1 – 2.

1982. *Cytherella dentifera* MÉHES. – MONOSTORI, pp. 47–48.
pl. III. fig. 1–4. (cum syn.)

Remarks

Description see in the Kiscellian fauna of Budapest (MONOSTORI, 1982).

Occurrence

Alcsútdoboz – 3 borehole: 487.1 m
Cserépváralja – 1 borehole: 416.9 – 417.1 m
Kiscell – 1 borehole· 89.5 m
SZOT – 1 borehole (Budapest): 16.0 m

Material

3 right valves, 4 left valves

Dimensions

right valve: Length = 0.76 – 0.87 mm
Height = 0.48 – 0.52 mm
Length/Height ratio = 1.56 – 1.68
left valve: L = 0.70 – 0.94 mm H = 0.38 – 0.44 mm
L/H = 1.84 – 2.16

Stratigraphical and geographical distribution according to previous descriptions:

Hungary and Czechoslovakia: Kiscellian, Egerian

Cytherella (Cytherella) compressa (VON MÜNSTER, 1830)

1982. *Cytherella compressa* (VON MÜNSTER) – Monostori,
pp. 45–47. pl. II, fig. 6–9 (cum syn.)

Remarks

Description see at the Kiscellian fauna of Budapest (MONOSTORI. 1982) Variability of forms is especially great in this material.

Occurrence

Alcsútdoboz – 3 borehole: 487.1 m
Cserépváralja 1 borehole: 402.0 – 402.2 m; 407.4 – 407.6 m; 412.4 – – 412.6 m; 416.9 – 417.1 m, 419.0 419.2 m; 422.3 – 422.5 m; 435.6 – 435.8 m
Kiscell – 1 borehole 91.5 m
Budapest, Pusztaszeri út outcrop. samples no. 2 and 20
Noszvaj, Síkfőkút quarry: samples no. 11. 18. 21

Material

8 right valves, 14 left valves, 12 carapaces, 5 fragments

Dimensions

right valve. L = 0.83 – 0.86 mm H = 0.51 – 0.53 mm
L/H = 1.62 – 1.64
carapace: L = 0.84 – 0.87 mm H = 0.52 – 0.53 mm
L/H = 1.61 – 1.64 W = 0.35 – 0.40 mm

Stratigraphic and geographical distribution according to previous descriptions:

The Netherlands· Bartonian – Rupelian ?, Belgium· Upper Ypresian – Rupelian, Great Britain: Bartonian, Austria: Middle Eocene; Soviet Union: Eocene; Hugary and Czechoslovakia: Kiscellian – Egerian.

Cytherella (Cytherella) aff. *méhesi* Brestenská, 1975
Pl. 1. fig. 3 – 4.

1982. *Cytherella* aff. *méhesi* Brestenská – Monostori, pp. 50 – 51. pl. IV. f. 4 – 7 (cum syn.)

Remarks

Variability of forms is greater than that of the Kiscellian fauna in Budapest (Monostori, 1982). Distinctness of posterior ornamentation is extremely variable. Many juvenile specimens.

Occurrence

Alcsútdoboz – 3 borehole: 455.5 m, 487.1 m; 742.5 m
Cserépváralja – 1 borehole: 407.4 – 407.6 m; 412.4 – 412.6 m, 416.9 – – 417.1 m, 419.0 – 419.2 m; 422.3 – 422.5 m, 435.6 – 435.8 m

Kiscell – 1 borehole: 83.4 m; 107.3 m
Budapest, Pusztaszeri út outcrop: samples no. 2 and 5
Budapest, Ibolya utca, quarry: 7.0 m
Budapest, SZOT – 1 berehole: 5.5 m
Budapest, SZOT – 2 borehole: 46.0 m; 58.0 m
Noszvaj, Síkfőkút quarry: samples no. 18 and 21

Material

40 right valves, 33 left valves, 51 carapaces, 6 fragments
Dimensions: right valves: L = 0.61 0.71 mm H = 0.39 – 0.46 mm
L/H = 1.44 – 1.65
left valve. L = 0.60 – 0.76 mm H = 0.37 – 0.41 mm
L/H = 1.56 – 1.81
carapace: L = 0.61 – 0.73 mm H = 0.41 – 0.45 mm
L/H = 1.48 – 1.63 W = 0.27 – 0.30 mm

Cytherella (Cytherella) pestiensis (Méhes, 1941)
Pl. 1. fig. 5 – 7

1982. *Cytherella pestinensis* (Méhes) Monostori, pp. 48 – 49 Pl. III, fig. 5 – 8 (cum syn.)

Remarks

One of the most frequent *Cytherella* species in the Kiscellian. Detailed description of the morphological characters can be found in the paper on the Kiscellian ostracods of Budapest (Monostori, 1982). The outline shows considerable variability. Posterior lobe of the left valve and the corresponding posterior cut of the right valve are variably developed.

Occurrence

Alcsútdoboz – 3 borehole: 455.5 m; 487.1 m; 504.0 m
Cserépváralja – 1 borehole: 382.5 – 382.7 m(?); 407.4 – 407.6 m; 412.4 – 412.6 m, 416.9 – 417.0 m; 422.3 – 422.5 m

Kiscell – 1 borehole: 100.2 m
Budapest, Pusztaszeri út, outcrop: samples no. 5. 13. 21. 24. 26. 27
Budapest, Ibolya utca, quarry: 6.0 m
Budapest, SZOT – 2 borehole: 46.0 m
Budapest, SZOT – 6 borehole: 10.8 m; 11.0 m
Noszvaj, Síkfőkút, quarry: sample no. 18

Material· 41 right valves, 40 left valves, 28 carapaces, 4 fragments
Dimensions

right valve: L = 0.74 – 0.78 mm H = 0.45 – 0.51 mm
L/H = 1.53 – 1.66
left valves· L = 0.72 – 0.79 mm H = 0.38 – 0.42 mm
L/H = 1.79 – 1.94
carapaces: L = 0.79 – 0.83 mm H = 0.47 – 0.51 mm
L/H = 1.63 – 1.65 W = 0.34 – 0.35 mm

Stratigraphical and geographical distribution according to previous descriptions:

Hungary and Czechoslovakia: Kiscellian – Egerian

Cytherella (Cytherella) sp.

Remarks
Badly preserved specimens indeterminable to the species level.

Occurrence
Alcsútdoboz – 3 borehole. 336.0 m; 442.0 m
Cserépváralja – 1 borehole: 265.4 – 265.6 m, 285.8 – 286.0 m, 392.5 – 392.7 m, 397.1 – 397.3 m

Kiscell- borehole: 83.4 m, 100.2 m; 103.5 m
Budapest, Pusztaszeri út, outcrop: sample no. 3
Budapest, Ibolya utca. quarry: 2.5 m, 4.4 m; 7.9 m
Budapest, SZOT 1 borehole: 16.0 m
Budapest, SZOT – 2 borehole: 21.0 m, 58.0 m
Budapest, SZOT – 4 borehole: 54.0 m; 81.4 m
Noszvaj, Síkfőkút quarry: sample no. 15

Material

8 right valves, 10 left valves, 15 carapaces, 10 fragments

Subgenus *Cytherelloidea* JONES, 1849

Cytherella (Cytherelloidea) cf. *hieroglyphica* (BOSQUET, 1852)

Pl. 1. fig. 8.

Remarks
Poorly preserved specimens ranged with the *C. (C.) hieroglyphica* (BOSQUET. 1852) group after recognizable details of outline and ornamentation.

Occurrence

Budapest, Pusztaszeri út, outcrop: sample no. 27
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, Zugliget outcrop: sample no. 3

Material

1 right valve, 2 left valves, 1 carapax

Subordo Metacopa SYLVESTER-BRADLEY, 1976
Familia Saipanettidae MCKENZIE, 1968
Genus *Cardobairdia* VAN DEN BOLD, 1960

Cardobairdia hungarica MONOSTORI, 1982
Pl. 2, fig. 1.

1982. *Cardobairdia hungarica* n. sp. MONOSTORI, pp. 51 52, Pl. IV f. 8 – 9.

Remarks

External morphology of the specimens is well identifiable with that of the material from the type locality at Budapest (MONOSTORI, 1982). Internal characters could not be examined due to double valve preservation or infill of valves. Slight variability of elongation. Frequent posterior deformation of valves.

Occurrence

Alcsútdoboz 3 borehole 742.5 m
Cserépváralja – 1 borehole: 407.4 – 407.6 m, 412.4 – 412.6 m; 416.9 – 417.1 m; 435.6 – 435.8 m
Budapest, Pusztaszeri út, outcrop: samples no. 21. 22. 24. 26. 27.
Budapest, Ibolya utca, quarry: 7.0 m

Material

3 left valves. 51 carapaces

Dimensions: carapaces: L = 0.41 – 0.50 mm H = 0.22 – 0.27 mm
L/H = 0.71 – 2.05 mm

Stratigraphic and geographic distribution according to previous descriptions:

Hungary: Kiscellian

Cardobairdia? spinifera n. sp.
Pl. 2, fig 2 – 3.

Derivatio nominis: referring to the conspicious, spiniform process of the right valve.
Holotypus: a carapace.
Locus typicus: Cserépváralja – 1 borehole
Stratum typicum: Uppermost Eocene, 435.6 – 435.8 m interval
Diagnosis: the tapering caudal process of the right valve overlaps the left valve. Height in the central region.

Description

1. Shape. Outer lateral view of the left valve. The anterior outline is slightly asymmetrically rounded. The anterior outline turns into the dorsal one by gradual decrease of the curvature. The latter is nearly straight from 0.5 length. The dorsal outline turns into the posterior one by a 120° break at 0.9 length. The posterioir outline of relatively small radius turns into the nearly symmetrically convex ventral outline at lower 0.4 maximal height. The anterior outline rounds into the ventral one by an arc of slightly smaller radius than that of the anterior dorsal transition. This is the origin of the asymmetry mentioned above. Height is positioned at 0.5 length.

Outline of the right valve is significantly different due to the conspicuous overlap of the left one. The ventral outline is hardly convex. The upper part of the anterior outline and the dorsal outline forms a less curved arc. The posterior outline joins the dorsal one with a 150° break. The posterior outline displays a sharp break of less than 90° angle around 0.5 maximal length and forms a tapering caudal appendage.

Dorsal view. The left valve reach over the right one in anterior direction and the right valve reach over the left one in posterior direction. The lateral outline is symmetrically convex. Rise of the anterior part and slope of the posterior one is nearly equivalent. Width lies at 0.5 length.

2. Ornamentation. The surface of the valves is smooth without any ornamentation.

3. Dimensions. L = 0.45 mm W = 0.26 mm
H = 0.28 mm L/H = 1.58

4 – 8. The inner characters are not visible.

9. The left valve strongly overlaps the right one, except the caudal appendage.

10 – 11. Sexual dimorphism and individual variability cannot be examined on the single specimen.

Comparison

A similar caudal process can be found at *Krausella asymmetrica* described by VAN DEN BOLD (1946) from the Oligo – Miocene of the Caribbeans but its height occupies a more anterior position. RUSSO (1968) ranged this species into the genus *Cardobairdia.*

Occurrence

Cserépváralja – 1 borehole: 435.6 – 435.8 m

Material: 1 carapace

Familia Bairdiidae SARS, 1888
Genus *Bairdia* MCCOY, 1844

Bairdia cf. *brevis* LIENENKLAUS. 1900
Pl. 2, fig. 4.

Remarks

Mostly poorly preserved specimens. The outer characters can be examined only, which agree well with the type of LIENENKLAUS. The outline

displays individual variations which is characteristic for the genus and shows strong ontogenetic variability.
Occurrences

Cserépváralja – 1 borehole: 412.4 – 412.6 m, 422.3 – 422.5 m
Kiscell – 1 borehole: 100.2 m
Budapest, SZOT – 4 borehole: 54.0 m

Material. 9 right valves, 7 left valves, 5 carapaces
Dimensions· left valves· L = 0.71 – 0.83 mm H = 0.47 – 0.58 mm
L/H = 1.43 – 1.50

Bairdia rupelica Monostori, 1982
Pl. 2, fig. 6.

1982. *Bairdia rupelica* n. sp. – Monostori, pp. 52 – 53, pl. V, fig. 1 – 2.

Remarks

Shape of the specimens shows a close resemblance to that of the Kiscellian type material from Budapest (Monostori, 1982). Many damaged and juvenile specimens. Ventral outline of the left valve can be slightly convex compared to the type.

Occurrence

Cserépváralja – 1 borehole: 407.4 – 407.6 m; 412.4 – 412.6 m; 422.3 – 422.5 m

Budapest, Pusztaszeri út, outcrop: samples no. 3. 21. 22. 27
Budapest, Ibolya utca, quarry: 7.9 m
Budapest, SZOT – 1 borehole. 7.0 m
Budapest, SZOT – 6 borehole: 6.0 m; 10.8 m

Material: 8 right valves, 5 left valves, 23 carapaces

Dimensions: carapaces. L = 1.00 – 1.09 mm
H = 0.63 – 0.72 mm
L/H = 1.51 – 1.60

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian

Bairdia sp.

Remarks

Damaged, mostly juvenile carapaces and valves of poor preservation, indeterminable to the species level.

Occurrence

Cserépváralja – 1 borehole: 392.5 – 392.7 m; 416.9 – 417.1 m, 422.3 – 422.5 m, 435.6 – 435.8 m
Kiscell- borehole: 89.5 m; 91.5 m, 103.5 m
Budapest, Pusztaszeri út, outcrop: samples no. 2. 3. 5. 10. 13. 17. 20. 21. 22. 24. 26. 27

Budapest, Ibolya utca. quarry: 1.2 m, 4.4 m, 5.5 m, 6.0 m, 7.9 m
Budapest, SZOT – 1 borehole. 7.0 m, 16.0 m
Budapest, SZOT – 6 borehole: 6.0 m; 10.8 m
Noszvaj, Síkfőkút quarry: sample no. 22

Material· 17 right valves, 25 left valves, 113 carapaces, 13 fragments

Bairdia? sp.
Pl. 2, fig. 5.

Remarks

Elongated carapaces. Their outlines bear resemblance to the genus *Bairdia*, especially the overlapping character of the two valves.

Occurrence

Cserépváralja – 1 borehole· 407.4 – 407.6 m
Kiscell – 1 borehole: 83.4 m
Budapest. Pusztaszeri út. outcrop: sample no. 22
Budapest, SZOT – 1 borehole: 5.5 m; 7.0 m, 16.0 m
Budapest, SZOT – 2 borehole: 58.0 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole. 10.8 m

Material: 18 carapaces

Familia Bythocyprididae MADDOCKS, 1969
Genus *Bythocypris* BRADY, 1880

Bythocypris cf. *arcuata* (MÜNSTER, 1830)

Remarks

Poorly preserved specimens, attributable to this group according to the outlines.

Occurrence

Budapest, SZOT – 1 borehole: 7.0 m
Budapest, SZOT – 6 borehole· 11.0 m

Material: 2 carapaces (including 1 juvenile specimen)

Familia Cytheridae BAIRD, 1850
Subfamilia Cytherinae BAIRD, 1850
Genus *Cytheromorpha* HIRSCHMANN, 1909

Cytheromorpha subalpina dorsodepressa n. ssp.
Pl. 2, fig. 7 8.

Derivatio nominis: after the depression on the dorsal side of the valve.
Holotypus: a carapace
Locus typicus: Kiscell – 1 borehole
Stratum typicum: 62.5 m; Kiscellian
Diagnosis: from bearing a definite anterodorsal valve depression.

Description

1. Shape. Left valve, outer lateral view Anterior outline is asymmetrically rounded, its upper part is slightly obliquely cut. The anterior outline turns into the nearly straight, hardly perceptibly sinuous dorsal outline by a 130° break at 0.2 lenght. A definite, small outline depression can be observed on the dorsal side at 0.8 length. Behind there is a bulge of small radius. The dorsal and posterior outlines form a nearly right angle. The ventral outline bears a slight sinus between the break at the approx. half of the maximal height and 0.3 – 0.4 length. Max. convexity lies before 0.8 length, max. concavity lies at about 0.5 length. Ventral and dorsal outlines strongly converge in the posterior direction. Height lies at the cardinal angle.

The right valve is more narrowing towards posterior direction than the left one. Posteroventral convexity of the outline is much weaker (overlap). The posterior outline and the dorsal one make a larger than rectangular angle.

Dorsal view. 0.1 length: anterior section with parallel valve surfaces; until 0.7 length: 10 – 20° rising slope (bearing a small depression between 0.3 – 0.5 length); then 50 – 60° slope till the end of the carapace.

2. Ornamentation. The valve surface bears irregular, dense reticulation. There is a weaker reticulation on the anterior and posterior parts. The anterodorsal parts of the valves bear definite, triangular depressions, narrowing downwards. The depressions extend to half lenght of the dorsal outline and terminate below at the median height of the valves. There is a weak, slightly perceptible anteromarginal lath near the anterior margin.

3. Dimensions carapace: L = 0.38 – 0.41 mm, H = 0.21 – 0.22 mm, L/H = 1.94 – 1.98 W = 0.18 – 0.19 mm.

4 – 8. The inner characters cannot be examined.

9. No eye-spot.

10. Ventral overlap of the right valve by the left one can be well observed.

11. Male forms are more elongate.

12. Sinuosity of the ventral outline shows individual variability

Comparison

The generally definite anterodorsal depression, which is divergent from the type, causes a slight divergence in the dorsal view (width is definitely posterior). The Egerian *C. bimarginata* BRESTENSKÁ (BRESTENSKÁ, 1975) bears a similar depression, but the characters of the ornamentation and outline are significantly different.

Occurrence

Kiscell – 1 borehole: 55.5 m; 57.5 m; 58.5 m; 62.5 m;

Budapest, Zugliget, outcrop: samples no. 7 and 9.

Material: 1 left valve, 20 carapaces

Genus *Microcytherura* G. W. MÜLLER, 1894.

Microcytherura sp.

Remarks

A carapace can be attributed to this genus after its outline, but the

ornamentation cannot be studied well.
Occurrence: Budapest, SZOT – 1 dorehole: 7.0 m
Material: 1 carapace

Genus *Schizocythere* TRIEBEL, 1950

Schizocythere sp. juv

Remarks

Juvenile specimens of poor preservation, with characteristic ventral keel, dorsal depression and posterodorsal spine.

Occurrence

Alcsútdoboz – 1 borehole: 742.5 m
Cserépváralja – 1 borehole: 240.0 – 240.2 m, 265.4 – 265.6 m; 416.9 – – 417.1 m.
Kiscell – 1 borehole: 89.5 m
Material: 3 right valves, 3 left valves

Schizocythere ? sp.

Remarks

Poorly preserved specimens. Ranging them into a genus is uncertain due to the unknown hinges.

Occurrence

Budapest, Pusztaszeri út, outcrop: samples no. 2. 5. 17. 21. 24. 26. 27
Budapest, Ibolya utca, quarry: 1.2 m, 7.0 m, 7.9 m
Noszvaj, Síkfőkút. quarry. sample no. 18.
Material: 17 right valves, 11 left valves, 1 carapace, 2 fragments.

Genus *Paijenborchella* KINGMA, 1948
Subgenus *Eopaijenborchella* KEIJ, 1966

Paijenborchella (Eopaijenborchella) sturovensis BRESTENSKÁ, 1975
Pl. 2, fig. 9.

1975. *Paijenborchella (Eopaijenborchella) sturovensis* n. sp. – BRESTENSKÁ, pp. 401 – 403. pl. 9. figs. 1 – 9.

Description

1. Shape. Outer lateral view, left valve. The anterior outline is asymmetrically rounded and gradually rounds into the straight dorsal outline, which bears a break at 0.4 length. The dorsal outline turns into the posterior outline with a break behind 0.8 length. The two sections of the dorsal outline make a 130 – 140° angle, as well, as the dorsal and the posterior outlines. The posterior 0.1 length is made of the damaged caudal process. This has been strongly tapering and might be two times longer than in its present state. The lower part of the caudal process gradually turns into the asymmetrically convex ventral outline. Maximal convexity lies at 0.4 lenght. The ventral outline turns into the anterior one by a weak sinus, caused by a weak anteroventral widening of the outline. The transition

bears a definite break which causes the asymmetry. Height lies at the break of the dorsal outline (shifted to anterior direction from the median lenght).

2. Ornamentation. Between 0.1 and 0.8 length there is a sharp ventral keel, forming the ventral outline. Above it there is a nearly parallel keel from before 0.2 length to behind 0.6 length. Its anterior part is diverging from the ventral keel. Around the break in the dorsal outline there is a dorsoventral sulcus which shallows and disappears above the ventral keel. There is a sharp median keel along the longitudinal median line of the valve between 0.3 and 0.6 length. A slightly forwardly convex rib is positioned between the anterior termination of the median keel and the break in the dorsal outline. There are two converging ribs running from the posterior termination of the median keel and at the posterior margin of the sulcus nearly perpendicularly to the median keel. They disappear in the vicinity of the dorsal outline. The surface is slightly and irregularly reticulated except the flat anterodorsal and caudal parts.

3. Dimensions. Left valve:

L = 0.41 mm H = 0.26 mm
L/H = 1.59 (the caudal process is damaged)

4. The inner lamella is quite wide anteriorly.

5. and 7–8. The marginal pore canals, the normal pores and muscle scars cannot be studied well.

6. Hinge. The crenulate posteromedian bar and the lobate anteromedian tooth can be well observed in the left valve. The anterior and posterior sockets cannot be studied in detail.

9. No eye-spot.

Remarks

All characters of the specimen are in agreement with that of the more stubby specimens figured by Brestenská (1975). Full variation cannot be observed due to absence of further specimens.
Occurence: Alcsútdoboz + 3 borehole: 455.5 m
Material: 1 left valve
Stratigraphical and geographical distribution according to previous descriptions: Hungary and Czechoslovakia: Rupelian – Egerian.

Familia Leptocytheridae Hanai, 1957
Genus *Callistocythere* Ruggieri, 1953

Callistocythere sp.

Remarks

Elongated right valve of poor preservation. It has an ornamentation made of strong, irregular crinkles. A keel-like, nearly posteromarginal crinkle is especially characteristic.
Occurrence: Kiscell – 1 borehole: 57.5 m

Material: 1 right valve

Familia Cytherideidae SARS, 1925
Subfamilia Cytherideinae SARS, 1925
Genus *Eucytheridea* BRONSTEIN, 1930

Eucytheridea reticulata GOERLICH, 1953
Pl. 2. fig, 10.

1982. *Eucytheridea reticulata* GOERLICH – MONOSTORI, pp. 67 – 68
Pl. VII, fig. 5 – 7 (cum syn).

Remarks

The identifiable characters are in good agreement with those of the Kiscellian material described from Budapest (MONOSTORI, 1982). Strength of reticulation is somewhat variable on undamaged adult carapaces and valves from sample no. 3 of the Zugliget outcrop.

Occurrence

Csrépváralja – 1 borehole: 336.8 – 337.0 m; 435.6 – 435.8 m,
Kiscell – 1 borehole: 59.5 m; 62.5 m
Budapest, Ibolya utca, quarry: 4.4 m
Budapest, Zugligeti út, outcrop: sample no. 3.
Eger, Kiseged, road cut: samples no. 2a. 3a. 3b. 4. 13

Material: 83 right valves, 26 left valves, 147 carapaces
Dimensions: right valve:

L (adult) = 0.67 – 0.80 mm
H (adult) = 0.38 – 0.39 mm
L/H (adult) = 1.78 – 1.85
L (juvenile) = 0.53 – 0.58 mm
H (juvenile) = 0.33 – 0.34 mm
L/H (juvenile) = 1.61 – 1.69
carapaces· L = 0.68 – 0.74 mm H = 0.38 – 0.40 mm
L/H = 1.79 – 1.85 W = 0.31 – 0.34 mm

Stratigraphical and geographical distribution according to previous descriptions: BRD: Rupelian; Switzerland: Rupelian; Hungary: Kiscellian.

Subfamilia Cytherideinae SARS, 1925
Genus *Cytheridea* BOSQUET, 1852

Cytheridea mülleri (v. MÜNSTER, 1830) sensu FAUPEL, 1975
Pl. 3. fig. 1 – 3.

1975. *Cytheridea mülleri* (v. MÜNSTER) – FAUPEL, pp. 23 – 24. pl. 8. fig. 2.

Description

1. Shape. Outer lateral view, left valve. The anterior outline is asymmetrically rounded: the radius of the upper part is larger. The anterior outline turns into the dorsal one by a slight break at 0.4 length. The dorsal and ventral outlines are converging towards posterior direction. The dorsal

outline turns into a highly asymmetrical posterior outline by a strong break at 0.8 length. The upper part of the posterior outline is rounded by a long radius arc. It turns into the ventral outline by an extremely small radius arc at the level of the ventral outline. The posterior part of the ventral outline is slightly asymmetrically concave. Its straight anterior part gradually rounds into the anterior outline. Height lies at 0.4 length. There are 4 – 5 pointless denticles in outer lateral view.

Outer lateral view, right valve. Turning point of the anterior outline into the dorsal outline shifted to 0.5 length. Break between dorsal and posterior outline is stronger. Upper part of the posterior outline is nearly straightly cut. The lower part, turning into the ventral outline, is more pointed. The whole ventral outline is asymmetrically concave. The maximal sinuosity is placed between 0.6 and 0.8 length. There are 4 – 5 anterior and 2 posterior marginal denticles.

Dorsal view, left valve. The surface has a steep rise till 1/3 maximal width. Then the rise decreases from 30° to 0° till 0.4 length. Then the outline is nearly parallel with the plane separating the valves till 0.9 length, bearing a small depression at 0.8 length. The outline terminates with an increasingly steep (from 45° to 90°) slope in dorsal view.

2. Ornamentation. The surface of the valves is coarsely pitted, showing a more or less concentric pattern on the anterior and ventral parts. The pits are smaller, more scattered and more disordered at the muscle-scar area. The anterior pit rows are bordered by definite, concentric, continuous and slightly protuberant ribs. The posteroventral part of the valves is slightly bulbous. There is a small ventral depression before it. The bulbous part has a steep termination posteriorly, with especially sharp ribs separating the pits. The valves are slightly depressed above the muscle scar area.

3. Dimensions.
right valves: L = 0.67 – 0.70 mm H = 0.31 – 0.35 mm
L/H = 1.97 – 2.19
left valves: L = 0.66 – 0.80 mm H = 0.35 – 0.37 mm
L/H = 1.87 – 1.97

4. The inner lamella is wide anteroventrally, bearing a narrow vestibulum.

5. There are many simple straight marginal pore canals anteriorly

6. The anterior hinge element in the right valve is a tooth of long denticles. The median element is a crenulate furrow turning into a crenulate bar. Also the posterior hinge element is an elongated tooth made of denticles.

7. The normal pores cannot be studied.

8. The muscle scar area of the left valve contains 4 stubby adductor scars and a crescentic frontal scar opening anterodorsally before them.

9. No eye-spot.

10. The left valve mainly ventrally overlaps the right one.

11. The specimens can be grouped into more elongate and more stubby groups. The stubby forms show a less obtuse angle at the join of the anterior

and dorsal outlines on the right valve, and the anterior outline is straight before joining the dorsal one. These phenomena may be attributed to sexual dimorphism. the elongated specimens may be the male ones.

12. Strength of the ventral sinus shows individual variability. Some specimens do not bear spines, probably due to poor preservation.

Remarks

The material shows good agreement with the *C. mülleri*, described by FAUPEL (1975). The forms bearing this name are strongly different. GOERLICH (1952) figures a left valve only describing his neotype. Some figures in the literature show a distinct convex ventral outline. The posteroventral bulge not mentioned in any other paper can be observed only on the figure of FAUPEL. The break indicating the anterior–dorsal outline transition occupies a slightly forward position on the right valve of FAUPEL's specimen. In the case of the similar *C pernota* OERTLI ET KEY, 1955 the irregular pitting is a a strongly diversifying character. The form described here is very similar to the *C acuminata* BOSQUET, 1852 species in its ornamentation. The pitting is less ordered in our form and the ventral outline of the right valve is generally concave. The ventral outline of the left valve is never convex, but rather slightly concave due to a slight turn of the posterior end. The Lower Miocene specimens of *C acuminata* figured by GOERLICH (1953) and the Lower Miocene subspecies *C acuminata caumontensis* of CARBONNEL (1969) appears to be more near to our form in ornamentation and shape. The strong relationship of *C acuminata* and *C mülleri* cannot be doubted. Probably they form an evolutionary line, within which the species and subspecies can be separated by a detailed revision only. The *C lacunosa* of KOLLMANN (1960) ornamented by more coarse and bigger pits than any of the mentioned forms from the Lower Miocene of Austria may belong to this line.

Occurrence: Alcsútdoboz – 3 borehole· 223.0 m, 239.0 m

Material. 13 right valves, 9 left valves, 5 fragments

Stratigraphical and geographical distribution according to previous descriptions: BRD: Upper Oligocene

Cytheridea mülleri truncatula GOERLICH, 1953
Pl. 3. fig. 4.

1953. *Cytheridea (Cytheridea) mülleri truncatula* n. ssp. – GOERLICH, pp. 131–132, Taf. 1, Fig. 6.

1957 *Cytheridae (C) mülleri truncatula* GOERLICH GOERLICH, p. 78.

1975. *Cytheridae mülleri truncatula* GOERLICH – BRESTENSKÁ, pp. 396–397, Taf. 5, Fig. 7–11

Remarks

A definite posterior downward curve can be observed on both valves compared to the type species, causing strong asymmetry of the ventral outline. The upper (bigger) part of the posterior outline is straightly cut, moreover it is slightly concave in the middle on right valves. The very weak marginal denticles can be observed on the anterior part, but mostly in inner lateral view only The lateral surface on the anterior and posterior parts is more steep than on the type subspecies. It is nearly parallel with the plane separating the valves and is slightly concave before the postero-ventral bulge. The larger specimens of the present ones agree very well with the type of Goerlich (1953). The figured specimens of Brestenská are more stubby and our smaller individuals are similar to them.

Occurrence

Alcsútdoboz – 3 borehole. 120.1 m (cf.); 126.0 m; 246.0 m

Material 10 right valves, 5 left valves. 20 fragments

Dimensions· right valve: L = 0.71 mm; 0.63 mm
H = 0.35 mm; 0.35 mm
L/H = 2.00; 1.77
left valve: L = 0.70 mm, 0.67 mm
H = 0.33 mm, 0.35 mm
L/H = 2.11; 1.90

(The first number shows the larger, the second the smaller variety)

Stratigraphical and geographical distribution according to previous descriptions: Czechoslovakia and Hungary: Egerian

Cytheridea sp. ex gr. *mülleri* (V Münster, 1830)

Remarks

Fragments of adult specimens and indamaged juvenile ones, probably belonging to this group.

Occurrence: Alcsútdoboz 3 borehole· 170.0 m

Material: 55 juvenile valves, 15 adult fragments

Cytheridea pernota Oertli et Key, 1956

Pl. 3, fig. 5.

1955. *Cytheridea pernota* n. sp. – Oertli et Key, pp. 19 25, T 1, F 1–13, Abb. 2.
1956. *Cytheridea pernota* Oertli et Key – Oertli, p. 36, T. 2, F. 33 – 38
1957 *Cytheridea pernota* Oertli et Key. p. 56, Pl. III, Fig. 22 – 26
1959. *Cytheridea pernota* Oertli et Key – Moyes, pp. 10 – 11, Pl. 3, fig. 2.
1964. *Cytheridea pernota* Oertli et Key – Scheremeta, p. 115, t. III, F. 9 – 11
1969. *Cytheridea pernota* Oertli et Key – Scheremeta, pp. 70 – 71, t. IV, f. 9 – 13
1972. *Cytheridea pernota* Oertli et Key – Keen, pp. 289 – 290, t. 56, f. 2.
1975. *Cytheridea pernota* Oertli et Key – Brestenská, p. 397, T. 5, F. 12 – 14
1981. *Cytheridea (Cytheridea) pernota* Oertli et Key – Uffenorde, p. 138, T. 1, F. 9 – 10, 13.

Description

1. Shape. Outer lateral view, left valve. The anterior outline is nearly symmetrically rounded. It turns into the dorsal one by a break at 0.4

length. The dorsal outline is straight till 0.8 length, then gradually turns into the posterior outline. The posterior outline turns into the ventral one by a short radius arc, like a break at 1/4 of maximal height. The ventral outline is sinuous maximal concavity is at 0.7 lenght, maximal convexity is before 0.4 length. Five marginal denticles are well observable anteriorly.

Dorsal view, left valve. The anterior surface is very steep, nearly perpendicularly rises till 1/3 of maximal width. Then the surface rise decreases from 45° to 10° till 0.2 length, and from 10° to 0° till 0.4 length. Then a section follows wich is parallel with the plane separating the valves. Then the surface declines from 0° to 20° between 0.7 – 0.9 length and ends with a steeply (until 90°) declining slope. The slight crinkling of the anterior part can be viewed well from the dorsal side only.

2. Ornamentation. The surface of valves is irregularly pitted, the anterior and posterior ones being coarser. The dorsal surface near the hinges is unornamented.

3. Dimensions.
left valves: L = 0.80 – 0.73 mm H = 0.44 – 0.42 mm
L/H = 1.84 – 1 72

4. The inner lamella is wide anteroventrally, with a narrow vestibulum.

5. The anterior part bears many simple, straight marginal pore canals.

6. The anterior hinge element is an elongated socket, constituting small sockets in the left valve. The median element forms a short anterodorsal crenulate bar and a longer posterodorsal crenulate furrow. The posterior element is an elongate socket consisting several smaller sockets.

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

Remarks

The left valve is more elongate and slightly concave posteroventrally comparing to the type. Pitting of the smaller specimens is weak. The dorsal and ventral oulines are more converging posteriorly (or the height is quicker lowering posteriorly). The only well observable left valve is in good agreement with the figures of Brestenská (1975).

Occurrence· Alcsútdoboz – 3 borehole: 120.0 m, 246.0 m

Material: 2 left valves, 4 fragments

Stratigraphical and geographical distribution according to previous descriptions: Switzerland: Rupelian – Chattian; Belgium: Rupelian – Tongrian, France: Oligocene – Lowermost Miocene; Soviet Union: Oligocene; BRD: Upper Oligocene – Lower Miocene; England: Oligocene; Czechoslovakia: Egerian.

Cytheridea sp.

Remarks

Fragments indeterminable to the species level but attributable to this genus.

Occurrence

Alcsútdoboz – 3 borehole: 164.0 m; 246.0 m, 277. 0 m, 336.0 m; 373.0 m

Material: 13 fragments

Genus *Cyamocytheridea* OERTLI, 1956

Cyamocytheridea punctatella (BOSQUET, 1852)

Pl. 3, fig. 6.

1852. *Bairdia punctatella* n. sp. – BOSQUET, p. 26, Pl. 1, f. 10
1896. *Bairdia cuneata* n. sp. – LIENENKLAUS, p. 27, T 2, f. 7
1941. *Bythocypris punctatella* (BOSQUET) – MÉHES, p. 16, t. II, f. 5–7
1956. *Cyamocytheridea punctatella* (BOSQUET) OERTLI, pp. 50–53, T 5 f. 128–143
1957 *Halocytheridea punctatella* (BOSQUET) – KEIJ, p. 63, Pl. II, f. 11–12, Pl. III, f. 13–15
1958. *Cyamocytheridea punctatella* (BOSQUET) – KOLLMANN, p. 154, T. 2, f. 5, t. 1D, f. 5–6, 15+16
1966. *Cyamocytheridea punctatella* (BOSQUET) – MOUSSOU, pp. 33–34, Pl. 8, f. 30–31
1969. *Cyamocytheridea punctatella* (BOSQUET) DUCASSE, p. 48, Pl. III, f. 60–61
1969. *Cyamocytheridea punctatella* (BOUSQUET) – CARBONNEL, p. 74, Pl. 4, f. 21–22
1975. *Cyamocytheridea punctatella* (BOSQUET) – BRESTENSKÁ, p. 397, T. 4 f. 9, 12–15.
1975. *Cyamocytheridea punctatella* (BOSQUET) – DOEBL ET SONNE, p. 142, T. 2, f. 9.

Description

1. Shape. Outer lateral view, right valve. The anterior outline is nearly symmetrically rounded, having a relatively small radius. The anterior outline gradually turns into the dorsal outline having a large radius arc. The dorsal outline gradually turns into the posterior outline, which has a small radius, similarly to the anterior outline, but is slightly asymmetrically rounded. The ventral outline is slightly concave. The ventral outline has a more gradual transition towards the anterior outline than for the posteroir one, and this is the cause of the slight posterior asymmetry. Height in the middle.

Dorsal view, right valve. The rise of the valve surface decrease from 60° to 10° till 0.3 length, at first very quickly. The rise decrease to 0° till 0.8 length. Behind the surface displays a slope growing to 60°, at the end turns back.

2. Ornamentation. There are small pits scattered on the valve surface.

3. Dimensions: right valve: L = 0.58 mm; H = 0.30 mm
L/H = 1.96

4. The inner lamella is wide anteroventrally, quite narrow posteriorly. A difinite vestibulum is placed anteriorly The selvage is strong and withdraws from the outer margin anteriorly and posteriorly in the right valve.

5. Many marginal pore canals anteroventrally. Some of them are partly ramifying.

6. The anterior and posterior elements are teeth consisting of a row of denticles. The median element is a crenulate bar.

7 Number of normal pores is moderate.

8. In the muscle scar area, before the vertical row of the four adductor scars, in the height between the upper two ones there is a crescentic frontal scar opening anteriorly. Another larger scar can be observed below the level of the lowermost adductor scar, vertically in line with the frontal scar.

9. No eye-spot.

Remarks

The species displays a slight morphological variation which can be observed studying the literature. But it cannot be studied on our material due to the few specimens.

Occurrence: Alcsútdoboz – 3 borehole: 199.0 m; 277.0 m

Material: 2 right valves, 1 fragment

Stratigraphical and geographical distribution according to previous descriptions: France: Stampian – Aquitanian, Switzerland: Rupelian – Chattian; Belgium· Rupelian, Czechoslovakia and Hungary. Egerian, BRD: Rupelian.

Genus *Hemicyprideis* MALZ ET TRIEBEL, 1970
Hemicyprideis helvetica (LIENENKLAUS, 1895)

Pl. 3, fig. 7 – 8.

1982. *Hemicyprideis helvetica* (LIENENKLAUS) – MONOSTORI, pp. 34 – 35, Pl. I, fig. 3 – 5 (cum syn.)

Remarks

Adult forms scarcely bear swellings. On juvenile forms with swellings the position of swellings differ from that of on the specimens from Pilisszentkereszt. There is a narrow uninterrupted marginal swelling from 0.4 length dorsally till 0.6 length ventrally leaving the outline anteriorly, There is an unbroken swelling in the surroundings of the muscle scar area. Swellings of the posterior half and those of the Pilisszentkereszt material are alike. There are literature descriptions on both swelling varieties on this species, accordingly not much taxonomic value can be attributed to this feature. However, it must be mentioned that in a sample only the appearance or disappearance, or in the latter case the strength of the swellings displays considerable variety. Their position exhibits consistency, so all individuals bear the same ornamentation pattern.

Occurrence· Alcsútdoboz – 3 borehole· 199.0 m, 201.0 m, 277.0 m

Material· 4 right valves, 4 left valves, 4 fragments

Dimensions: right valve (adult) L = 0.70 mm H = 0.37 mm
L/H = 1.76
right valve (juvenile) L = 0.58 mm H = 0.33 mm
L/H = 1.76
left valve (adult) L = 0.70 mm H = 0.40 mm
L/H = 1.75
left valve (juvenile) L = 0.45 mm H = 0.34 mm
L/H = 1.59

Stratigraphical and geographical distribution according to previous descriptions: BRD: Chattian, France: Oligocene; Belgium: Tongrian - Rupelian; Netherlands: Upper Tongrian; Switzerland: Rupelian – Lower Chattian; Soviet Union: Oligocene; Czechoslovakia: Kiscellian – Egerian, Hungary: Kiscellian.

Genus *Miocyprideis* KOLLMANN, 1960

Miocyprideis rara (GOERLICH, 1953)

Pl. 3, fig. 9 – 10., Pl. 4, f. 1.

1953. *Cyprideis ? rara* n. sp. – GOERLICH, pp. 130 – 131, T. 1, F 1 – 3
1957. *Cyprideis rara* GOERLICH – GOERLICH, p. 78,
1975. *Miocyprideis rara* (GOERLICH) – BRESTENSKÁ, p. 398, T. 5, F. 1 – 6
1982. *Miocyprideis rara derupta* n. ssp. – MONOSTORI, pp. 36 – 37, Pl. IX, fig. 8 – 9

Remarks

The differentiating feature of *M. rara derupta* n. ssp. described from Pilisszentkereszt (MONOSTORI, 1982) was proven to be an ecological variety only after the examination of the Alcsútdoboz material. Its separation as a new subspecies cannot be justified. The description can be completed on the grounds of the Alcsútdoboz material of much better preservation.

Shape. Left valve. The dorsal outline is nearly straight till 0.9 length. There it breaks into the posterior outline, which is more asymmetrical than of the right valve, the upper two-thirds of which is nearly straight. The break in the ventral – anterior outline transition is more gentle than on the right valve.

Right valve. The dorsal outline breaks in 150 – 160° angle after 0.7 length. The dorsal outline turns into the slightly asymmetrical posterior outline at 0.9 length.

In a part of the Alcsútdoboz material there occur only the dorsal depressions over the muscle scar area and the ventral depressions slightly behind half length. The anterior rise is slightly arcuate in dorsal view. The 10° rise part is not uneven; it bears a slight depression only.

Ornamentaion. There is a bipartite tubercle on ornamented forms between 0.2 and 0.4 length at the outline. Sometimes the break in the marginal surfaces near the outline on the anterior and ventral parts appears as a long, continuous swelling due to the intermediate depressive surfaces. The pits are smaller anteriorly The anteroventral margin bears hardly perceptible denticulations.

The marginal zone is wide anteriorly There is no vestibulum. There are many marginal pore canals: these are simple and straight. In the hinge of the right valve there are a long anterior tooth made of denticles, a short, reticulate median furrow and an arcuate posterior tooth made of denticles.

On the muscle scar area there is a V-shaped frontal scar opening forward before the line of the four stubby adductor scars in the right valve.

Occurrence

Alcsútdoboz – 3 borehole: 199.0 m, 201.0 m; 223.0 m

Material· 27 right valves, 18 left valves

Dimensions: right valves L = 0.66 – 0.73 mm
H = 0.35 – 0.39 mm
L/H = 1.87 – 1.88
left valves L = 0.67 – 0.72 mm
H = 0.38 – 0.39 mm
L/H = 1.78 – 1.85 mm

Stratigraphical and geographical distribution according to previous descriptions· BRD· Chattian, Czechcslovakia· Egerian; Hungary: Kiscellian.

Schuleridea dorsoarcuata (MÉHES. 1941)
Pl. 4. fig. 2.

1941. *Cytheridea dorsoarcuata* n. sp. – MÉHES, pp. 70 – 71, II. t., 5 – 6. á., 56. 137 text figures

1975. *Schuleridea (Aequacytheridea) dorsoarcuata* (MÉHES) – BRESTENSKÁ, pp. 398 – 399, T 6, F 13 14

Description.

1. Shape. Left valve, outer lateral view. The anterior outline is asymmetrically rounded, its upper half is obliquely cut. The anterior outline turns into the straight dorsal outline with a 130° break at 0.4 length. The dorsal outline turns into the posterior outline with a slight break at 0.9 lenght. The lower and upper parts of the posterior outline are both convex having a small break between them at one-third maximal height. The posterior outline gradually turns into the slightly convex ventral outline. Height is situated slightly anteriorly

Left valve, dorsal view The surface rises in a 20° angle till 0.2 length, then in a 30° angle till behind 0.5 length. It has a growing slope of 20° to 60° till the end of the valve.

2. Ornamentation. The valve bears a dense and coarse pitting, showing a concentric pattern. There is a double row of spines anteroventrally. The posteroventral corner is covered by a small group of spines.

3. Dimensions. Left valve: L = 0.90 mm H = 0.51 mm
L/H = 1.77

4. The inner lamella is very wide anteriorly. There is no vestibulum. The selvage occupies a marginal position.

5. The marginal pore canals are simple, straight, their number is very large anteriorly

6. In the hinge of the left valve there is a pipe-like frontal scar before the vertical row of the four elongated adductor scars.

9. There is a flat swelling on the outer valve surface in the eye area.

Remarks

Shape and ornamentation is nearly equal to those of *Sch. oculata* MOOS, 1970. Marginal spines are similar to that of *Sch. perforata cambesienesis*

(KEIJ, 1955). The type of *Cytheridea dorsoarcuata* of MÉHES having a nearly equal stratigraphic position and from a nearby locality as the specimen described here has been lost. His figure slightly differs in the outline from that of BRESTENSKÁ (1975) and from the figure published here. MÉHES does not mention the doubleness of the anterior row of spines and the spine field character of the posteroventral spines. Contrary the differences listed here I think that the forms from Alcsútdoboz can be identified with the species of MÉHES. Being only a single specimen, variability cannot be studied and we cannot decide if the species and subspecies of MOOS and KEIJ, respectively, are junior synonyms of the species of MÉHES, or not.
Occurrence: Alcsútdoboz – 3 borehole: 246.0 m
Material: 1 left valve
Stratigraphical and geographical distribution according to previous descriptions: Hungary and Czechoslovakia: Egerian.

Schulteridea rauraciformis n. sp.

Pl. 4, fig. 3.

Derivatio nominis: after the form of the posterior end which is similar to *Sch. rauracica*.
Holotypus: carapace.
Locus typicus: Eger, Kiseged, road cut.
Stratum typicum: sample no, 3b. Lower Oligocene.
Diagnosis: From having a definite break in the posterior outline. The caudal angle formed by the break lies near the half height. The surface of valves bears no ornamentation or scarce punctuation.

Description

1. Shape. Left valve, outer lateral view The anterior outline is asymmetrically rounded, its upper part is straightly cut. The anterior outline turns into the straight dorsal outline with a wide arc at 0.5 lenght. The dorsal outline joins the posterior outline with a break slightly before 0.9 length. The upper part of the posterior outline is nearly straight, the lower part is convex. The two parts enclosing 90° angle has a sharp break at the level of 0.5 height. The posterior outline gradually turns into the slightly and asymmetrically convex ventral outline. Height lies at middle length.

Right valve. The upper half of the anterior outline is more cut than that on the left valve. There is a break between anterior and dorsal outlines, the rounding has a small arc. The ventral outline is hardly convex, consequently the break between the branches of the posterior outline is placed slightly lower than 0.5 height.

Double valve, dorsal view. The left valve displays a decreasing rise from 45° to 0° till the part between 0.4 – 0.5 length, then has a growing slope of 0° to 30° till the end of the valve. The right valve is slightly flatter.

2. Ornamentation. Thes surface of the valves is smooth or scarcely punctuated.

3. Dimensions. carapace: L = 0.98 – 1.11 mm
H = 0.66 – 0.68 mm
L/H = 1.48 – 1.62
W = 0.47 mm

4 – 8. The inner characters cannot be examined.

11. Part of the specimens is more elongate: these can be males. Outline of the left valve becomes similar to that of the right valve. Ventral outline is near straight on the left valve as well. Position of height shifted slightly forward.

Comparisons

It is similar to *Schuleridea rauracica* of OERTLI (1956) on the form of the posterior end, but differs in general shape of the outline and in absence of ornamentation.

Occurrence

Budapest, Zugliget, outcrop: sample no. 3
Eger, Kiseged, road cut: samples no. 3b, 12

Material: 13 carapaces

Subfamilia Cuneocytherinae MANDELSTAM, 1959

Genus *Cuneocythere* LIENENKLAUS, 1894
Subgenus *Cuneocythere* LIENENKLAUS, 1984

Cuneocythere (Cuneocythere) marginata anterodepressa MONOSTORI, 1982
Pl. 4, fig. 4 – 6.

1982. *Cuneocythere marginata anterodepressa* n. ssp. – MONOSTORI, pp. pp. 68 – 70, pl. VII, fig. 8 – 10.

Remarks

Characters of the material are equal to those of from the type locality of the Kiscellian in Budapest (MONOSTORI, 1982). Strength of reticulation displays individual variability as well. The right valve is more strongly reticulated than the left one.

Occurrence: Kiscell – 1 borehole: 51.6 m; 55.5 m, 56.5 m, 59.5 m, 62,5 m.
Budapest, Zugliget, outcrop: sample no. 7
Eger, Kiseged, road cut: samples no. 2a, 3a, 3b, 4. 12, 13

Material: 15 right valves, 30 left valves, 121 carapaces

Dimensions· right valves· L = 0.57 mm H = 0.28 mm
L/H = 2.00
left valves· L = 0.55 – 0.61 mm
H = 0.33 0.40 mm
L/H = 1.35 1.71
carapaces: L = 0.60 mm H = 0.37 mm
L/H = 1.65 W = 0.25 mm

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian.

Cuneocythere (Cuneocythere) marginata marginata (BOSQUET, 1852)

1852. *Bairdia marginata* n. sp. – BOSQUET, p. 28, t. I, f. 12
1957 *Curneocythere (Cuneocythere) marginata* (BOSQUET) KEIJ, p. 75, T. IX, f. 17–22
1964. *Cuneocythere (Curneocythere) marginata* (BOSQUET)–SCHEREMETA, pp. 119–120, T IV, f. 11–12
1969. *Cuneocythere marginata* (BOSQUET)–SCHEREMETA, p. 86, t. VI, f. 13–15.
1969. *Cuneocythere (Cuneocythere)* cf. *marginata* (BOSQUET)–PIETRZENIUK, p. 37, t. VI, f. 1–3, t. XIX, f. 1–2, t. XXIII. f. 16–19
1973. *Cuneocythere marginata* (BOSQUET)–SÖNMEZ–GÖKCEN, p. 53, t. VI. f, 27–28
?1975 *Cuneocythere (Cuneocythere) marginata* (BOSQUET)–BRESTENSKÁ, p. 399, t. 6, f. 10–12.

Remarks

This form shows good agreement with the figures of the type form. The more tapering character of the posterior end in dorsal view is a slight deviation from the type figure, like the specimens of PIETRZENIUK (1969)

It is different from the *C marginata anterodepressa* subspecies, which is frequent in the Kiscellian of Hungary, by the weakness of the anterior depression and the stronger reticulation which shows an ordered pattern anteriorly The form of Brestenská can be correlated by *C truncata* LIENENKLAUS, as well. Due to absence of a description and the figures of low quality this problem cannot be solved.

Occurrence: Budapest, Zugliget, outcrop: samples no. 3, 12
Material: 8 carapaces

Dimensions: carapaces: L = 0.53 0.75 mm
H = 0.33–0.37 mm
L/H = 1.52–1.61 W = 0.24 0.25 mm

Stratigraphical and geographical distribution according to previous descriptions: Belgium, Netherlands, BRD: Rupelian, GDR: Upper Eocene; Soviet Union: Oligocene; Turkey: Stampian, (?) Czechoslovakia: Kiscellian and Egerian.

Cuneocythere truncata LIENENKLAUS, 1894
Pl. 4. fig. 7

1894. *Cuneocythere truncata* n. sp.–LIENENKLAUS, p. 260, T XVIII, F 6.
1973. *Cuneocythere (C) truncata* LIENENKLAUS–MOOS, p. 48, T. 6, f. 6.
1975. *Cuneocythere (C) truncata* LIENENKLAUS–FAUPEL, pp. 28 29, T. 13, F. 2.7.
?1975 *Cuneocythere (C) marginata* (BOSQUET) BRESTENSKÁ, – p. 399, T 6, F 10 12.

Description.

1. Shape. Left valve, outer lateral view The anterior outline nearly symmetrically rounded. It gradually turns into the dorsal outline. The latter is hardly convex from 0.4 length till the end, then turns into the straight posterior outline by a 120° break. The posterior outline gradually turns into the ventral outline at the lower one-third level of maximal height. The ventral outline is scarcely concave between 0.3 and 0.8 length. Its direction is perpendicular to the posterior outline. The ventral outline gradually turns into the anterior outline. Height is in anterior position.

Right valve. The dorsal outline is more straight. The transition from the anterior outline is not gradual but has a break. The upper, straight section of the posterior outline encloses an angle greater than 120° with the dorsal outline and an angle smaller than 90° with the ventral outline. The ventral outline is more concave than on the left valve.

Left valve, dorsal view The lateral surface shows a decrease (from 25 – 30° to 0°) of the rise, except the immediate vicinity of the anteromarginal keel. It is parallel with the plane separating the valves in the posterior half of the length and terminates in 90° posteriorly. Maximal width lies posteriorly.

2. Ornamentation. Surface of the valves is coarsely and irregularly reticulated. The riblets forming the reticulation are sharp. Reticulation is ordered anteriorly but is indistinct anteromarginally There is a sharp anteromarginal keel, followed by a narrow furrow The valve has a distinct posteromarginal keel. The marginal keel is slightly observable dorsally, but ventrally it is quite strong. Anterior section of the marginal keel runs over the posterior section ventrally, about at median length. The surface terminates at the posterior end by a specific angular swelling.

3. Dimensions: left valve: L = 0.48 mm H = 0.31 mm
L/H = 1.58
right valve: L = 0.51 mm H = 0.27 mm
L/H = 1.87

4. The inner lamella is wide anteriorly, having a distinct vestibulum anteriorly which is indistinct posteroventrally Selvage is near the margin and is sharp on the right valve.

5. There are very many marginal pore canals anteriorly. These are simple and arcuate.

6. In the left valve the hinge is a wide (and more widening at its ends) furrow, bordered by a narrow bar Terminations of the bar are tooth-like tubercles.

7 – 8. Normal pores and muscle scars can be poorly studied.

9 No eye-tubercle.

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

Remarks

FAUPEL (1975) mentions two definite distinctive characters of this species contrary to *C. marginata* (BOSQUET). First, the specific posterior surface with angular swellings can be observed well on our specimens. But the riblets running to the anterior margin are very weak; this character is nearer to *C marginata* (according to FAUPEL's opinion). The *C marginata* of BRESTENSKÁ may belong to our species (see the remarks at *C marginata* in this paper). It is questionable that *C. marginata* and *C truncata* can be separated on a species or on subspecies level or ecological varieties only.

Occurrence

Alcsútdoboz – 3 borehole: 170.0 m, 373.0 m Material: 1 right valve, 1 left valve, 2 fragments.

Stratigraphical and geographical distribution according to previous descriptions: BRD: Rupelian – Chattian; Czechoslovakia (?), Kiscellian – Egerian

Familia Cushmanideidae PURI, 1973

Genus *Pontocythere*, DUBOWSKY, 1939

(?) *Pontocythere denticulata* (LIENENKLAUS, 1984)

Remarks

A sole left valve, which is in agreement with the species in outline ornamentation. Strong vestibulum is characteristic, especially anteriorly, where the inner lamella is very wide. Instead of blunt anterior denticulation there are only traces of a fine anteroventral denticulation, so its belonging to the *denticulata* species cannot be proven. This denticulation is characteristic for *P. truncata* (LIENENKLAUS, 1984) with ornamented valves, which was originally described as a variety of *P dentata*, and can be found in the same here as well. A material having more individuals of this species may provide possibilities for an exact determination of this form and to clear its relations with *P. truncata* (conspecific, separate subspecies or separate species).

Occurrence: Alcsútdoboz – 3 borehole: 126.0 m

Material: 1 left valve

Dimensions: left valve, L = 0.66 mm H = 0.24 mm

L/H = 2.80

Pontocythere truncata (LIENENKLAUS, 1984)

Pl. 4, fig. 8.

1894. *Cytherideis denticulata* var *truncata* n. var – LIENENKLAUS, p. 258

1941 *Cytherideis longissima* n. sp. – MÉHES, p. 24, t. 6, Á. 9 – 11.

1975. *Pontocythere truncata* (LIENENKLAUS) – BRESTENSKÁ, p. 399, T. 2, F 11 – 14

Description

1. Shape. Left valve, outer lateral view Anterior outline is strongly asymmetrically rounded. Radius of the upper part arc is much longer than that of the lover part. With a 150° break at 0.3 length the anterior outline turns into the nearly straight dorsal outline, which bears a slight depression behind 0.5 length. The dorsal outline turns into nearly symmetrically

rounded posterior outline with an arc of very small radius behind 0.9 length. The posterior outline turns into a slightly assymmetrically concave ventral outline by an arc of very small radius. Height is in anterior position.

Left valve, dorsal view The valve surface rises by a 45° angle till 0.1 length, then it is nearly parallel with the plane separating the valves till 0.3 length. Then rises by 20° till 0.5 length. Then a small depression follows, then parallel till 0.9 length. having a small depression 0.8 length. It has a 60–70° slope from 0.9 length till the end of the valve.

2. Ornamentation. The valve surface is irregularly, coarsely reticulated. There are ribs parallel with the ventral margin ventrally. Reticulation is more coarse anteriorly and has a keel-like sharpening perpendicular to the ventral outline at 0.8 length. The muscle scar area bears a protuberant ornamented section. At 3/4 length the valve is depressive posteroventrally.

There is a weak anteroventral marginal denticulation.

3. Dimensions: left valve: L = 0.54 mm H = 0.24 mm
L/H = 2.30

4. The inner lamella is narrow, vestibulum can be scarcely observed.
5. Many simple, straight marginal pore canals.
6. Hinge of the left valve contains an extremely long anterior socket, an elongated median bar and a short, arcuate posterior socket.
7–8. Normal pores and muscle scars cannot be studied.
9. No eye-spot.

Remarks

Compared to the figures of BRESTENSKÁ (1975) the outline is slightly different (this form is more stubby and the posterior–dorsal transition is more sharp).
Occurrence: Alcsútdoboz–3 borehole: 126.0 m
Material. 1 left valve
Stratigraphical and geographical distribution according to previous descriptions: BRD: Upper Oligocene; Hungary and Czechoslovakia: Egerian.

Familia Krithidae MANDELSTAM, 1960
Genus *Krithe* BRADY, CROSSKEY et ROBERTSON, 1874

Krithe pernoides (BORNEMANN. 1855)
Pl. 4, fig. 9.

1981. *Krithe pernoides* (BORNEMANN)–UFFENORDE, p. 146
1982. *Krithe pernoides* (BORNEMANN)–MONOSTORI, pp. 55–56, Pl. V, fig. 4–10. (cum syn.)

Remarks

Inner characters cannot be studied generally On some forms the dorsal outline is not straight but arcuate. These ones are somewhat similar to *Kr. cancuenensis ambigua* of POKORNÝ (1980), but the form of the posterior outline is more characteristic for *Kr. pernoides*. Morphological variation is considerable within one sample, too. The angle between the straight branch of the posterior outline and the dorsal or ventral outline is variable. There are every degree in the camber of the dorsal outline from definitely arcuate to straight but with a considerable dominance of the straight ones. Position of height is variable due to variability of the morphology There are many juvenile forms in the investigated fauna.

Occurrence

Cserépváralja – 1 borehole: 211.0 – 211.2 m; 240.0 – 240.2 m; 262.0 – – 262.2 m; 265.4 – 265.6 m; 285.8 – 286.0 m, 407.4 407.6 m; 412.4 – 412.6 m, 416.9 – 417.1 m, 422.3 – 422.5 m, 435.6 – 435.8 m.
Kiscell – 1 borehole: 83.4 m; 100.2 m, 103.5 m
Budapest, Pusztaszeri út. outcrop: samples no 2, 13, 20, 21, 22, 24, 27
Budapest, Ibolya utca, quarry: 1.2 m
Budapest, SZOT – 1 borehole: 7.0 m
Budapest, SZOT – 2 borehole: 46.0 m
Budapest, SZOT – 4 borehole: 54.0 m

Material: 28 right valves, 13 left valves, 70 carapaces
Dimensions: right valves: L = 0.63 – 0.72 mm
H = 0.27 – 0.34 mm
L/H = 2.10 – 2.30
left valves: L = 0.63 – 0.77 mm
H = 0.30 – 0.38 mm
L/H = 2.03 – 2.12
carapaces: L = 0.47 – 0.66 mm
H = 0.26 – 0.33 mm
L/H = 1.82 – 2.43
W = 0.20 – 0.32 mm

Stratigraphical and geographical distribution according to previous descriptions: BRD: Upper Oligocene – Lower Miocene; GDR: Upper Eocene; Belgium, Netherlands: Rupelian; Italy: Miocene; Soviet Union: Oligocene; Hungary: Kiscellian.

Krithe sp.

Remarks

Fragments belonging to the group of *Kr papillosa* (Bosquet, 1852).
Occurrence: Alcsútdoboz – 3 borehole: 120.0 m
Material: 2 fragments

Krithe ? sp.

Remarks

Specimens similar to *Kr. rutoti* Keij in form, but inner characters cannot be examined.
Occurrence: Cserépváralja – 1 borehole: 435.6 – 435.8 m
Material: 2 right valves, 3 carapaces

Genus *Parakrithe* VAN DEN BOLD, 1958

Parakrithe ? sp.
Pl. 4, fig. 10.

Remarks

Specimens similar to *Parakrithe costatomarginata* MONOSTORI, 1982 in their outline, but anteromarginal and posteromarginal keel cannot be observed. Inner characters cannot be investigated.

Occurrence

Budapest, Pusztaszeri út, outcrop: samples no. 3, 5, 10, 13, 21, 27,

Material 10 carapaces

Genus *Turmaekrithe* PIETRZENIUK, 1969

? *Turmaekrithe fragilis* PIETRZENIUK, 1969

Remarks

Carapaces similar to this species in their outline, but their inner characters cannot be studied.

Occurrence

Cserépváralja – 1 borehole: 435.6 435.8 m

Material: 3 carapaces

Familia Trachyleberididae SYLVESTER – BRADLEY, 1948

Subfamilia Trachyleberidinae SYLVESTER – BRADLEY, 1948

Genus *Trachyleberis* BRADY, 1898

Trachyleberis sp.

Remarks

Left valve of poor preservation. It can be attributed to the group of *T spinosa* after its ornamentation and outline.

Occurrence: Budapest, SZOT 1 borehole: 16.0 m

Material: 1 left valve

Genus *Agrenocythere* BENSON, 1972

Agrenocythere bensoni POKORNÝ, 1977
Pl. 5, fig. 1 – 2.

1977. *Agrenocythere bensoni* n. sp. – POKORNÝ, pp. 384 – 390, text-fig. 1 – 5, Pl. I, fig. 1 – 3.

1982. *Agrenocythere aculeataformis* n. sp. – MONOSTORI, pp. 58 – 60, pl. VI, fig. 2.

Remarks

The species described in 1982 as *A. aculeataformis* differs only in outline and in two details of ornamentation from *A bensoni*. This new material revealed that the plate-like widening of the keel in the anterodorsal corner has a varying strength and sometimes it may disappear. The interruption of the ventral outline may be due to damage on the type of *A aculeataformis*. There is one similar specimen in the present material as well, but the uniform ventral keel is more characteristic. The outline shows variations in lateral and dorsal views as well; consequently smaller differences in outline from *A. bensoni* cannot be considered as valuable in erecting a new species.

Besides adult specimens the material contains considerable quantities of smaller and more stubby valves, most probably representing the last larval stage.

Occurrence

Cserépváralja – 1 borehole: 407.4 – 407.6 m; 412.4 – 412.5 m
Budapest, Pusztaszeri út, outcrop, samples no. 17, 24, 27.
Budapest, Ibolya utca, quarry: 7.9 m
Budapest, SZOT – 6 borehole: 10.8 m

Material: 8 juvenile right valves, 13 juvenile left valves, 6 carapaces, 5 fragments

Dimensions:
juvenile right valve: L = 0.89 mm H = 0.48 mm
L/H = 1.83
juvenile left valve L = 0.68 – 0.74 mm
H = 0.40 – 0.41 mm
L/H = 1.71 – 1.80
adult carapace L = 1.06 – 1.12 mm
H = 0.54 mm w = 0.53 – 0.60 mm
L/H = 1.96 – 2.70
L/W = 1.87 – 2.00

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian; Czechoslovakia: Lower – Middle Eocene

Genus *Costa* Neviani, 1928

Costa cf. *hermi* Witt, 1967

Remarks

Observable characters of the fragmentary specimens are similar to this species.

Occurrence

Alcsútdoboz – 3 borehole: 442.0 m, 504.0 m
Cserépváralja – 1 borehole: 416.9 – 417.1 m

Material: 2 right valves, 5 left valves, 1 carapace, 3 fragments

Costa sp.

Remarks

A carapace different form the *C. hermi* species, but unidentifiable to the species level.

Occurrence

Budapest, Pusztaszeri út, outcrop: sample no. 21.

Material: 1 carapace

Genus *Hazelina* Moos, 1966

Hazelina indigena Moos, 1966
Pl. 5, fig. 3.

1966. *Hazelina indigena* n. sp. – Moos, pp. 286–288, T. 24, f. 1–12
1969. *Hazelina indigena* Moos Pietrzeniuk, p. 52, T. X, f. 4, T. XX, f. 1–2, T. XXV, f. 1–3, Abb. 1.
1977. *Hazelina indigena* Moos–Keen, Pl. 48, f. 3 4
1977. *Hazelina indigena* Moos–Szczechura, P. 67, Pl. 23, f. 1–7
1978. *Hazelina indigena* Moos–Keen, Pl. 11, f. 9.

Description

1. Shape. Left valve, outer lateral view. The anterior outline is slightly asymmetrically rounded, bearing 5 coarse denticles on the lower part. The anterior outline turns into the dorsal outline at 0.2 length. The latter is straight but there is an arc of the dorsal keel from 0.6 length to behind 0.8 length. The dorsal outline has a protruding termination like the cardinal angle. Then it turns into the posterior outline by a 120° break. Upper half of the posterior outline is slightly concave, the lower half is slightly convex. The posterior outline turns into the ventral outline by a slight break. The dorsal and ventral outlines are convergent towards posterior direction. Height lies at the cardinal angle.

2. Ornamentation. The anteromarginal keel starting from the cardinal angle has a continuous transition into the ventral keel, which ends at 0.8 length. The ventral keel is slightly divergent from the ventral outline and has a steep termination posteriorly The median keel starts slightly before 0.2 length below the middle of the local height and reaches 0.8 length. Its anterior half is wide, looks like a swelling, the posterior half becomes sharp. The sharp rib connecting the dorsal and median keel is perpendicular to the median keel. The dorsal keel is arched and forms the dorsal outline from behind 0.5 length till 0.8 length. It fades into the lateral surface at 0.3 length below the eye-tubercle. The area between the keels is coarsely reticulated and shows an ordered pattern formed by radial and concentric riblets anteriorly The radial ribs running over the anteromarginal keel are very characteristic (the ordered reticulation also continues outside the keel).

3. Dimensions: left valve: ..L = 0.67 mm H = 0.37 mm
L/H = 1.84

4–8. Inner characters cannot be studied.

9. Strong eye-tubercle.

Remarks

The observable morphological characters are in good agreement with the description of Moos (1966).

Occurrence

Cserépváralja–1 borehole: 416.9–417.1 m
Budapest, Ibolya utca, quarry: 2.5 m
Noszvaj, Síkfőkút, quarry: sample no. 15.

Material: 3 right valves: 1 left valve
Stratigraphical and geographical distribution according to previous descriptions: BRD: Latdorfian; GDR: Upper Eocene; Poland: Upper Eocene; England· Bartonian.

Genus *Trachyleberidea* BOWEN, 1953

Trachyleberidea cf. *posteroacuta* (LIENENKLAUS, 1900)

Remarks

Observable characters of the poorly preserved specimens are in good agreement with the figures of PIETRZEINUK (1969).

Occurrence

Cserépváralja – 1 borehole: 406.4 – 407.6 m; 419.0 – 419.2 m
Material: 2 right valves.

Genus *Pterygocythereis* BLAKE, 1933

Pterygocythereis retinodosa OERTLI, 1956
Pl. 5, fig. 4.

1956. *Pterygocythereis retinodosa* n. sp. – OERTLI, pp. 83 – 85. T. 11, f. 291 – 298, 307, T. 15, f. 397 – 398, T 16, f. 410

1969. *Pterygocythereis retinodosa* OERTLI – SCHEREMETA, pp. 109 – 110, t. IX, f. 7

Description

1. Shape. Left valve, lateral view The anterior outline is nearly symmetrically rounded having a slightly larger radius in the upper half. Behind 0.4 length it turns into the naerly straight dorsal outline with a 140° break. The dorsal outline bears a small depression behind the eye-tubercle and a protruding hinge-ear at 0.8 length. The dorsal outline turns into the posterior outline at 0.8 length with a 140° break. Upper part of the posterior outline is slightly concave, the lower part is sligthly convex. The upper and lower parts enclose a rectangle. The posterior outline turns into the naerly straight ventral outline. The latter is formed by a ventrolateral wing-like widening between 0.7 and 0.3 length, overlapping the ventral margin. Height lies at the cardinal angle.

Left valve, dorsal view The outline rises in 30° to 0.7 length (due to the wing-like widening), then has a jump back with one-third maximal width (by about 60° slope). Then there is a slope of 40 – 45° till behind 0.8 length (having a gradual, arched transition to the preceding section) Then the surface is parallel with the plane separating the valves till the end of the valve at one-quarter maximal width. This considerable width is mostly due to the marginal row of spines.

2. Ornamentation. The strong anteromarginal keel originating from the eye-tubercle continues in the ventral keel. The latter forms a wing-like widening and overlaps the ventral outline between 0.3 and 0.7 length. Then it forms a gradually changing angle from 60° to 90° and fades into

the lateral surface before the half of the local height. The ventral keel and the dorsal outline slightly converge and form spine-like tip at the end. This spine like ending slightly bends towards the plane separating the valves in dorsal view There is a strong, short marginal rib between from the posterior part of the eye-tubercle to 0.4 length dorsally. The posteromarginal keel is mostly displayed at the central branch of the posterior outline. The ventral keel bears no spines but an uneven surface. There is a definite denticulation anteroventrally and posteroventrally. The double row of denticles described by OERTLI can be observed anteriorly There is an elongated, reticulated swelling dorsally between 0.5 and 0.8 length. The valve surface is also reticulated on a small spot below the swelling.

3. Dimensions· left valve: L = 0.79 mm H = 0.35 mm
L/H = 2.23

4. The inner lamella is moderately wide.

5. Few, simple, straight marginal pore canals:

6. Hinge of the left valve consists of a large anterior socket, a strong and bended anteromedian tooth, a reticulated posteromedian bar and a large and arched posterior socket.

7–8. Normal pores and muscle scars cannot be found.

9. Strong eye-tubercle slightly shifted posteriorly from the cardinal angle.

Remarks

Agreement in characteristic features makes possible a certain determination. Ornamentation is weaker: e.g. the nodes on the ventral keel are displayed as an uneven surface only; reticulation is less widespread, than described in the diagnosis, but the type description reveals a definite variability; but our material consists of a single specimen only

Occurrence: Alcsútdoboz – 3 borehole: 170.0 m

Material: 1 left valve

Stratigraphical and geographical distribution according to previous descriptions: Switzerland: Rupelian, Soviet Union· Oligocene.

Pterygocythereis sp.

Remarks

Fragments only: damaged valves and steinkerns with remnants of the valves. They can be clearly recognized as belonging to this genus.

Occurrence

Alcsútdoboz – 3 borehole: 246.0 m; 277.0 m, 373.0 m; 442.0 m, 504.0 m
Cserépváralja – 1 borehole: 416.9 – 417.1 m
Kiscell – 1 borehole: 56.6 m

Eger, Kiseged, road cut: samples no. 3a, 3b, 4, 12
Noszvaj, Síkfőkút, quarry: samples no. 11 and 18.

Genus *Henryhowella* PURI, 1957

Henryhowella asperrima (REUSS, 1850)

Pl. 5, fig. 5–6.

1981. *Henryhowella asperrima* (Reuss) – Uffenorde, pp. 148 – 149, T. 2, F. 14 – 15, 17 – 19
1982. *Henryhowella asperrima* (Reuss) – Monostori, pp. 60 – 62, Pl. VI, f. 3 – 5 (cum syn)

Remarks

The specimens correspond to the ones described from the Kiscellian fauna of Budapest (Monostori, 1982) in all their observable characters. Part of them displays the features and characters of the last larval stage. The longitudinal swellings scarcely or not appear at all in the ornamentation of the latters and the carapax shows a faster narrowing in posterior direction.

Occurrence

Cserépváralja – 1 borehole: 265.4 – 265.6 m, 387.5 – 387.7 m
Kiscell – 1 borehole: 83.4 m; 98.5 m

Material: 4 right valves, 3 left valves, 6 carapaces

Dimensions: carapace: L = 0.67 – 0.72 mm
H = 0.37 – 0.39 mm
L/H = 1.54 – 1.97 W = 0.32 – 0.33 mm
juvenile carapace: L = 0.61 mm H = 0.37 mm
L/H = 1.68 W = 0.28 mm
right valve: L = 0.76 mm H = 0.40 mm
L/H = 1.88
juvenile right valve: L 0.59 mm H = 0.34 mm
L/H = 1.63

Stratigraphical and geographical distribution according to previous descriptions: BRD: Oligocene – Miocene; France: Oligocene – Pliocene; Italy: Mioecene; Czechoslovakia: Oligocene – Miocene: Hungary: Oligocene.

Subfamilia Campylocytherinae Puri, 1953

Genus *Leguminocythereis* Howe et Law, 1936

Leguminocythereis ex gr. *sorneana* Oertli. 1956

Pl. 5, fig. 7 – 8.

Remarks

The adult specimens are damaged. Coarse and anteriorly concentrically patterned reticulation of the lateral surface shows relations with this species. But there is a small eye-tubercle in the eye-area and no strengthened concentric rib originates from it, contrary to the species of Oertli. The definite caudal angle is characteristic. Upper part orf the posterior outline is slightly concave and forms a more protruding angle with the dorsal outline than on the species of Oertli. In dorsal view the outline has a very steep slope after 0.8 length and forms a caudal process from 0.9 length of one-third of the maximal width. The ventral swelling suddenly terminates.

The outline is similar to *L. heistensis* Keij, 1957, but caudal angle shifted backwards, the ventral swelling has a steeper slope posteriorly and the ornamentation is more uneven and less ordered. Our one be a new species but it cannot be described in absence of appropriate material.
Occurrence

Budapest, Zugliget, outcrop: sample no. 3
Eger, Kiseged, road cut: samples no. 3a, 12
Material: 1 left valve, 10 carapaces. 2 fragments

Leguminocythereis sp.

Remarks

Coarsely reticulated, large forms; fragments only
Occurrence

Alcsútdoboz – 3 borehole, 373.0 m; (120.0 ? m)
Material: 8 fragment

Familia Hemicytheridae PURI, 1953
Subfamilia Hemicytherinae PURI, 1953

Genus *Murrayina* PURI, 1954
Murrayina? gibberula (REUSS, 1856)
Pl. 6, fig 1 – 2.

1856. *Cythere gibberula* n. sp. – REUSS, p. 255, T X, F. 97.
1863. *Cythere gibberula* REUSS – SPEYER, p. 19, T IV, f. 11.
1975. *Hazelina* cf. *gibberula* (REUSS) – BRESTENSKÁ, pp. 388 389, T. 6, F 7 – 9, T 10, f. 14.

Description

1. Shape. Left valve, outer lateral view. The anterior outline is slightly asymmetrically rounded. radius of the upper part is larger. The anterior outline turns into the straight dorsal outline at one-fourth length by a 140° break. The dorsal outline bears a dorsal keel between 0.6 and 0.8 length. The dorsal outline turns into the posterior outline at 0.9 length by a 100 – 120° break. Upper part of the latter is slightly concave, the lower one is scarcely convex. The posterior outline turns into the nearly straight ventral outline by a short radius arc. The dorsal and ventral outlines are slightly diverging in anterior direction. Height lies anteriorly at the caudal angle.

Right valve, The dorsal outline turns into the posterior outline by a 130 140° break. Upper branch of the posterior outline is more concave, so the caudal part is more elongated below. The dorsal and ventral outlines are a little more divergent in anterior direction than on the left valve. The ventral outline is slightly sinuous.

Left valve, ventral view The lateral surface rises at first in 90° then in 45° till 0.1 length. Then it is depressive in a short section, then rises by 30° till behind 0.4 length. Then has a slope of 45° till behind 0.5 length. Then it is parallel with the plane between the valves till 0.8 length. Then perpendicularly drops one-third of the maximal width, then has a slope of 50 – 60° till 0.9 length. At the end it is parallel with the plane between the valves at one-fourth of the maximal valve width.

2. Ornamentation. The left valve bears a flat, wide anteromarginal swelling, followed by a depression originated from the eye-tubercle. The tubercle around the centre lasts from one-fourth to one-half length. Its posterior half is more protruding. There is a dorsal swelling between 0.5 and 0.8 length, starting from the vicinity of the dorsal margin and rising above it, having a steep termination posteriorly. The ventral swelling starts near the ventral outline at the same length as the central tubercle ends and terminates at the same length as the dorsal swelling ends. This ventral swelling is nearly parallel with the ventral outline. Its termination is more steep than that of the dorsal swelling, giving a tubercle-like appearance to it. All the valve surface is coarsely reticulated. The reticulation forms ordered concentric rows anteriorly The valve margin is denticulated anteroventrally and posteroventrally

3. Dimensions:

right valve (adult): L = 0.55 mm H = 0.32 mm
L/H = 1.74
right valve (juvenile): L = 0.44 mm H = 0.24 mm
L/H = 1.85
left valve. L = 0.53 mm H = 0.31 mm
L/H = 1.73 mm

There are larger specimens as well· a fragment shows H = 0.38 mm

4. The inner lamella is relatively narrow, with a very narrow anteroventral vestibulum.

5. Few, simple, straight marginal pore canals.

6. The hinge of the right valve contains two-stepped anterior tooth, a narrow median furrow and an elongated, arched posterior tooth.

7 – 8. Normal pores and muscle scars cannot be studied.

9. Strong eye-tubercle at the cardinal angle.

10. The left valve slightly overlaps the right one ventrally and posterodorsally

12. On well-preserved juvenile forms the anterior, dorsal and ventral swellings appear as sharp keels. The dorsal and ventral keels terminates as a spine posteriorly beacause these have a short continuation turning backwards and toward each other and joining in an acute angle. Reticulation occupies the anteromarginal keel on juvenile specimens as well and extends to the margin of the valve.

Remarks

The species described here is certainly identical with the species figured as *Hazelina* cf. *gibberula* (REUSS) by BRESTENSKÁ (1975). It corresponds well with the original figures of REUSS (1856) and the figures of SPEYER (1863). *M. lyrata* (REUSS, 1856) is related to it in outline and ornamentation, but this latter one bears no definite swellings neither anteriorly nor dorsally according to the figures of FAUPEL (1975). The posterior end is much more cut than that of *M gibberula.* The ornamentation and character of the posterior termination are both different from those of the *Hazelina* genus. The posterior termination on the type of the genus *Murrayina* is different than that of on these two specimens compared here. Consequently although the attribution to this species can be made according to the description and figures of REUSS (1856) the attribution to a genus remains questionable.

Occurrence

Alcsútdoboz 3 borehole 126.0 m, 164.0 m, 223.0 m, 336.0 m
Material. 4 right valves, 3 left valves, 2 fragments
Stratigraphical and geographical distribution according to previous descriptions· BRD Chattian, Czechoslovakia Egerian.

Genus *Megahemicythere* WITT, 1967

? *Megahemicythere oertlii* WITT, 1976

Remarks

As there were carapaces found only, without the knowledge of the inner characters also the attribution to the genus is conditional only

Surface of the valves is nearly smooth, but ventrally some specimens bear faint traces of reticulation ventrally The ventrolateral part of the valve is swelled, generally not sharpening. Posterior part of the swelling has a steep slope. Some specimens bear some weak longitudinal ribs posteroventrally

The form of the outline also differs from ***Bosquetina zalányi*** occurring in the same sample.

From of the outline is in agreement with that of the type material. including the variations figured there. The progressive reduction of the ornamentation is characteristic, resulting in a faint appearance of the posteroventral keel. This character is near to that of the *ornata* subspecies. It may be an ecological variety of the species of WITT A similar weakening of the ornamentation can be proven for the *Echinocytheresis dadayanus* (MÉHES, 1936) from the Lutetian of Hungary when salinity oscillates (MONOSTORI, 1975)

Occurrence· Eger, Kiseged, road cut samples no. 2a, 3a, 3d, 12.
Material 60 carapaces, 1 fragment

Genus *Pokornyella* OERTLI, 1956

Pokornyella ex gr *limbata* (BOSQUET, 1852)

Pl. 6, fig. 5 6.

Remarks

Poorly preserved specimens. Their outline, the character of the ornamentation, the coarse, reticulation-like pitting, the 2 sharpening longitudinal ribs along the ventral outline indicate this species.

Occurrence:

Budapest, Pusztaszeri út, outcrop· samples no. 17, 22.
Material: 2 carapaces

Pokornyella ex gr. *moyesi* DUCASSE, 1967
Pl. 6, fig. 3–4.

Remarks

Poorly preserved specimens, outline and ornamentation indicates this species. All forms are stubby and high. On all specimens the ornamentation changes from slightly pitted to smooth. The rib near the ventral outline is slightly perceptible on the smooth specimen.
Occurrence· Budapest, Ibolya utca, quarry: 4.4 m, 9.9 m.
Material. 3 carapaces

Subfamilia Thaerocytherinae Hazel, 1967
Genus *Hermanites* PURI, 1955

Hermanites cf. *laticarinatus* (LIENENKLAUS, 1900)

Remarks

Badly preserved specimens. Their outline and ornamentation is similar to this species.
Occurrence· Budapest, Pusztaszeri út, outcrop. samples no. 22. 27
Material: 2 carapaces

Genus *Quadracythere* HORNIBROOK, 1952

Quadracythere cf. *macropora* (BOSQUET, 1852)
Pl. 6, fig. 8.

Remarks

Stubby forms resembling mostly to this species in their outline and ornamentation. No better determination can be achieved due to poor preservation and small number of specimens.
Occurrence· Budapest, Ibolya utca, quarry. 1.2 m, 9.9.m
Material: 2 carapaces

Quadracythere cf. *vahrenkampi* MOOS, 1965
Pl. 6, fig. 7.

Remarks

Elongated forms, their outline and ornamentation strongly indicates this species. At most specimens the posterodorsal and posteroventral termination of keel is especially spine-like, as can be observed on the material from Latdorf (Moos, 1968).

Occurrence

Budapest, Pusztaszeri út, outcrop: samples no. 3. 5. 17. 21. 27.
Budapest, Ibolya utca, quarry: 7.0 m
Budapest, SZOT – 1 borehole: 5.5 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole: 10.8 m; 11.0 m

Material: 3 right valves, 1 juvenile right valve, 1 left valve, 3 juvenile left valves, 2 carapaces, 2 juvenile carapaces.

Thaerocytherinae gen. et sp. indet.

Poorly preserved specimens. They may represent different species which may belong to the *Hermanites* and *Quadracythere* genera, according to some observable elements of ornamentation.

Occurrence

Cserépváralja – 1 borehole: 416.9 – 417.1 m; 422.3 – 422.5 m; 435.6 – – 435.8 m
Budapest, SZOT – 1 borehole: 7.0 m; 16.9 m
Budapest, SZOT – 4 borehole: 81.4 m

Material: 1 right valve, 3 left valves, 2 carapaces, 1 fragment.

Subfamilia Tracyhleberididae or Hemicytheridae
Genus *Bosquetina* KEIJ, 1957

Bosquetina zalanyii BRESTENSKÁ. 1975
Pl. 6, fig. 9 – 10.

1975. *Bosquetina zalanyii* n. sp. – BRESTENSKÁ, pp. 390 – 392, t. 8, f. 1 – 3.

Remarks

Most of the specimens are more or less damaged; there are mainly fragments. The characteristic 3 longitudinal ribs can be well observed on some less damaged specimens. Sometimes the ventral edge is scarcely developed. The fine pitting of the surface characteristic for the type cannot be observed, except on a single fragment. The poorly preserved specimens described as *Brachycythere* sp. by MONOSTORI (1982) from the Kiscellian of Budapest can be ranged to this group as well.

Occurrence

Alcsútdoboz – 3 borehole: 455.5 m; 487.1 m
Cserépváralja – 1 borehole: 336.8 – 337.0 m
Kiscell – 1 borehole: 51.6 m; 55.5 m; 56.6 m; 57.5 m; 58.5 m; 59.5 m; 62.5 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, Zugliget outcrop: samples no. 3, 7
Eger, Kiseged, road cut: samples no. 3a, 3b, 12.

Material, 35 carapaces, 80 fragments

Statigraphical and geographical distribution according to previous descriptions: Czechoslovakia: Kiscellian – Egerian.

Bosquetina cf. *reticulata* (SCHEREMETA, 1969) sensu BRESTENSKÁ, 1975
Pl. 7, fig. 1–2.

1975. *Bosquetina* cf. *reticulata* (SCHEREMETA, 1969) – BRESTENSKÁ, p. 389, t. 8, f. 8.

Remarks

Outline and ornamentation of forms correspond to those of figured and described by BRESTENSKÁ (1975). The ventral keel and the outline is very close to *B. zalányii*. Reticulation varies in extension and strength. It is possible that the two forms are subspecies of the same species or these may be ecological varieties only (these occur in the same sample, too).

Occurrence: Eger, Kiseged, road cut: samples no. 12, 13.

Material: 1 left valve, 10 carapaces

Stratigraphical and geographical distribution according to previous descriptions: Czechoslovakia: Egerian.

Genus *Occultocythereis* HOWE, 1951

Occultocythereis rupelica MONOSTORI, 1982

1982. *Occultocythereis rupelica* n. sp. – MONOSTORI, pp. 63–64, Pl. VII, fig. 1.

Remarks

This specimen is a little more elongate than the type. Its posterior end is more narrowing. The ventral keel occupies a slightly higher position. There is a scarcely visible trace of the keel between two tubercle-like remnants of the median ornamentation on the lateral surface. This difference – mainly on the form – may be due to sexual dimorphism: it is a more elongate carapace of a male specimen.

Occurrence: Cserépváralja – 1 borehole: 412.4 – 412.6 m

Material: 1 carapace

Dimensions: carapace:	L = 0.55 mm	H = 0.27 mm
	L/H = 2.04	W = 0.19 mm

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian.

Occultocythereis ex. gr. *mutabilis* TRIEBEL, 1961

Remarks

Poorly preserved carapaces showing similarities to this species in outline and ornamentation.

Occurence:

Kiscell – 1 borehole: 103.5 m
Budapest, Pusztaszeri út, outcrop: sample no. 2,
Budapest, Ibolya utca, quarry, 5.5 m
Noszvaj, Síkfőkút, quarry: samlpe no. 21.

Material: 4 carapaces

Familia Cytherettidae TRIEBEL, 1952
Genus *Cytheretta* TRIEBEL, 1952

Cytheretta posticalis TRIEBEL, 1952

1952. *Cytheretta posticialis* n. sp. TRIEBEL, p. 23, T. 3, f. 18–21
1956. *Cytheretta posticalis* TRIEBEL OERTLI, pp. 59–60, T 6, F 160–162
1972. *Cytheretta posticalis posticalis* TRIEBEL KEEN, p. 320,
1973. *Cytheretta posticalis* TRIEBEL.–SONNE, Abb. 6.
1975. *Cytheretta posticalis* TRIEBEL – BRESTENSKÁ, p. 394
1975. *Cytheretta posticalis* TRIEBEL – FAUPEL, pp. 19–20, T. 2, F 4.

Description

1. Shape. Left valve, lateral view The anterior outline is strongly asymmetrically rounded. The anterior outline turns into the nearly straight dorsal outline at 0.3 length by a 150° break. The dorsal outline is sinuous between 0.6 and 0.9 length. Due to this sinus the dorsal outline is slightly protruding at the turn to the posterior outline, which shows a 130° break. Upper one-third of the posterior outline is slightly concave, the lower two-third is convex and gradually turns into the ventral outline. The ventral outline is straight between 0.6–0.2 length then turns into the anterior outline.

Right valve. The ventral outline is sinuous. The maximal sinus is around 0.4 length. Upper branch of the posterior outline is more concave than on the left valve. Ventral view of the carapace. Maximal width lies at 0.6 length. Rise of the lateral surface gradually decreases from 30–35° to 0°, then the rise gradually increases from 0° to 45°

2. Ornamentation. Lateral surface is unornamented. The carapace is swelled posteroventrally

3. Dimensions. Carapace: L = 0.98 mm H = 0.52 mm
L/H = 1.89 W = 0.46 mm

4–8. Inner characters cannot be observed.

9. No eye-spot.

10. The left valve nearly completely overlaps the right one.

Remarks

Details of the outline indicate this species besides the unornamented valve surface.

Occurrence: Budapest, Zugliget, outcrop. sample no. 3.

Material. 1 carapace

Stratigraphical and geographical distribution according to previous descriptions· BRD: Oligocene; Switzerland. Oligocene; Czechoslovakia: Oligocene.

Cytheretta cf. *tenuistriata* (REUSS, 1853)

Remarks

Poorly preserved material, which is similar to this species in outline and ornamentation.

Occurrences

Alcsútdoboz – 3 borehole: 223.0 m, 239.0 m; 246.0 m; 277.0 m
Material· 1 left valve, 3 fragments

Familia Loxoconchidae SARS, 1925
Genus *Loxoconcha* SARS, 1866

Loxoconcha carinata tardense n. ssp.

Pl. 7, fig. 3 – 4.

Derivatio nominis: after its occurrence in the Tard Clay Formation.
Holotypus: carapace
Locus typicus· Kiscell – 1 borehole
Stratum typicum· 56.5 m, Kiscellian
Diagnosis· form bearing a laterally directed spine-like widening on the posterior part of the ventral edge.
Description

1 Shape. Left valve, outer lateral view. The anterior outline is nearly symmetrically rounded. Its upper part is slightly cut. The anterior outline turns into the dorsal outline at one-sixth length by a 120° break. The dorsal outline is sinuous. The cardinal angle is slightly protruding, then the outline is slightly depressed, having its maximum at 0.4 length. Then the dorsal outline is convex, having its maximum at 0.6 length. Behind 0.8 length there is a small depression, after which the strongly asymmetrical posterior outline begins. Upper one-third of the posterior outline is arched having a short radius, the lower two – third is arched having a long radius. The posterior outline turns into the nearly straight ventral outline at 0.6 length. Height lies at the cardinal angle.

Right valve. Its outline is slightly different from that of the left one The upper part of the posterior outline is slightly concave and the lower part is more straight.

Dorsal view of the carapace. The lateral surface rises by 30° till 0.1 length, by 45° till behind 0.2 length then slightly till 0.5 length. It rises by 45° till 0.7 length, then has a slope of 70 – 80°, forming a spine-like widening. After this widening it slopes by 45° till 0.9 length then caudally tapers at the end.

2. Ornamentation. The lateral surface is covered by coarse reticulation. The ventrolateral edge is rounded: begins at 0.2 length, forms a laterally directed spine around 0.7 length then fades into the lateral surface at 0.8 length. The posterior end bears no ornamentation.

3. Dimensions. Carapace· L 0.45 – 0.40 mm
H = 0.21 mm
L/H = 1.89 – 2.11
W = 0.22 mm

4 – 8. The inner characters cannot be examined well.
9. The cardinal angle bears a small eye-tubercle.
10. The left valve scarcely overlaps the right valve.

11. A prt of the forms is definitely more elongate; these might be the male ones.

12. On some specimens the two branches of the posterior outline is slightly convex or straight on the left valve as well, the upper branch may be even concave.

Comparison

The spine-like lateral widening of the ventral edge is different from the original figure of the types subspecies (LIENENKLAUS, 1894) and from the figure of BRESTENSKÁ (1975). The *L. c. alata* subspecies described by SCHNEIDER (1939) from the Miocene bears a similar lateral protuberance. But this is a lobe-like swelling and the outline also strongly differs from the new subspecies described here.

Occurrence

Kiscell – 1 borehole: 51.6 m, 55.5 m, 57.5 m, 58.5 m, 62.5 m

Eger, Kiseged, road cut. samples no. 2a, 4 12.

Material· 1 right valve, 2 left valves, 34 carapaces.

Loxoconcha delemontensis hungarica MONOSTORI, 1982

1982. *Loxoconcha delemontensis* n. ssp. – MONOSTORI, pp. 71–72, Pl. VIII, fig. 1–6.

Description

Based on these specimens of better preservation the followings can be supplemented to the original description.

4. The inner lamella is wide anteriorly and posteroventrally. The anterior vestibulum is definitely recognizable. The selvage is close to the margin on the left valve.

5. Few simple, straight marginal pore canals anteriorly and posteriorly.

6. In the hinge of the left valve the anteromedian tooth surrounding the anterior socket, the denticulated median bar and the elongated, indented posterior socket can be well observed.

Remarks

Upper branch of the posterior outline is straight, the lower one may be slightly convex also. Their radius shows some variability Asymmetry of the anterior outline cannot be observed well on some specimens due to their damaged condition.

Occurrence

Alcsútdoboz – 3 borehole: (737.0 m: cf.)

Kiscell – 1 borehole· 51.6 m, 55.5 m; 56.5 m, 57.5 m; 58.5 m; 59.6 m. cf.

Budapest, Zugliget, outcrop: samples no. 7, 11

Eger, Kiseged, road cut: samples no. 3b, 12

Material: 1 right valve, 10 left valves, 81 carapaces

Dimensions: left valve: L = 0.40 – 0.47 mm
H = 0.24 – 0.25 mm
L/H = 1.62 – 2.00
carapace: L = 0.40 – 0.48 mm
H = 0.21 – 0.25 mm
L/H = 1.75 – 1.95 W = 0.19 – 0.25 mm

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian.

Loxoconcha favata KUIPER, 1918
Pl. 7, fig. 5–6.

1918. *Loxoconcha favata* n. sp. KUIPER, pp. 25–26, T. I, F. 7.
1956. *Loxoconcha favata* KUIPER – OERTLI, pp. 67–68, T. 8, F. 198–207
? 1969. *Loxoconcha favata* KUIPER – CARBONNEL, p. 196, Pl. 8, f. 27–28
? 1969. *Loxoconcha favata* KUIPER – SCHEREMETA, pp. 157–158, t. XV, f. 11.
? 1973. *Loxoconcha favata* KUIPER – SONNE, Abb. 8.
1975. *Loxoconcha favata* KUIPER – BRESTENSKÁ, p. 405, T. 10, F. 1–6.
? 1981. *Loxoconcha* sp. – UFFENORDE, p. 179, T 8, F 22, T 9, F 1–2.
? 1981. *Loxoconcha (Kuiperina)* aff. *boldi* BASSIOUNI, 1965 – UFFENORDE, p. 180, t. 3, f. 22–23.

Description

1. Shape. Left valve. outer lateral view. The anterior outline is asymmetrically rounded: radius of the upper part is much larger than that of the lower part. The anterior outline turns into the nearly straight dorsal outline at 0.3 length by a 140° break. The cardinal angle is slightly protruding. The dorsal outline turns into the posterior outline behind 0.8 length by a 120° break. The upper, smaller branch of the posterior outline is slightly concave, then it becomes slightly convex after a 110–120° break. The posterior outline turns into the near straight ventral outline behind 0.8 length. Height occupies an anterior position.

Right valve. The dorsal outline is more straight.

Left valve, dorsal view. Behind a short, flat anterior margin the rise of the valve surface decreases from 60° to 0° till 0.3 length. Then it is parallel with the plane separating the valves till 0.7 length then shows a gradual steepening. At 0.9 length it becomes nearly perpendicular to the plane between the valves. Then the surface ends with a flat caudal process.

2. Ornamentation. The lateral surface is irregularly, coarsely reticulated. Riblets of the reticulation are very sharp. The anterior margin and the caudal area bears no reticulation. There is a weak anteromarginal and posteromarginal keel, well visible in dorsal view. Reticulation starts with a concentric rib parallel with the marginal keel. The dorsal surface is less swelled than the ventral.

3. Dimensions: right valve: L = 0.55–0.57 mm
H = 0.32–0.33 mm
L/H = 1.71–1.74
left valve: L = 0.54–0.57 mm
H = 0.31–0.32 mm
L/H = 1.74–1.85

4. The inner lamella is wide anteriorly and posteroventrally, having a definite vestibulum.

5. Few, simple, straight marginal pore canals far from each other.

6. In the hinge of the left valve the small anterior socket is surrounded by the anteromedian tooth, which is continued in a reticulated posteromedian bar The larger, elongate posterior socket is divided by a ridge. In the right valve the small anterior tooth is surrounded in a half circle by an anteriomedian socket. This is followed by a reticulated posteromedian furrow and an elongate posterior tooth divided into two parts.

7 – 8. Normal pores and muscle scars cannot be studied well.

9. Small, definite eye-tubercle. An anteromarginal keel starts from there.

10. The left valve slightly overlaps the right one ventrally and posterodorsally.

11 Part of the specimens is more elongate. These might be the male ones.

12. Outline and ornamentation shows variability within the same sample as well. The dorsal and ventral outlines may be straight or slightly sinuous as well. Ornamentation may be smaller and weaker on some specimens. The valve surface is slightly depressed above the muscle scar area on some specimens. Angle between the two branches of the posterior outline and the angle between the upper branch and the dorsal outline may be slightly variable. Appearance of one or two concentric ribs parallel with the marginal keel is variable, too.

Remarks

These specimens are in good agreement with the figured ones of OERTLI (1956) and BRESTENSKÁ (1975). The depression before median length in dorsal view figured by OERTLI is weak or absent. Figured specimens of CARBONNEL (1969) and SCHEREMETA (1969) differ in outline, of SONNE (1973) in ornamentation (also it differs from the type, too.) Specimens of UFFENORDE (1981) ranged in an other group are very close to *L. kuiperi*. This significant morphological variability recognizable in a single sample suggests a widespread species of considerable variability

Occurrence

Alcsútdoboz – 3 borehole 170.0 m, 336.0 m, 373.0 m; 413.0 m
Cserépváralja – 1 borehole: 336.8 – 337.0 m

Material· 5 right valves, 7 left valves

Stratigraphical and geographical distribution according to previous descriptions: Netherlands: Rupelian – Miocene; Switzerland: Rupelian; (?) France: Miocene; (?) Soviet Union: Oligocene; (?) BRD: Oligocene – Lower Miocene; Czechoslovakia and Hungary: Egerian.

Loxoconcha ex gr. *subovata* (VON MÜNSTER, 1830)

Remarks

Coarsely reticulated forms characterized by strong, sharpening ventrolateral swelling. Ornamentation is absent anteromarginally and postero-

marginally The posterior valve surface is weak behind the swelling. The anterior and posterior outline are both asymmetrical. The dorsal outline is slightly, the ventral one is more definitely convex. These specimens are close to the ones figured as *L. subovata* (MUNSTER) by some authors. Many unrelated forms from Lower Eocene to Miocene are summarized under this name (*L. subovata*) so this species needs revision.
Occurrence: Alcsútdoboz – 3 borehole: 442.0 m
Material: 2 left valves, 1 carapace.

Loxoconcha sp.

Remarks

Stubby, rhomboidal valves bearing a very finely pitted lateral surface. The most similar forms have been described from Upper Miocene only This material is not sufficient to erect a new species.

Occurrence:
Kiscell – 1 borehole: 51.6 m, 56.5 m
Budapest, Zugliget. outcrop: sample no. 3 (?)

Material: 1 right valve, 2 carapaces.

Familia Paracytherideidae PURI, 1957
Genus *Paracytheridea* G. W. MÜLLER, 1894

Paracytheridea sp.

Remarks

This forms is related to *P. gradate* (BOSQUET, 1852) in its outline and observable elements of ornamentation.
Occurrence: Alcsúdoboz – 3 borehole: 742.5 m
Budapest, Pusztaszeri út outcrop: sample no. 24.
Material: 2 right valves.

Familia Cytheruridae G W. MÜLLER, 1894
Subfamilia Cytherurinae G W MÜLLER, 1894
Genus *Eucytherura* G. W MÜLLER, 1894

Eucytherura dentata LIENENKLAUS, 1905
Pl. 7, fig. 7.

1905. *Eucytherura dentata* n. sp. – LIENENKLAUS, p. 57, T IV, f. 31.
1957. *Eucytherura dentata* (LIENENKLAUS) – KEIJ, p. 151, Pl. XXIII, f. 4 – 8
1969. *Eucytherura dentata* LIENENKLAUS – SCHEREMETA, pp. 129 – 130, t. XI. f. 12 – 13
1973. *Eucytherura dentata* LIENENKLAUS – MOOS, t. 1, f. 21.
1975. *Eucytherura dentata* LIENENKLAUS – BRESTENSKÁ, p. 400, T. 9, F. 10 – 14
1975. *Eucytherura dentata* LIENENKLAUS – DOEBL, SONNE, pp. 143 – 144, T. 2. f. 14.

Description

1. Shape. Right valve, lateral view The anterior outline is scarcely asymmetrical. It bears coarse, uneven denticulation. The anterior outline turns into the dorsal outline by a break at 0.4 length. The latter is uneven due to the strong ornamentation. The dorsal outline turns into the posterior outline by a sharp break slightly behind 0.8 length. Upper branch of the posterior outline is concave, the lower branch is straight, enclosing an 50–60° break with the dorsal outline. The caudal end is strongly tapering at the level below one-fourth of maximal height. The ventral outline is slightly convex from 0.7 length, behind this it is covered by the posteroventral projection.

2. Ornamentation. The valve surface is coarsely, irregularly reticulated. There is a stronger rim from the vicinity of the anterior edge at one-third of the local height. This rib terminates slightly before the ventral keel at the half of the local height. The wing-like ventral widening terminates as a protruding edge at 0.8 length. On the lower part of this wing-like widening there are two, nearly parallel sharp riblets running from the anterior margin to about half length. Height is in anterior position.

3. Dimensions: right valve: L = 0.41 mm H = 0.22 mm
L/H = 1.84

4–8. The inner characters cannot be examined.

9. Slightly observable small eye-tubercle.

Remarks

Our specimen is in good agreement with the figures of KEIJ (1957). Its relations to the species *E keiji* (PIETRZENIUK, 1969) cannot be cleared on literature data.

Occurrence

Kiscell 1 borehole: 103.5 m

Noszvaj, Síkfőkút, outcrop· sample no. 15.

Material· 1 right valve, 1 carapace

Stratigraphical and geographical distribution according to previous descriptions· BRD· Rupelian, Belgium; Bartonian – Rupelian, Soviet Union: Bartonian – Lower Oligocene; Czechoslovakia: Rupelian – Egerian.

Genus *Semicytherura* WAGNER, 1959

Semicytherura ex gr. *gracilis* (LIENENKLAUS, 1895)

Pl. 7, fig. 8–9.

Remarks

Double valves. Details of the ornamentation cannot be studied well due to bad preservation. The shape is elongated, the dorsal outline is slightly convex, the ventral outline is slightly concave, the anterior outline is asymmetrically rounded with a small arc in its lower half. The strong caudal process lies in the median line. The upper branch of the posterior outline is less concave than the lower one. The upper branch gradually turns into the dorsal outline, the lower branch turns into the ventral outline by a break.

The lateral surface breaks perpendicularly to the valve surface on the ventral part, especially posteriorly. The lateral surface bears a more or less even longitudinal ribbing. The ribs converge anteriorly and posteriorly; part of them join on their anterior or posterior parts.

Occurrence:

Budapest, Pusztaszeri út, outcrop: samples no. 2, 21, 22, 24,26.
Material: 14 carapaces.

Semicytherura ? sp.

Remarks

This poorly preserved specimen can be related to *Semicytherura gracilis* (LIENENKLAUS) after its form. But the caudal process is very short and ornamentation cannot be observed.

Occurrence:

Budapest, Pusztaszeri út, outcrop: sample no. 20.
Material: 1 carapace

Subfamilia Cytheropterinae HANAI, 1957
Genus *Cytheropteron* SARS, 1866

Cytheropteron brevalata PIETRZENIUK, 1969

1969. *Cytheropteron (Cytheropteron) brevalata* n. sp. – PIETRZENIUK. p. 104, T. VIII, f 5–8, T. XVII, f. 10, T. XXIII, f. 13–14.
1973. *Cytheropteron (Cytheropteron) brevalata* PIETRZENIUK – MOOS, pp. 55–56, T. 8, f. 1–3
1977. *Cytheropteron (Cytheropteron) brevalata* PIETRZENIUK – SZCZECHURA. p. 74, Pl. 15, f. 5, Pl. 26, f. 1–4

Description

1. Shape. Left valve, outer lateral view. The anterior outline is asymmetrically rounded; radius of the lower part is small, of the upper part is large. The anterior outline turns into the arched dorsal outline gradually. After 0.8 length, at the beginning of the relatively wide caudal process the outline has a small break, it is depressive. The lower and upper branches of the posterior outline enclose a 60–70° angle. The lower branch gradually turns into the ventral outline. The ventral outline is formed by the ventral wing-like widening between one-fourth and three-fourth length. The tip of the caudal process lies about at the longitudinal half line of the valve, Height is in slightly posterior position.

Dorsal view of double valve. The lateral surface rises in 40° till 0.3 length. than after a very short, much more steep section the rise decreases to 0° till behind 0.7 length. There width of the valves decrease to the half perpendicularly to the plane separating the valves. Then there is a 40° slope till 0.9 length and a 10–20° flat, caudal termination.

2. Ornamentation. The wing-like widening bears a ventral edge.

Above this the valve surface is depressive, bearing definite pitting.

3. Dimensions: carapace: L = 0.51 mm H = 0.30 mm
L/H = 1.72 W = 0.35 mm

4 – 8. Inner characters cannot be examined.

9. No eye-spot.

Remarks

Shape of the wing-like widening is somewhat different from the type; it is well observable in dorsal view. No taxonomic value can be attributed to this character on this single specimen.

Occurrence:

Budapest, Zugliget, outcrop. sample no. 3.

Material: 1 carapace

Stratigraphical and geographical distribution according to previous descriptions: GDR: Upper Eocene – Lower Oligocene; Poland· Upper Eocene.

Cytheropteron emmeneggeri SCHERER, 1964

1982. *Cytheropteron emmeneggeri* SCHERER – MONOSTORI, pp. 72 – 74, Pl. VIII. fig. 7 – 11 (cum syn.)

Remarks

Morphological characters of this material are the same as those of the Kiscellian material from Budapest (MONOSTORI, 1982). The individial variability described there can be observed here, too.

Occurrence

Kiscell – 1 borehole: 51.6 m, 55.5 m, 56.5 m; 58.5 m; 59.5 m; 62.5 m
Eger, Kiseged, road cut: samples no. 2a, 3a, 3b, 4, 12, 13.

Material: 7 right valves. 11 left valves. 94 carapaces.

Dimensions: right valve: L = 0.52 mm H = 0.30 mm
L/H = 1.76
left valve: L = 0.44 – 0.52 mm
H = 0.25 – 0.28 mm
L/H = 1.76 – 1.83
carapace: L = 0.51 – 0.55 mm
W = 0.31 – 0.33 mm

Stratigraphical and geographical distribution according to previous descriptions: Switzerland: Rupelian; Hungary: Kiscellian.

Cytheropteron sp.

Remarks

Damaged, compressed specimen from the group of *C. brevalata* PIETRZENIUK, 1969.

Occurrence: Budapest, SZOT – 6 borehole: 11.0 m

Material: 1 left valve

Familia Xestoleberididae SARS, 1928

Genus *Xestoleberis* SARS, 1866

Xestoleberis sp.

Remarks

Adult specimens are more rare than juvenile ones. These may form several species, but more probably a single, very variable species. Their relatives may be looked after in the group *X. mülleriana* LIENENKLAUS, 1900 *X. elongata* LIENENKLAUS, 1894 – *X. complanata* DELTEL, 1961. Besides the carapaces we have extremely damaged single valves only This material is not sufficient for a better determination.

Occurrence

Alcsútdoboz – 3 borehole· 737.0 m; 742.5 m; 752.5 m
Kiscell – 1 borehole· 91.5 m
Budapest, Pusztaszeri út, outcrop: samples no. 2, 3, 5, 10, 20, 21, 22, 24, 26, 27.

Budapest, SZOT – 1 borehole: 7.0 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole. 6.0 m; 10.8 m
Budapest, Zugliget, outcrop: sample no. 3
Noszvaj, Síkfőkút, quarry: bed no. 18

Material: 2 right valves, 2 left valves, 43 carapaces

Genus *Uroleberis* TRIEBEL, 1958

Uroleberis odessensis SCHEREMETA, 1969

Pl. 7, fig 10 – 13.

1969. *Uroleberis odessensis* n. sp. – SCHEREMETA, pp. 218 – 219, t. XXI, f. 6

Description

1. Shape. Left valve, outer lateral view The anterior outline is strongly asymmetrically rounded and gradually turns into the arched dorsal outline. The dorsal outline has a slight break at 0.4 length and a stronger break at 0.8 lenght. After the latter break follows the near straight posterior outline. The posterior end is tapering with a 60° tip at the level of the lower one-fourth of maximal height. After the sharp break the ventral outline is slightly and asymmetrically arched. Maximal convexity of the arc is shifted from the median length. Height lies in the centre.

Dorsal view of the carapace. After a short, flat anterior section the rise of the surface decreases from 60° to 0°, then the slope increases from 0° to 90° till the end of the valves.

2. Ornamentation. The ventral lateral surface has a sharp break. This break forms the ventral outline. The lateral surface bends backwards below it. This break becomes sharper, keel-like posteriorly. There are furrows parallel with the edge on the depressive surface below the break. They are separated by two parallel ribs. There are only fine pits on the lateral surface above the edge.

3. Dimensions. Carapace: L = 0.45 0.48 mm
H = 0.24–0.27 mm
L/H = 1.78–1.79
W = 0.21 0.33 mm

4 8. Inner characters cannot be examined.

9. No eye-spot.

11. Part of the specimens are more elongate, lower and narrower in dorsal view than the others. These may be the male forms.

12. The outline may show significant variations within a sample. The dorsal outline may be less arched, the posterior end is less tapering sometimes and may occupy a higher position. The ventral outline may be straight and even highly concave as well. The ventral edge is frequently weak; even the overlap may be arched towards the ventral surface. The grooving of the ventral surface may be weak and sometimes cannot be observed on edgeless forms.

Remarks

Deviations in outline and ornamentation from the type description do not suggest a new taxon due to the significant morphological variability Separation from the Paleocene *U mazoviensis* Szczechura, 1965 needs a detailed comparison with type materials due to the significant morphological variability

Occurrence

Alcsútdoboz–3 borehole 737.0 m, 742.5 m
Kiscell 1 borehole 89.5 m, 100.2 m, 103. 5m, 108.3 m,
Budapest, Pusztaszeri út, outcrop: samples no. 2, 3, 5, 10, 13, 20, 21, 22, 24, 26, 27.
Budapest, Ibolya utca. quarry 1.2 m, 4.4 m, 7.0 m
Budapest, SZOT–1 borehole 5.5 m
Noszvaj, Síkfőkút, quarry sample no. 18.

Material: 2 right valves, 5 left valves, 65 carapaces.
Stratigraphical and geographical distribution according to prevoius descriptions. Soviet Union: Upper Eocene.

Uroleberis striatopunctata (Ducasse. 1967)

1959. *Eocytheropteron striatopunctatum* n. sp. – Ducasse, pp. 44 45, t. XIX, f. 2a b
1961. *Uroleberis striatopunctata* (Ducasse)–Deltel, p. 137, t. 12, f. 209
1966. *Uroleberis striatopunctata* (Ducasse)–Moussou, p. 75, t. 21, f. 85a–85a–b
1967. *Uroleberis striatopunctatus* n. sp. – Ducasse, pp. 61–62, t. III. f. 67
1969. *Uroleberis striatopunctata* Ducasse–Ducasse, p. 103, t. VII, f. 148
1971 *Uroleberis striatopunctata* Ducasse Blondeau, p. 97, t. X, f. 16.
1973. *Uroleberis striatopunctatum* Ducasse–Sönmez Gökcen, p. 95, t. XII. f. 36–37

Description

1. Shape. Left valve, outer lateral view. The anterior outline is strongly asymmetrical. Its lower one-third is rounded by a small-radius arc, the upper two-third is near straight. The anterior outline turns into the dorsal outline gradually behind 0.2 lenght. The latter is strongly arched. The dorsal outline turns into the posterior outline forming the caudal process with a slight break behind 0.9 lenght. The upper branch of the posterior outline is slightly concave. Its tip lies slightly above one third of maximal height. The lower branch is slightly concave as well. The posterior outline turns into the asymmetrical ventral outline at 0.9 length. The latter is convex at the beginning, but soon becomes straight.

Right valve. The upper branch of the anterior outline is more straight, the upper branch of the posterior outline is more concave.

Double valve, dorsal view. The rise of the surface decreases from 45° to 0° till 0.5 length. Then the slope increases from 0° till 45° till behind 0.9 length. The end is a short, parallel valve surface with caudal process.

2. Ornamentation. The surface of the valves is pitted. Details cannot be studied well. Traces of concentric pattern ventrally.

3. Dimensions: carapace: L = 0.55 mm H = 0.39 mm
L/H = 1.41 W = 0.35 mm

4–8. Inner characters cannot be examined.

9. No eye-spot.

Remarks

Form and examinable details of the ornamentation are in good agreement with the type of DUCASSE.
Occurrence: Noszvaj, Síkfőkút, quarry: sample no. 21
Material: 1 carapace

Stratigraphical and geographical distribution according to previous descriptions: France· Lower Eocene–Stampian, Turkey· Bartonian.

Uroleberis sp.

Remarks

Poorly preserved specimen attributable to this genus. It cannot be determined to the species level.

Occurrence:
Budapest, Ibolya utca. quarry: 5.5 m
Budapest, SZOT–6 borehole: 10.8 m

Material: 2 carapaces

Familia Bythocytheridae SARS, 1866
Genus *Monceratina* ROTH, 1928

Monoceratina ? cf. *striata* DELTEL, 1961

Remarks

Outlines in lateral and dorsal view, characters and form of the wing-like widening, position and details of the dorso-ventral sulcus and the weak antero-ventral depression are in good agreement with the description and figures of DELTEL on this poorly preserved specimen. Parallel longitudinal riblets can be recognized in traces on the ventral side of the wing-like widening in ventral view

Occurrence: Budapest, Pusztaszeri út, outcrop: sample no. 27.

Material: 1 carapace.

Familia Macrocyprididae G. W. MÜLLER, 1912

Genus *Macrocypris* BRADY, 1868

Macrocypris cf. *cylindracea* (BORNEMANN, 1855)

Remarks

Relatively poorly preserved specimens. They can be attributed to this species, because the outline and especially the beak-like form of the posterior end are in good agreement with the figures of TRIEBEL (1960). Its cause is the weaker and the stronger concavity on the posterior and ventral outlines forming the tapering, respectively.

Occurrence:

Cserépváralja – 1 borehole. 435.6 – 435.8 m
Budapest, Pusztaszeri út, outcrop: sample no. 5
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, Zugliget, outcrop: sample no. 12

Material: 5 carapaces

Dimensions: carapaces: L = 0.93 – 0.94 mm

Familia Pontocyprididae G W MÜLLER, 1894

Genus *Abyssocypris* VAN DEN BLOD, 1974

Abyssocypris palavensis POKORNÝ, 1979

Pl. 7, fig. 14 – 15.

1979. *Abyssocypris (Proabyssocypris) palavensis* n. sp. – POKORNÝ, pp. 196 – 199, Pl. I, f. 1 – 3, Text-figs. 1 – 3

Description

1. Shape. Left valve, outer lateral view. The anterior outline is nearly symmetrically rounded. The anterior outline turns into the dorsal outline with a barely recognizable break at 0.1 length. The latter is rounded in a long-radius arc. The dorsal outline turns into the posterior outline with a slight break behind 0.8 length. The upper two-third of the posterior outline is near straight, the lower one-third is rounded by a short-radius arc. The ventral outline is asymmetrical. Its anterior part is straight or slightly concave and it is definitely convex posteriorly, having its maximum at 0.6 length. Arc of the ventral outline has much more longer radius than the dorsal one. Height lies at about half length.

Right valve. Its outline is considerably different, especially ventrally It is scarcely sinuous but near straight. Arc of the dorsal outline breaks before 0.4 length and at 0.8 length. Its sections are nearly straight. The tapering part of the posterior outline of very short radius can be found in a lower position of the maximal length than on the left valve, due to the shape of the ventral outline.

Dorsal view of the carapace. Overlapping of the left valve can be well observed. Consequently, arc of the left valve is perpendicular at first to the plane separating the valves anteriorly and posteriorly Then it is flat anteriorly after a significant break. On the posterior end the outline turns into a breakless arc of growing radius from the perpendicular end in anterior direction. Maximal height lies slightly behind 0.5 length.

2. Ornamentation. Surface of the valves is smooth.

3. Dimensions: carapace: L = 0.60 – 0.65 mm
H = 0.37 – 0.38 mm
L/H = 1.65 – 1.77
W = 0.31 – 0.33 mm

4 – 8. The inner characters cannot be studied.
9. No eye-spot.
10. The left valve wholly overlaps the right one.
12. There is a slight variation in the outline only

Remarks

Even details of the Hungarian specimens are in agreement with the Czechoslovak type material, so the identification can be carried out without the knowledge of the inner characters.

Occurrence

Cserépváralja – 1 borehole 407.4 – 407.6 m 412.4 – 412.6 m
Kiscell – 1 borehole: 100.2 m
Budapest, Ibolya utca, quarry: 4.4 m
Budapest, SZOT – 1 borehole: 7.0 m
Budapest, SZOT – 6 borehole: 10.8 m, 11.0 m

Stratigraphical and geographical distribution according to previous descriptions: Czechoslovakia: Lower Oligocene.

Genus *Argilloecia* Sars, 1866

Argilloecia quasiramphasta n. sp.

Pl. 8, fig. 1 – 3.

Derivatio nominis: from its similarity to *A ramphasta.*
Holotypus: carapace
Locus typicus: Cserépváralja – 1 borehole
Stratum typicum: Uppermost Eocene, 407. – 407.6 m
Diagnosis: Form having a flat dorsal outline. Strongly tapering posterior end of the left valve is not at the bottom of maximal length, but somewhat below its one-fourth.

Description

1. Shape. Right valve. outer lateral view. The anterior outline is slightly asymmetrically rounded. It turns into the flatly arched dorsal outline before 0.1 length. The dorsal outline turns into the posterior outline by a gradually steeper arc after 0.7 lenght. The posterior outline turns into the ventral outline by a tiny asymmetric sinus, making the posterior end strongly tapering. This tapering is situated slightly above the bottom of the maximal height. After the tiny sinus the ventral outline has a definite, slightly asymmetrical sinus, having its maximal protuberance behind 0.7 length and maximal sinuosity at 0.4 length. The ventral outline turns into the anterior outline more gradually than the anterior outline into the dorsal outline, making the anterior outline slightly asymmetrical. Height is positioned slightly anteriorly

Left valve. Asymmetry of the anterior outline is stronger and arc of the dorsal outline is more symmetrical. Tip of the posterior outline lies slightly below one-fourth of maximal length. There is no tiny sinus on the ventral outline like on the right valve. The ventral sinus is definite and nearly symmetrical.

Dorsal view of the carapace. Rise of the lateral surface starts by 40–45° both anteriorly and posteriorly Width is in the middle region. On the posterior part the increase of the slope from 0° to 40–45° is more gradual than on the anterior part.

2. Ornamentation. The lateral surface is smooth.

3. Dimensions· right valve. L = 0.51–0.52 mm
H = 0.22–0.24 mm
L/H = 2.15–2.32
left valve L = 0.53 mm H = 0.20 mm
L/H = 2.65
carapace: L = 0.53 0.54 mm
L/H = 2.19 2.42
H = 0.22 0.25 mm
W = 0.19 0.20 mm

4–8. The inner characters cannot be examined.
9. No eye-spot.
10. The right valve overlaps the left one.
12. Slight variability in shape and elongation.

Comparison

The species described here is nearest to *A. ramphasta* of Bold (1946). The more flat dorsal outline and the position of the posterior end of the left valve (this latter lies at the bottom of the maximal height of the left valve on the figures of *A. ramphasta*) is definitely different from the sketchy original description and figures and from the form described by Pietrzeniuk (1969) under the name *A. ramphasta*.

Occurrence

Alcsútdoboz – 3 borehole. 742.5 m, 752.5 m
Cserépváralja – 1 borehole: 240.0 240.2 (?); 407.4 – 407.6 m; 412.4 – 412.6 m, 416.9 – 417.0 m; 419.0 419.2 m (?); 435.6 – 435.8 m
Kiscell – 1 borehole: 83.4 m (?), 98.5 m, 100.2 m, 103.5 m
Budapest, Pusztaszeri út, outcrop. samples no. 2, 3, 5, 22, 26, 27.
Budapest, Ibolya utca. quarry: 7.9 m (?)
Noszvaj, Síkfőkút, quarry: samples no. 18 (?). 21 (?)

Material: 11 right valves, 5 left valves, 62 carapaces

Familia Candonidae Kaufmann, 1900
Subfamilia Paracypridinae Sars, 1923

Genus *Paracypris* Sars, 1866
Paracypris aff. *aerodynamica* Oertli, 1956

Description

1. Shape. Left valve, outer lateral view The anterior outline is asymmetrically rounded. It turns into the straight dorsal outline by a 130° break slightly before 0.2 length. The dorsal outline is slightly arcuate after a very weak break from 0.5 length. The posterior outline has a very short-radius arc and tapers at the level of the lower one-third of maximal height. The ventral outline is strongly sinuous. From the posterior end the ventral outline is slightly convex at first at three-quarter of maximal length, then strongly concave (max. concavity at 0.5 length). The ventral outline turns into the anterior outline by a gradually steepening arc. In the upper one-third of the anterior outline the radius of the arc lengthens and the outline is nearly straight before the anterodorsal angle. Height lies at about 0.2 length.

2. Ornamentation. Valve surfaces are smooth.
3. Dimensions: left valve: L = 1.00 mm H = 0.35 mm
L/H = 2.83
4 – 8. Inner characters cannot be studied.
9. No eye-spot.

Remarks

The ventral outline is more sinuous and the height shifted forward than on the type.
Occurrence: Budapest, SZOT – 4 borehole: 54.0 m
Material: 1 left valve

Paracypris cf. *aerodynamica* Oertli, 1956

Remarks

Outline of this poorly preserved specimen is in agreement with this species on the section where it can be studied.
Occurrence: Eger, Kiseged, road cut: sample no. 4.
Material· 1 carapace

Paracypris cf. *propinqua* TRIEBEL, 1963

Description

1. Shape. Left valve, outer lateral view. The anterior outline is simmetrically rounded and gradually turns into the dorsal outline. The dorsal outline is near straight till 0.3 length, then it has a 150° break. After the break it is arcuate till 0.7 length. Then a similar break follows, then it is straight till the posterior outline and turns into it by a very short-radius arc. After the turn the ventral outline is nearly straight and it encloses a 45° break together with the posterior straight section of the dorsal outline. The ventral outline bears a very weak sinus in the middle.

Right valve. It bears a definite, strong sinus on the middle part of the ventral outline.

2. Ornamentation. The lateral surface is smooth.

3. Dimensions. carapace L = 1.13 mm H = 0.46 mm
L/H = 2.46

4 – 8. Inner characters cannot be examined.

9. No eye-spot.

Remarks

Outline of this single, compressed specimen indicates this species.

Occurrence Cserépváralja – 1 borehole· 407.4 407.6 m
Material: 1 carapace

Paracypris ? *rupelica* MONOSTORI, 1982

1982. *Paracypris* ? *rupelica* n. sp. – MONOSTORI, pp. 65 – 66, Pl. VII, fig. 2 – 3

Remarks

The present specimens display mostly the same characters as the type material from Budapest (MONOSTORI, 1982). The following completing can be made.

The ventral outline may be near straight on the left valve. On both valves the transition towards the posterior outline is more steep; the radius of the arc decreases from 0.8 length. The posterior transition of outlines (tip) is more tapering and may be slightly lower before one-fourth of maximal height. In this case lower arc (turning into the ventral outline) may have a longer radius. Part of thes specimens from Pusztaszeri út is very small carapace, only 0.5 – 0.6 mm long (juvenile ?)

Occurrence

Cserépváralja 1 borehole: 240.0 240.2 m; 265.4 – 265.6 m; 285.8 – 296.0 m

Budapest, Pusztaszeri út, outcrop: samples no. 21, 22, 24, 26, 27.
Budapest, SZOT – 1 borehole: 5.5 m; 16.0 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole: 10.8 m
Eger, Kiseged, road cut: sample no. 10.

Material: 7 right valves, 4 left valves, 97 carapaces

Dimensions: right valve: L = 0.85 – 0.98 mm
H = 0.39 – 0.45 mm
L/H = 2.05 – 2.18 mm
left valve: L = 0.97 mm H = 0.50 mm
L/H = 1.95

Stratigraphical and geographical distribution according to previous descriptions: Hungary: Kiscellian.

Paracypris sp.

Remarks

Mostly juvenile carapaces of poor preservation, belonging to the group of *P. rupelica*.

Occurrence

Kiscell – 1 borehole: 91.5 m
Budapest, Pusztaszeri út, outcrop: samples no. 2. 5.

Material: 6 carapaces

Phlyctenophora oligocaenica (ZALÁNYI, 1929)

Pl. 8, fig. 4.

1929. *Pontocypris oligocaenica* n. sp. – ZALÁNYI, pp. 91 – 93, T. II, F. 1, Textfig. 38.
1938. *Pontocypris oligocaenica* ZALÁNYI – SCHWEYER, pp. 65, 69, t, f. 1 4
1964. *Pontocypris oligocenica* ZALÁNYI – SCHEREMETA, pp. 111 – 112, t. III. f. 1 – 2
1969. *Pontocypris oligocaenica* ZALÁNYI SCHEREMETA, p. 66, t. IV, f. 1 – 2
1975. ? *Phlyctenophora oligocaenica* (ZALÁNYI) – BRESTENSKÁ, pp. 386 387, T. 4, F. 1 – 6.

Description

1. Shape. Left valve, lateral view. The anterior outline is nearly symmetrically rounded and it gradually turns into the dorsal outline rounded by an arc of long radius. On the dorsal outline a decrease in the radius of the arc indicates the transition into the posterior outline from 0.7 length. The posterior outline turns into the ventral one by a very short radius arc slightly tapering at the lower one-third level of maximal height. The ventral outline is sinuous, the maximal sinuosity lies a little before 0.5 length. Height lies in the middle.

2. Ornamentation. Valve surface is smooth.

3. Dimensions left valve: L = 0.74 mm H = 0.34 mm
L/H = 2.17

4. The inner lamella is wide, having a large anteroventral and a smaller, but definite posterior vestibulum.

5. Very many, ramifying marginal pore canals.

6. Hinge of the left valve is a simple furrow.

7 There are scattered simple normal pores.

8. Between the muscle scars of the left valve, on the anterior part of the muscle scar area there are 4 adductor muscle scars ranged in a slightly arcuate row, decreasing in size in ventral direction. There are two more adductor muscle scars in the posterior part of the muscle scar area, in the same level as the lower two scars of the anterior row of scars. Before the anterior row of scars there are 2 obliquely lying scars below and an elongated scar above.

12. On some specimens the left valve bears dorsal outline with a straight part in the middle and with a posterior tapering situated a little lower

Remarks

The ventral outline is a little more sinuous than that of the type of ZALÁNYI. Morphological characters indicate the *Phlyctenophora* genus, except the larger dimensions of the inner lamella and the vestibulum anteriorly

Occurrence: Alcsútdoboz – 3 borehole: 199.0 m

Material 2 left valves, 2 fragments

Stratigraphical and geographical distribution according to previous descriptions: Hungary and Czechoslovakia: Egerian, Soviet Union: Oligocene.

Subfamilia Candoninae KAUFMANN, 1900

Genus *Candona* BAIRD, 1845

Candona ? *recta* LIENENKLAUS, 1905

Pl. 8, fig. 5.

1905. *Candona recta* n. sp. – LIENENKLAUS, pp. 22 – 23, T I, F 6.

1982. *Candona* ? aff. *recta* LIENENKLAUS – MONOSTORI, pp. 75 – 76, Pl. IX, fig. 2 – 3

Remarks

Due to the lack of tubercles mentioned in the type description we applied open nomenclature (MONOSTORI, 1982) The significant morphological similarity and the type figure suggest that these tubercles were only light refractory phenomena due to normal pores. Uncertainty in genus is caused by some inner characters (MONOSTORI, 1982) which are unusual in the genus *Candona*. Among these characters the hinge and the characters of the marginal pore canals shows some relations with some forms of the subfamily Paracypridinae. Consequently, we cannot exclude that this species is really a marine form.

The present fauna is fragmentary and compressed except the material from Zugliget and Kiseged. On some specimens the dorsal side maý be more arcuate and the ventral side more sinuous. In the latter case the anterior part of the valve is somewhat lower.

Occurrence

Kiscell – 1 borehole· 51.6 m; 55.5 m; 56.5 m; 58.5 m, 59.5 m

Budapest, Zugliget, outcrop: samples no. 3, 7, 9.

Eger, Kiseged, road cut: samples no. 3a, 3b, 12.

Material· 2 right valves, 1 left valve, 44 carapaces, 13 fragments

Dimensions: right valve: L = 0.98 mm H = 0.46 mm
L/H = 2.13
left valve· L = 0.94 mm H = 0.45 mm
L/H = 2.11
carapace: L = 1.10 mm H = 0.53 mm
L/H = 2.07 W = 0.39 mm

Stratigraphical and geographical distribution according to previous descriptions: BRD: Lowermost Miocene; Hungary: Kiscellian.

Candona sp.

Remarks

Poorly preserved forms, similar to *C. fertilis* TRIEBEL group in their outlines.

Occurrence: Budapest, SZOT – 1 borehole: 16.0 m

Material: 1 right valve, 1 carapace

Familia Cypridopsidae KAUFMANN, 1900

Cypridopsidae gen. et sp. indet. 1.

Remarks

Poorly preserved carapaces belonging to the group of *Curvopsis curvata* (LIENENKLAUS).

Occurrence

Budapest, Zugliget, outcrop: sample no. 3.

Eger, Kiseged, road cut, samples no. 3b and 12

Material: 13 carapaces

Cypridopsidae gen et sp. indet. 2.

Remarks

Poorly preserved carapace, dorsally rounded, its morphology indicates this family.

Occurrence

Budapest, Zugliget, outcrop: sample no. 7.

Material: 1 carapace

Cypridacea fam., gen. et sp. indet. 1.

Pl. 8, fig. 6.

Remarks

Nearly regular triangle. The anterior outline is slightly asymmetrically rounded. and the posterior outline is tapering. The two branches of the dorsal outline of nearly equal length (the posterior one is slightly longer) are straight except their mutual transition. The ventral outline is straight. too. Height in the middle. Similar forms are known in several families of the superfamily.

Occurrence

Cserépváralja – 1 borehole: 422.3 – 422.5 m

Budapest, Pusztaszeri út. outcrop: samples no. 21, 24, 26, 27.

Budapest, SZOT – 1 borehole: 7.0 m

Material: 33 carapaces

Cypridacea fam., gen. et sp. indet. 2.

Pl. 8, fig. 7 – 8.

Remarks

This form can be related with several families of this superfamily. The anterior outline is widely, asymmetrically rounded and turns into the straight dorsal outline by a break at 0.3 length. The posterior outline turns into the ventral one by a very short radius arc at the level of one-fourth of maximal length. The ventral outline is slightly convex at first but then it bears a large, asymmetrical sinus. Maximum of the sinousity lies ot 0.4 length. The ventral outline gradually turns into the anterior outline. The lower one-third of the anterior outline has a shorter radius than the upper two-third: this causes the asymmetry. The right valve slightly overlaps the left one.

Shape and outline shows individual variability. It is most near to the species *Paracypris propinqua* TRIEBEL.

Occurrence

Alcsútdoboz – 3 borehole: 737.0 m

Budapest, Pusztaszeri út, outcrop: samples no. 21, 22, 24, 26, 27.

Material: 29 carapaces

Dimensions: carapaces: L = 0.84 – 0.59 mm
H = 0.40 – 0.30 mm
L/H = 2.1 – 2.0

Cypridacea fam., gen. et sp. indet. 3.

Pl. 8, fig. 9 – 10.

Both anteriorly and posteriorly asymmetrically rounded carapaces. The dorsal outline is near symmetrically arcuate. The ventral outline bears a near symmetrical sinus. Radius of the upper part of the posterior outline is smaller, than that of the anterior outline. There is a very weak break at the transition of the dorsal and posterior outlines only.

Occurrence

Budapest, Pusztaszeri út, outcrop: samples no. 21, 22, 23.

Material: 14 carapaces

Cypridacea fam., gen. et sp. indet. 4.

Pl. 8, fig. 11.

Remarks

Valves rounded at both end. The dorsal outline is trapezoidal, the breaks are at 0.3 and 0.7 length. Ventral outline of the left valve is near straight, of the right valve is about symmetrically concave. The left valve strongly overlaps the right one dorsally. It may be ranged into the genus Lineocypris.

Occurrence
Eger, Kiseged, road cut, sample no. 3b
Material. 1 carapace

Cypridacea fam., gen. et sp. indet. div

Remarks
Poorly preserved specimens but may be ranged to this superfamily. They represent many species.
Occurrence

Cserépváralja – 1 borehole. 407.4 – 407.6 m
Kiscell – 1 borehole: 52.8 m; 89.5 m; 91.5 m, 103. 5m, 107.0 m
Budapest, Pusztaszeri út, outcrop· samples no. 2, 3, 5, 10, 13, 17, 21, 22, 24, 26, 27
Budapest, Ibolya, utca, quarry: 4.4 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole 11.0 m
Budapest, Zugliget, outcrop: samples no. 5. 11
Eger, Kiseged, samples no. 2a, 3a, 3b, 4, 12
Noszvaj, Síkfőkút, quarry: samples no. 11, 15

Material: 211 fragments, valves and carapaces

Ostracoda indet.

Remarks
These remnants can be identified as ostracod valves or carapaces only.
Occurrence

Alcsútdoboz – 3 borehole· 336.0 m, 373.0 m, 737.0 m
Budapest, Pusztaszeri út, outcrop· samples no. 5. 21
Budapest, Ibolya utca. quarry: 5.5 m; 6.0 m, 7.9 m
Budapest, SZOT – 1 borehole· 5.5 m
Budapest, SZOT – 2 borehole: 46.0 m
Budapest, SZOT – 4 borehole: 54.0 m
Budapest, SZOT – 6 borehole: 6.0 m, 11.0 m
Eger, Kiseged, road cut: samples no. 3a, 4, 12
Material: 63 fragmentary valves and carapaces.

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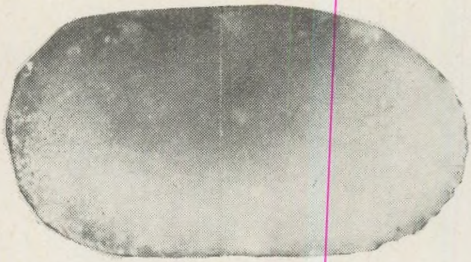

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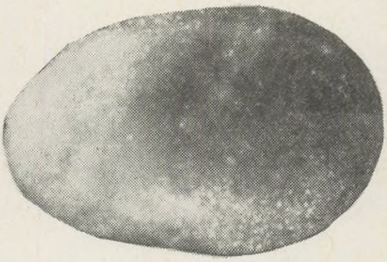

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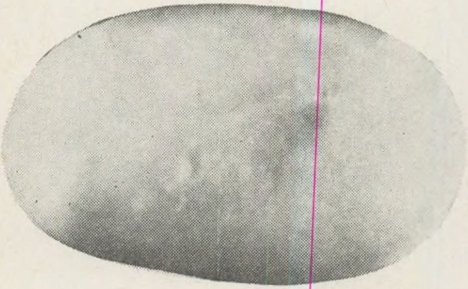

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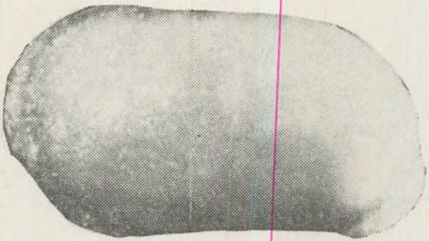

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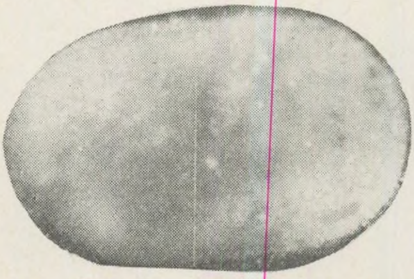

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PLATE 1.

Figs. 1 – 2. Cytherella (Cytherella) dentifera MÉHES, 1941 1. Left valve. 2. Right valve.
Figs. 3 – 4. Cytherella aff. méhesi BRESTENSKÁ, 1975 3. Right valve. 4. Left valve.
Figs. 5 – 7. Cytherella (Cytherella) pestiensis (MÉHES, 1941) 5 – 6. Left valve. 7. Right valve.
Fig. 8. Cytherella (Cytherelloidea) cf. *hieroglyphica* (BOSQUET, 1852). Left valve.

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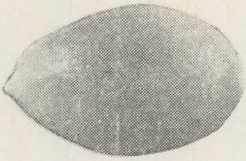

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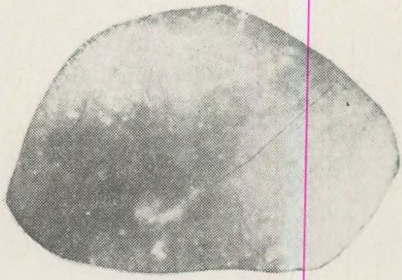

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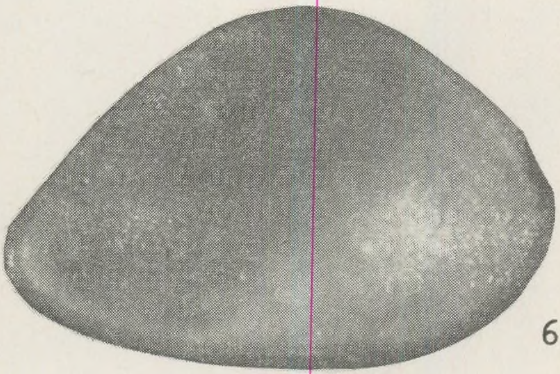

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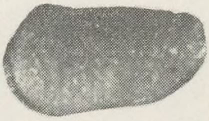

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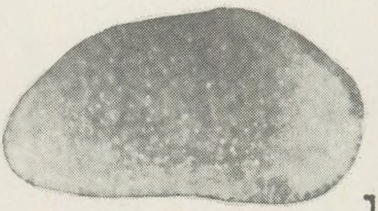

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PLATE 2.

Fig. 1. Cardobairdia hungarica Monostori, 1982 Carapace from the right valve.

Figs. 2 – 3. Carbobairdia ? spinifera n. sp. 2. Carapace from the right valve. 3. Carapace in dorsal view.

Fig. 4. Bairdia cf. *brevis* Lienenklaus, 1900 Right valve.

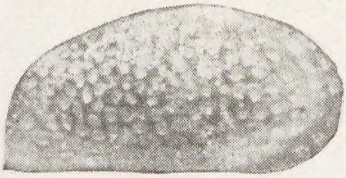
Fig. 5. Bairdia ? sp. Carapace from the right valve.

Fig. 6. Bairdia rupelica Monostori, 1982 Carapace from the right valve.

Figs. 7 – 8. Cytheromorpha subalpina dorsodepressa n. ssp. 7. Left valve. 8. Outline in dorsal view.

Fig. 9. Paijenborchella (Eopaijenborchella) sturovensis Brestenská, 1975. Left valve.

Fig. 10. Eocytheridea reticulata Goerlich, 1953. Right valve.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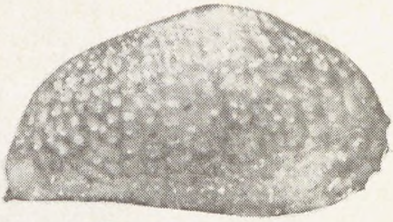
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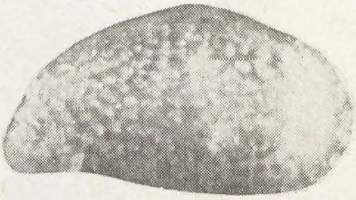
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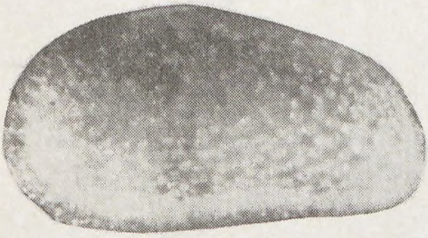
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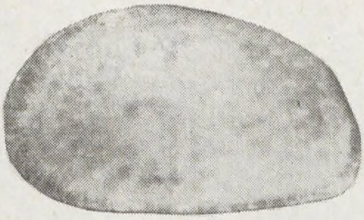
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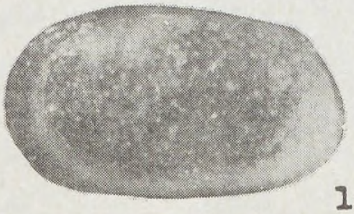
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PLATE 3.

Fig. 1 – 3. Cytheridea mülleri (v. MÜNSTER, 1830) sensu Faupel, 1975.
1 – 2 right valve. 3. Left valve.
Fig. 4. Cytheridea mülleri truncatula GOERLICH, 1953. Right valve.
Fig. 5. Cytheridea pernota QERTLI, 1956. Left valve.
Fig. 6. Cyamocytheridea punctatella (BOSQUET, 1852). Right valve.
Fig. 7 – 8. Hemicyprideis helvetica (LIENENKLAUS, 1895) 7. Juvenile right valve. 8. Left valve
Fig. 9 – 10. Miocyprideis rara (GOERLICH, 1953) 9. Right valve. 10. Left valve.

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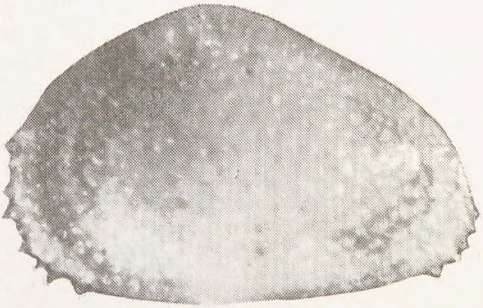

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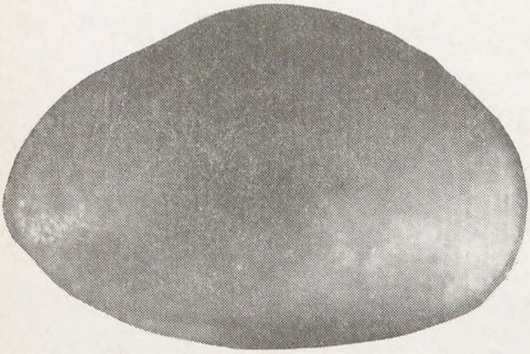

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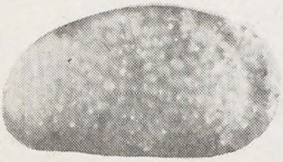

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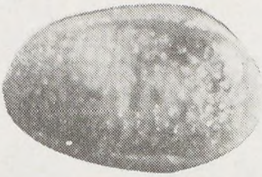

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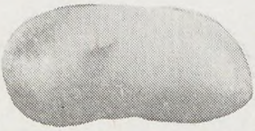

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PLATE 4.

Fig. 1. Miocyprideis rara (GOERLICH, 1953). Right valve.

Fig. 2 Schuleridea dorsoarcuata (MÉHES, 1941). Left valve.

Fig. 3. Schuleridea rauraciformis n. sp. Carapace view from the right valve.

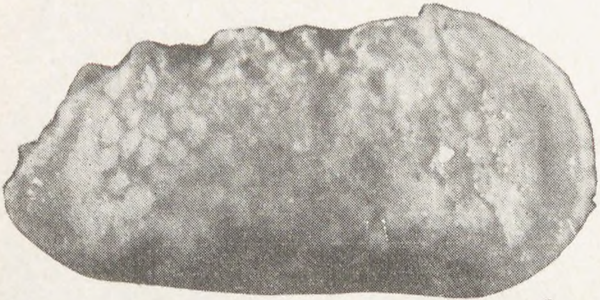
Fig. 4–6. *Cuneocythere marginata anterodepressa* MONOSTORI, 1982. 4. Left valve. 5. Right valve. 6. Carapaces, view from the right valve.

Fig. 7. Cuneocythere truncata LIENENKLAUS, 1894. Left valve.

Fig. 8. Pontocythere truncata (LIENENKLAUS, 1894) Left valve.

Fig. 9. Krithe pernoides (BORNEMANN, 1855) Left valve.

Fig. 10. Parakrithe ? sp. Carapace, view from the left valve.



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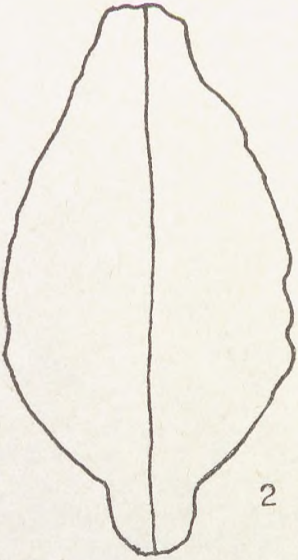

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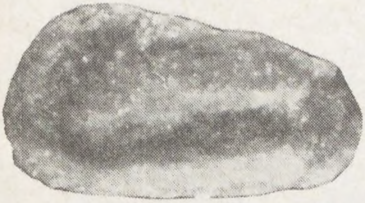

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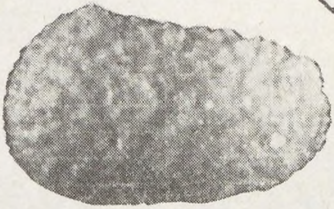

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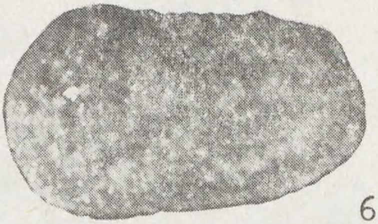

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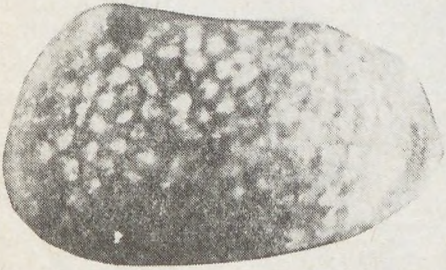

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PLATE 5.

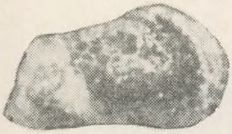
Figs. 1–2. Agrenocythere bensoni POKORNÝ, 1977. 1. Carapacev iew from the right valve 2. Outline of the carapace in dorsal view.

Fig. 3. Hazelina indigena MOOS, 1966. Left valve.

Fig. 4. Pterygocythereis retinodosa OERTLI, 1956. Left valve.

Figs. 5–6. Henryhovella asperrima (REUSS, 1850). 5–6. Left valve.

Figs. 7–8. Leguminocythereis ex. gr. *sorneana* OERTLI, 1956. 7. Left valve. 8. Right valve.



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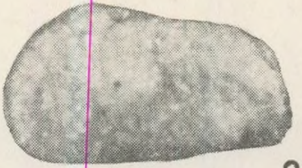

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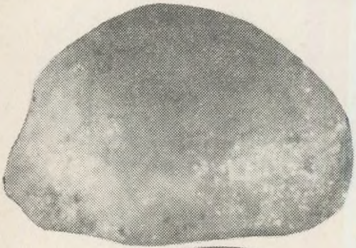

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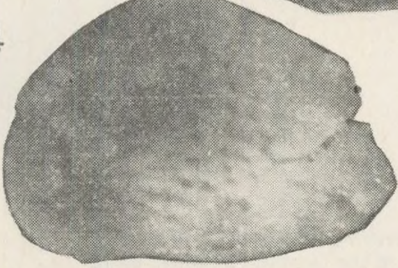

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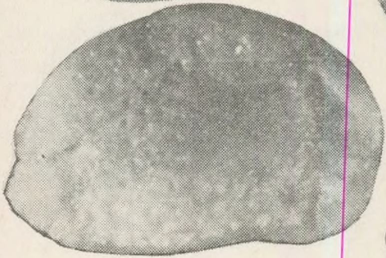

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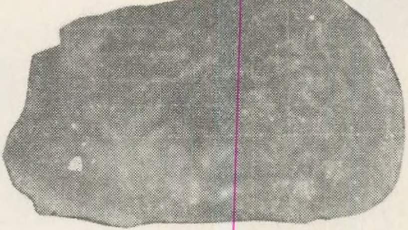

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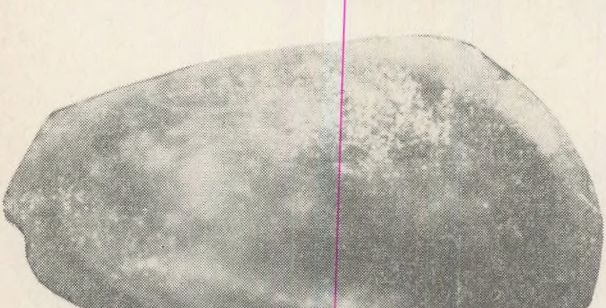

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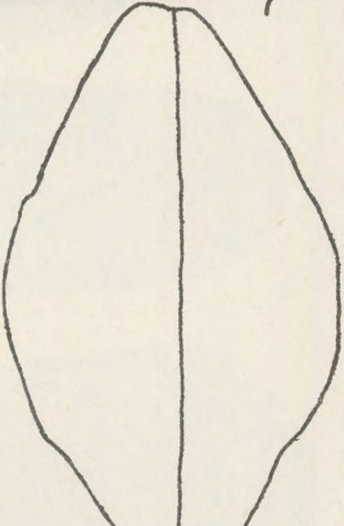

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PLATE 6.

Figs. 1 – 2. Murrayina? gibberula (REUSS, 1856) 1. Juvenile right valve. 2. Left valve.

Figs. 3 – 4. Pokornyella ex gr. *moyesi* DUCASSE, 1967.

3 – 4. Carapace from the right valve.

Figs. 5 – 6. Pokornyella ex gr. *limbata* (BOSQUET, 1852).

5. Carapace, view from the left valve.

6. Carapace, view from the right valve.

Fig. 7. Quadracythere cf. *vahrenkampi* MOOS, 1965.

Carapace, view from the right valve.

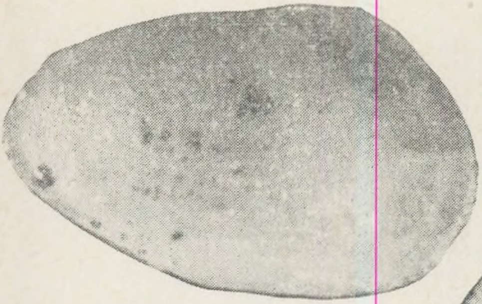
Fig. 8. Quadracythere cf. *macropora* (BOSQUET, 1852)

Carapace, view from the right valve.

Figs. 9 – 10. *Bosquetina zalanyii* BRESTENSKÁ, 1975.

9. Carapace, view from the right valve.

10. Carapace in dorsal view.



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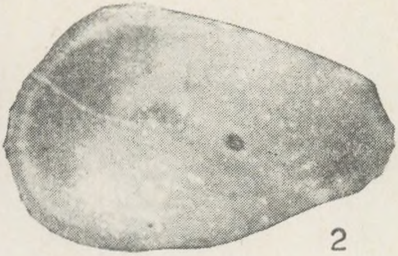

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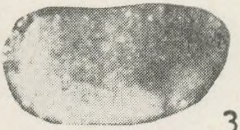

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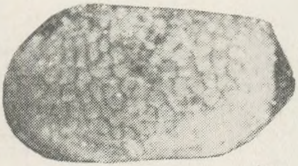

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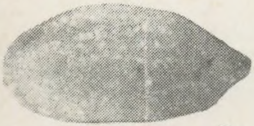

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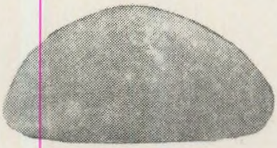

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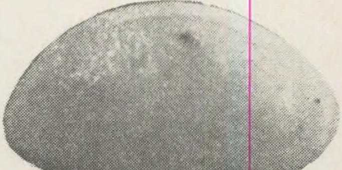

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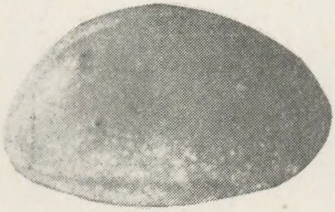

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PLATE 7

Figs. 1 – 2. *Bosquetina* cf. *reticulata* Scheremeta, 1969 sensu Brestenská, 1975.
1. Carapace, view from the right valve.
2. Left valve.

Figs. 3 – 4. Loxoconcha carinata tardense n.ssp.
3. Left valve.
4. Carapace in dorsal view.

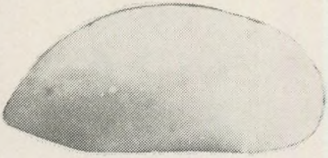
Figs. 5 – 6. Loxoconcha favata Kuiper, 1918.
5 – 6. Left valve.

Fig. 7. Eucytherura denbata Lienenklaus, 1905. Right valve.

Figs. 8 – 9. Semicytherura ex. gr. *gracilis* Lienenklaus, 1895.
8 – 9. Carapace, view from the left valve.

Figs. 10 – 13. Uroleberis odessensis Scheremeta, 1969.
10, 12. Right valve.
13. Left valve.
11. Carapace in ventral view.

Figs. 14 – 15. Abyssocypris palavensis Pokorný, 1979.
14 – 15. Carapace, view from the right valve.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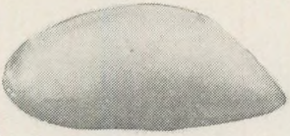
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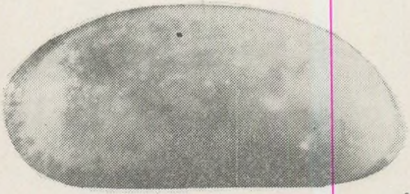
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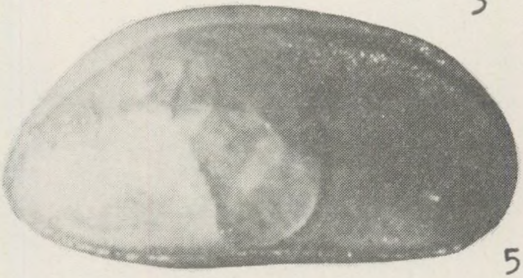
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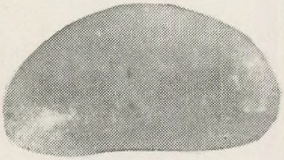
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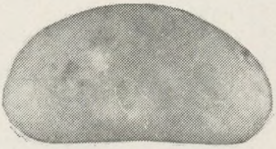
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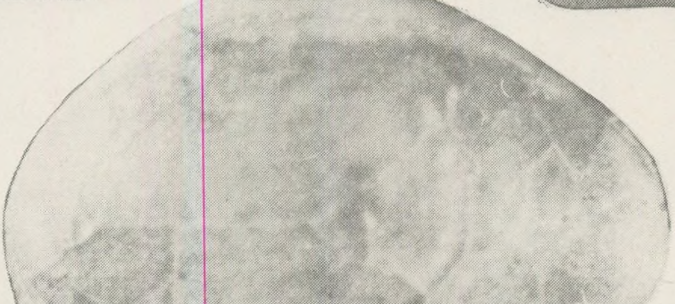
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PLATE 8.

Figs. 1 – 3. Argilloecia quasiramphasta n. sp.
1. Left valve.
2 – 3. Carapace, view from the left valve.

Fig. 4. Phlyctenophora oligocaenica (Zalányi, 1929). Left valve.

Fig. 5. Candona ? recta Lienenklaus, 1905.
Carapace,view from the right valve.

Fig. 6. Cypridacea fam., gen. et sp. indet. 1.
Carapace, view from the left valve.

Figs. 7 – 8. Cypridacea fam., gen. et sp. indet. 2.
7 – 8. Carapace, view from the left valve.

Figs. 9 – 10. Cypridacea fam., gen. et sp. indet. 3.
9. Carapace, view from the left valve.
10. Carapace, view from the right valve.

Fig. 11. Cypridacea fam., gen. et sp. indet. 4.
Carapace, view from the right valve.

INFLUENCE OF THE BOTTOM SEDIMENT ON QUALITY OF THE SEEPAGE WATER

by

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(Received: 15th March 1982)

Abstract

The bottom sediment of the still and stream water is loaded by recent and fossil sewage, which changes the chemical characteristics of the seepage water. The most difficult problem of the drinkwater production by bank filtration in Europe, the high content of iron and manganese, may be reduced to the low redoxpotential, which is a result of the seepage of the stream water on the reductive medium.

In this article we show the komplex scientific investigation of the phenomenon.

Introduction

The great quantity and the enlarging possibility of the drinkwater production by bankfiltration has turned the interest on the question of water quality.

Two factor are imporant:

a) staying length of time of the seepage water in the aquifer

b) seepager process across the bottom sediment.

This article is concerned with the last aspect.

Most part of the stream water contamination is filtered out in the course of the seepage on bottom sediment, but the water loses the solved oxygen too.

In such a way the medium has become reduce and dissolves the iron and manganese precipitates, which is syngenetical with the sediment rock.

We have got such a result during pragmatical investigation in the last years.

It has become evident, that the airing under the river-bed as a kind of possible methods necessitates detailed knowledge of the seepage process.

We made investigations of bottom sediments on the bank of the Csepel- and Szentendre-islands, where active waterwells or several observation-wells render the groundwater analysis possible at the same time.

Methodical introduction:

1. We utilized the varying water level of Danube and we made investigations in dry and underwater condition in the same profile. We chose as a basis the bank slope belonged to the 250 cm Danube water-level.

2. Investigations were made on slices of sediment. which were cut in 1 cm thickness on the plain of the bank slope almost horizontally.

3. Mineralogical, petrografical and hydrogeological investigations were made on one part the quality change of the seepage water was measured on other part in permeameter

4. The investigation of the solid material (sand, gravel, sludge) include the measurement of permeability and mineralogical analysis of the every single fractions.

5. The dissolved oxygen content, chemical oxygen demand and biochemical oxygen demand, actual redox-potential, pH, concentrations of several elements of the seepage water was investigated under and above of sludge-stratum.

6. The actual redox-potential was measured by RA – 226 type industrial measuring system, which has limited exactness (± 50mV) but the reprodycibility is satisfactory.

The dissolved oxygen was titrated by Winkler method both on locality and in laboratorium. Titration of the chemical oxygen demand and biochemical oxygen demand are elaborated in aqueous solution, but we had to titrate in solid stage. According to our own method, we followed the well-know process after multiple $KMnO_4$ overfeed, a lasting several hours boiling and filtering by glass-filter

The degree of overfeed and boiling were determined with preliminary examinations.

Description of sample pots

A) 1606.4 river station: in more profile 30 test-wells and an intermittent running horizontal well assured the investigation of change in time and place of the water quality.

The river-bed, stream-line and bank-line are straight. The river bottom is hard, 1 – 2 cm diameter quartz gravels are mixed with sludge. The stream is powerfull at all water-level.

B) 1630.2 river station: between an island and bank the river branch has been closed with a river wall, the branch is dry about till 300 cm, between 300 and 500 cm there is some still-water in the branchbed, over 500 cm the river flow across the branch. The river bottom has been filled up with sludge on several decimetre.

In more profile 50 test wells and long term pumping test provided the accesory dates.

C) 1632.3 river station: the measuring place was settled near the cross over of the river bed. The stram-line is near the opposed bank, the bank-line moves 80 m distance between 150 – 200 cm river water-level. The investigation of the ground water was assured by 20 test-wells and 2 intermittent running tube wells.

Results of the investigation in granulometry

As the granulometry of the fraction under 60 μm were determined by sedimentation method, the unknown specific density organic matter could not be estimated according to Stokes-rule, therefore after H_2O_2 processing only the mineral components were measured.

As a result of colmatation process the fine size grain is reduced downwards.

On the grain-size frequency curve only every fifth stratum is depicted in the cause of good arrangement. (1st; 2nd; 3rd figures)

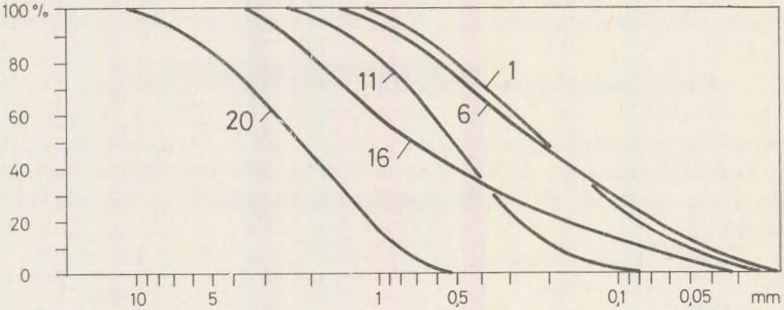

Fig. 1.

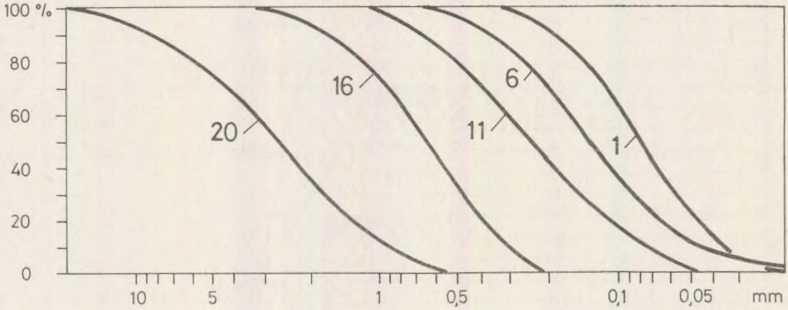

Fig. 2.

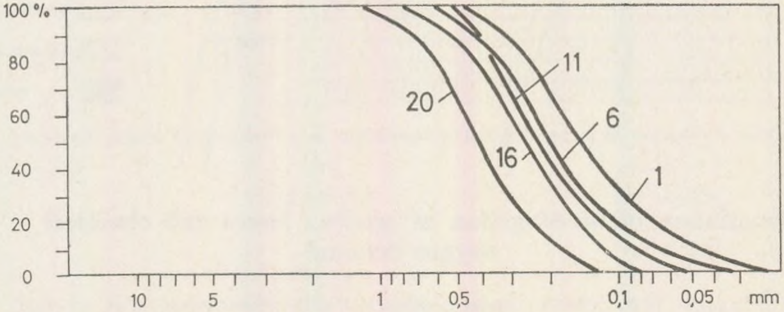

Fig. 3.

Between 0 – 8 μm size the grains are clay-minerals most of all. the large broken fragments are negligible, between 8 – 200 μm diametre there are only quartz grains (but among gravels there are several dolomite and andesite).

We did not investigate the small and indifferent heavy minerals!

As the surface activity of the quartz is very small, the adsorption is negligible. The adsorption coefficient of the mica is higher than quartz, but compared with the organic matter, its in negligible too.

The clay minerals, both their adsorption coefficient and speciefic surface cause the accumulate of organic matter. As their quantity are reduced downwards, the damaging effect is important near the bottom surface.

Mineralogical investigation of every single fractions

Preparing of samples were made partly with H_2O_2 destruction, partly heating before screening. As there was not significant difference between two preparing method, the measured results has been averaged. (4th; 5th figures)

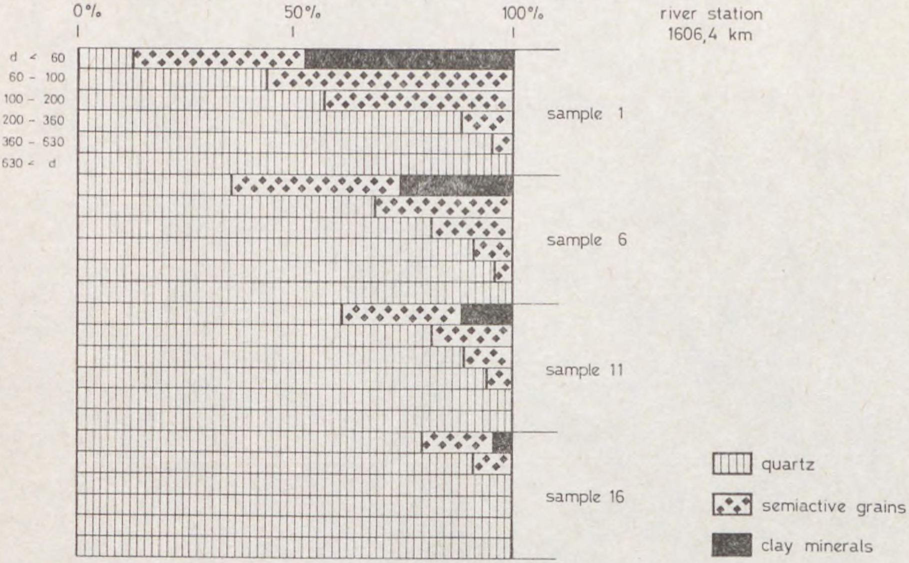

Fig. 4. Change of mineralogical composition as a function of single fractions.

Evaulation of investigation of ignition losses and chemical oxygen demand

Although the determination assay and measuring unit of two kinds of characteristic quality are different, the form of curves are similar. This

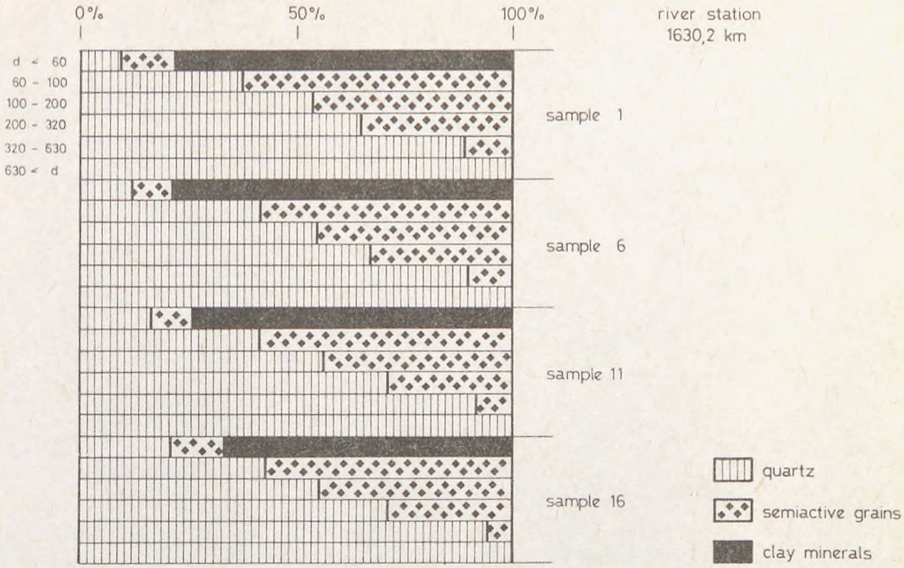

Fig. 5. Change of mineralogical composition as a function of single fractions

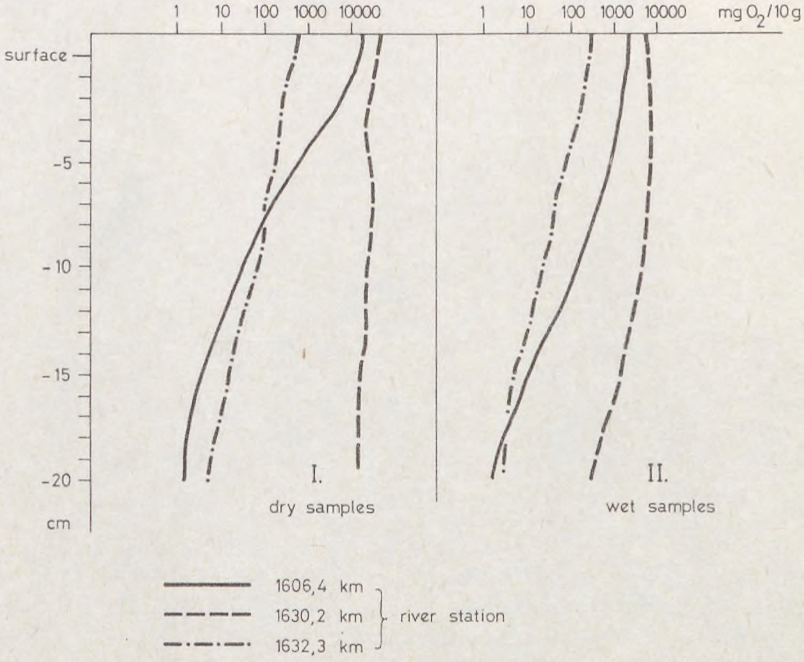

Fig. 6. Change of chemical oxygen demand as a function of depth.

fact indicate, that predominant part of the ignition losses consist of organic matter, water losses of the mineral components. first of all the clay minerals are not major share. (6th; 7th figures)

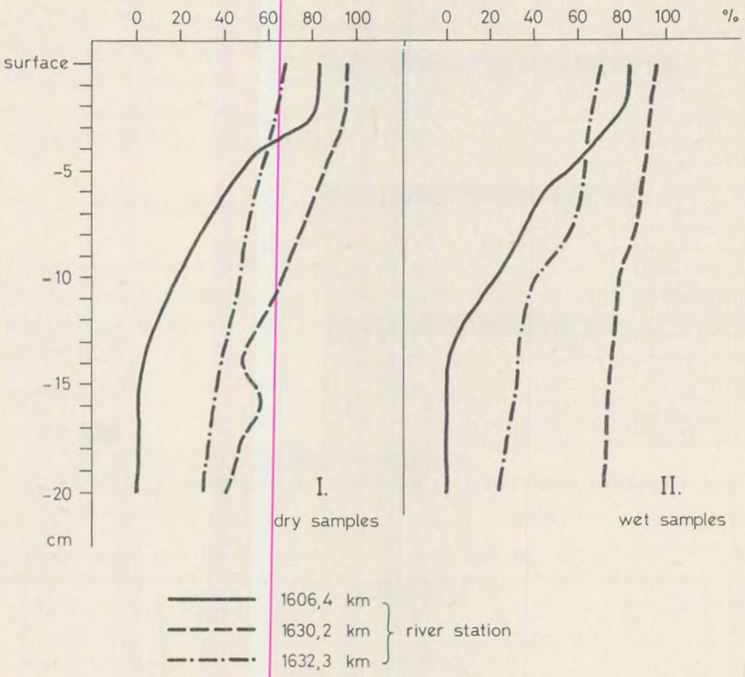

Fig. 7. Ignotion losses.

Comparison with granulometry

The grain size characteristics show various, but determined increase of grain size downward. The decrease of the chemical oxigen demand and the ignition losses shows, that the greater part of organic matter exists as single grain and in minor part they adhere to clay minerals as adsorptivum. Although in the dryed samples detritus can be found in grater grain size, its weight is unimportant, and also the ignition losses.

Comparison with the depht

At the profil of 1606.4 km and 1623.3 km river station, the ignition losses and a chemical oxygen demand reduce very much, in conformity with increasing of grain size downward. At the profil of 1630.2 km river station the grain size increases only to a small extent, in conforming with this the ignition losses and the chemical oxygen demand reduce hardly.

Water chemical investigations

The quality change of the seepage water was investigated in permeameter on single slices of sediment. Five strata of 1 cm thick sludge slice were put one over the other. As fluid was used natural Danube-water, ground water after bank filtration, distilled water and distilled water saturated with oxygen. The "h" value of the permeameter was chosen very small, therefore the seepage velocity was also low, the time of staying and chemical reaction long, and the circumstances might be compared with the natural seepage process.

Change of dissolved oxygen

In measuring time dissolved oxygen was:

5.0 – 7.0	mg/l in Danube-water
1.2 – 4.0	mg/l in ground water
0.0	mg/l in distilled water
10.0	mg/l in oxygen-saturated water

The Danube-water was took off river load by membran -filter.

According to the kind of depiction the distance between initial and end states are commensurate with loss of the dissolved oxygen.

On the basis of the former investigations was probable to reduce the loss of the dissolved oxygen downward, in outside profile to a larger extent than in the middle one.

Not expected result was that the dissolved oxygen content of the seepage water depended on very small from the initial oxygen content, if we disregard the distilled water, the result was almost the same. (8th figure)

The figure shows beginning of the processes, the investigations of the temporal changes were continued with oxygen saturated water on surface samples.

According to expectation the loss of dissolved oxygen reduced in time but not in equal degree.

The three profils cannot be compared directly because the "k" factor and also the quantity of seepage water were different. Respected to this fact, the loss of the dissolved oxygen was recounted to the same quantity of water, so the result has become more satisfied. (9th figure)

The in situ investigation could be made only by Danube water. in the determined depth sampler tubes were put.

The change of dissolved oxygen of seepage water was similar to experiences of experiment in laboratorium, but the absolut value of oxygen content less than half (10th figure)

According to as experiments as in situ investigations were authorized that the dissolved oxygen is used up to oxidize putrid organic slime on the highest several centimetre of bottom sediment.

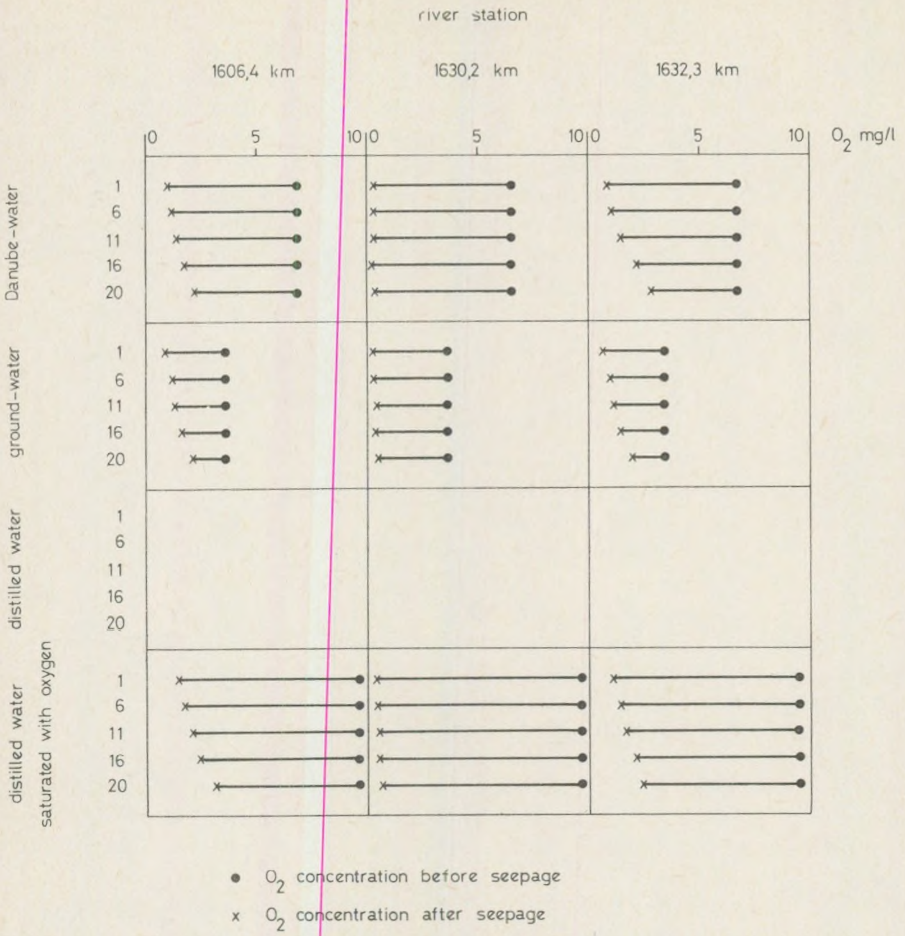

Fig. 8. Change of dissolved oxygen in laboratorial experiments.

Change of chemical oxygen demand

The experiments were continued according to the former writing. It cannot be considered the investigations with Danube water by reason of unreproducable. We have an opinion to postinterpreation: the floating organic matter and dissolved organic combinations, which determine the chemical oxygen demand, are filtered out, but seepage water takes up some organic matter The resulting of the two contrasting processes was occasional in our experimental conditions, and this factor caused the great deviation. The chemical oxygen demand of groundwater changed similarly to Danube water, so this problem needs further investigations.

The distilled water and oxygen-saturated water with constant initial value showed reliable result. (11th figure)

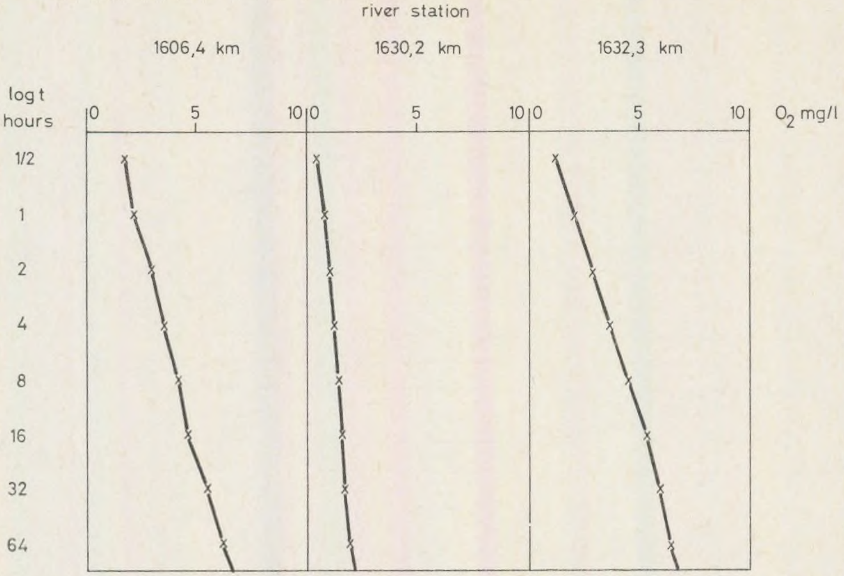

Fig. 9. Change of dissolved oxygen in laboratorial experiments as a function of time.

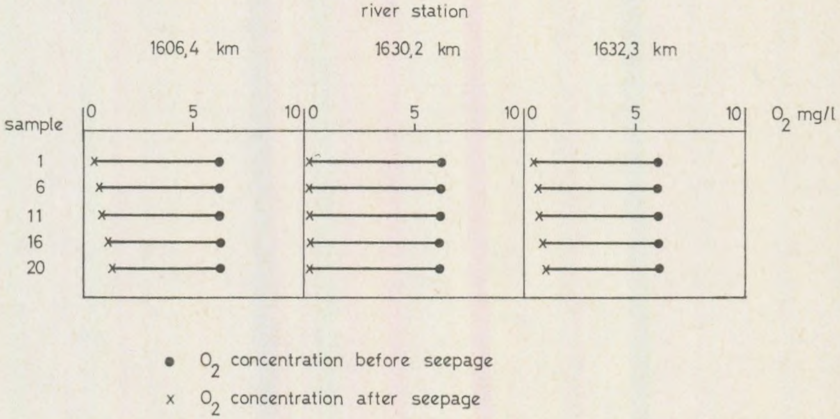

Fig. 10. Change of dissolved oxygen in "in situ" investigations.

After all the initial oxygen content reduced the increase of the chemical oxygen demand only in a few degree. The trends of changes show approximate reflexion in a mirror of dissolves oxygen changes.

At the in situ investigations the effect of one under to other strata was shown not isolatedly but in addition, and the standard deviation was also greater than former (12th figure)

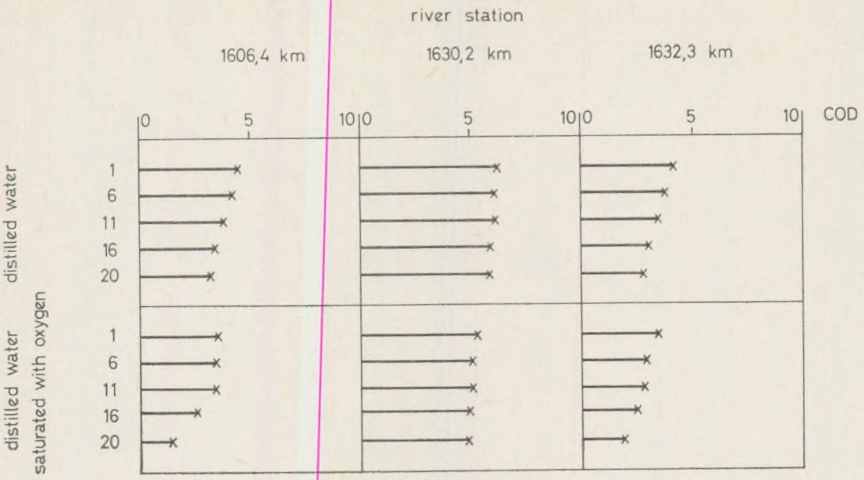

Fig. 11. Change of chemical oxygen demand in laboratorial experiments.

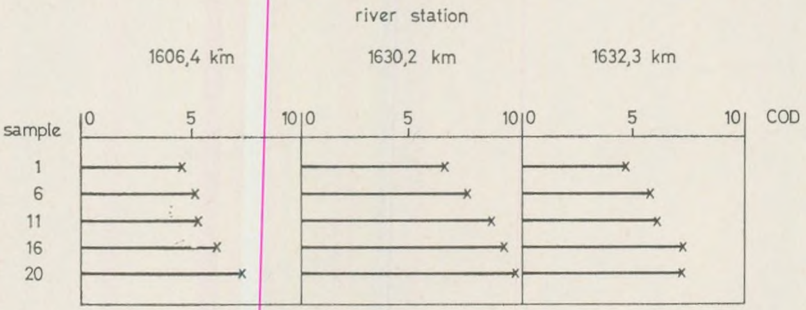

Fig. 12. Change of chemical oxygen demand in "in situ" investigations.

As in the test-wells value of chemical oxygen demand might be measured far less than the depths of bottom sediment (where we investigated it), in the intermediate strata the seepage water or takes up dissolved oxygen or material of chemical oxygen demand filters out. The settlement of this problem needs further investigations.

Change of redox-potential

Because of the interpretation difficulty of the joined redox system, we considered values of the typ. RA – 226 industrial redox equipment, but the mV values cannot be regarded absolutly, only relative number

The redox potential reduces the greatest degree in 1 – 3 cm under slime-surface, under these strata you can see slow increase, similarly to other component the increase greater in the outside profile than in middle one (13th figure).

The weighted addition of these facts are shows on figure of the in situ samples. (14th figure).

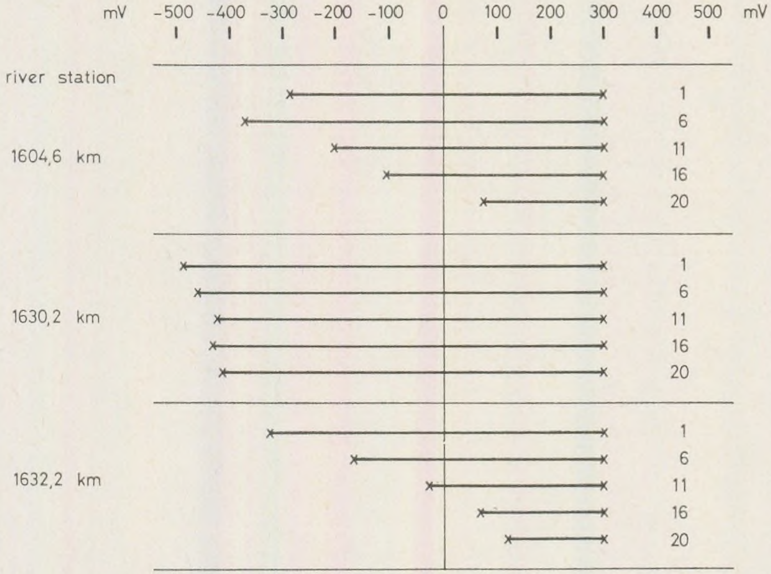

Fig. 13. Change of actual redox-potencial in laboratorial investigations.

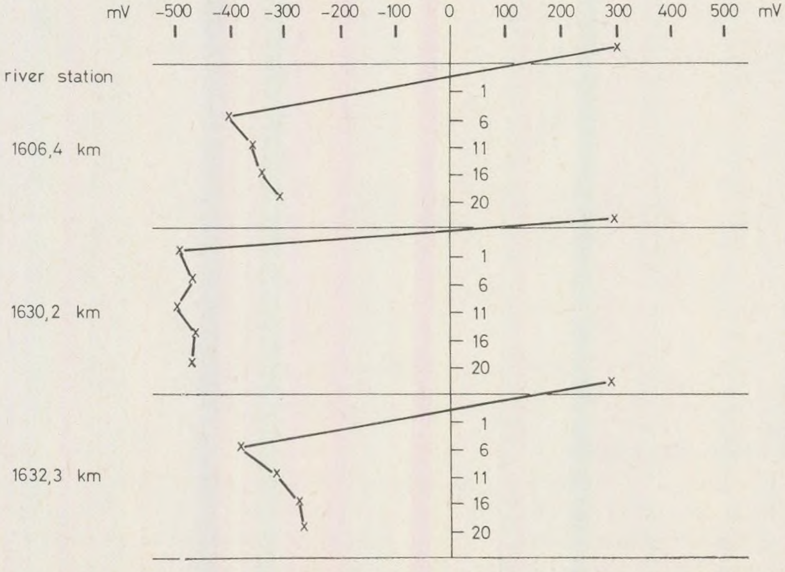

Fig. 14. Change of actual redox – potential in "in situ" investigations.

Changes of the concentration of chemical elements

Concentration of iron, maganese, clorid and alkalinity were measured constantly as in conditions as former one.

These component are less concentration in Danube water than in ground water, the origin of their quantity increase is different. The clorid and alkalinity come from background but, the iron and manganese are remobilized depending on redox, pH and other factors.

The permeameter the change of iron and manganese concentration depended on the time and velocity of seepage so great degree, that we had to disregard to illustrate it.

At the "in situ" investigations, the sampler tubes were set to 130 cm depth, where we measured the concentration of chemical element in the same degree as in the nearest test wells. (15th figure)

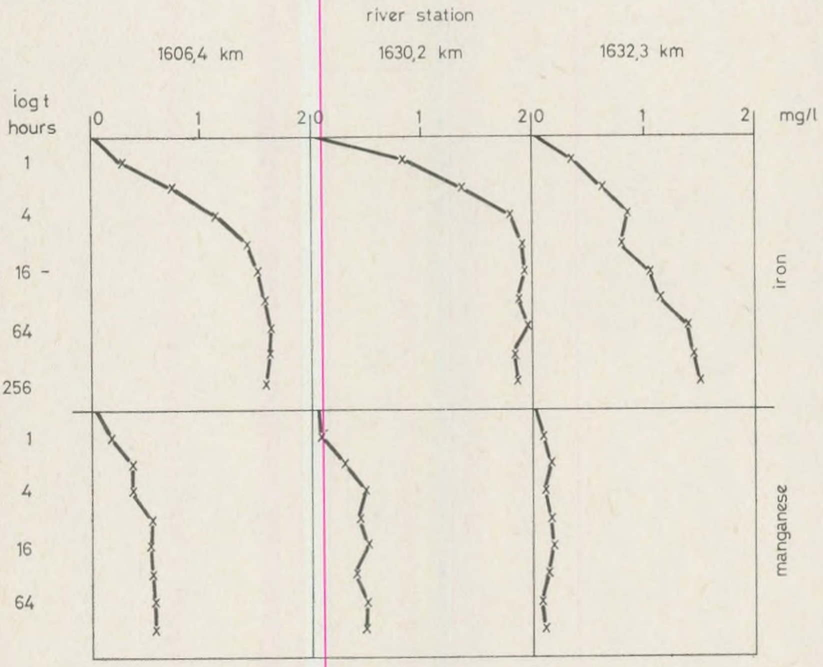

Fig. 15. Change of iron and manganese concentration in „in situ" investigations.

Summary

According to our investigations may be probable, that predominantly rate of bankfiltration processes are happened on the highes part of the bottom sediment. It is well known fact from the literature, that:

the mechanical filtration in 1 – 5 mm,
biological filtration in 5 – 15 mm,
chemical filtration in 10 – 50 mm
depth on 95 – 100%.

Our complementary investigations showed the same phenomena from other aspect.

As the active stratum is essential factor from aspect of water cleaning its removal would be unpractical. Its disadvantageous effect in oxygen equilibrum may be reduced by artificial aering under river bank.

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INVESTIGATION OF FOSSIL KOLMATATION IN BANK FILTRATION SYSTEM

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(Received: 15th March 1982)

Abstract

It is a well-known fact the permeability of benthal deposit of riverbed is much more less than of apron. The recent and fossil kolmatation are the cause of this phenomenon. This artickel investigates values of permeability to limited depth in three profiles and attempts to make model-test in artifical circumstances too.

Interpretation of kolmatation in bank filtration system

As a great part of rivers are deeper than the surface of ground water and water seepages only at extremely high flood into terrace aquifer, according to theoretical consideration phenomena of soffusion might be expected. But in contradiction generally benthal deposit is in the state of colmatation. We suppose the reason of virtual opposition that the recent stream direction are known only, the former stream might be in contrasted direction. The demand on transspiration of the original flood-plain vegetation might be far greater than the precipitation therefore the river might supply the ground water.

The development of fossil kolmatation was in relation to river-bed moving, change of water level fluctuation, and transspiration.

The influence of river-bed moving and fossils river-bed was published former by Orsovai, 1977

In this artickel are written about recent and fossil kolmatation, on the basis of direct measurement.

Methodical introduction

The "in situ" investigations were made on the actual left bank of the riverbed in three profiles, at 1606.4 km, 1630.2 km; 1632.3 km river stations.

In back ground of all the three profiles were test-pumping during a long time.

The sludge of the benthal sediment was sampled in an 1 cm thickness, these samples were the basis of the laboratory experiments.

On the actual deeping surface cm by cm absorbing well investigations were made, under the water-level specific water discharge was determined by test pumping.

Investigations by permeameter

The 5 cm thick sludge strata were put into the standard permeabimeter therefore the "k" factor could be measured in a normal circumstances. The samples may be considered in spite of the most careful effectuation.

But the fine size, small permeability sludge needs change water pressure, the investigations were made also by permanent water pressure.

At the laboratory experiments aqueduct water was used. The counted "k" factor are showed on the 1th figure.

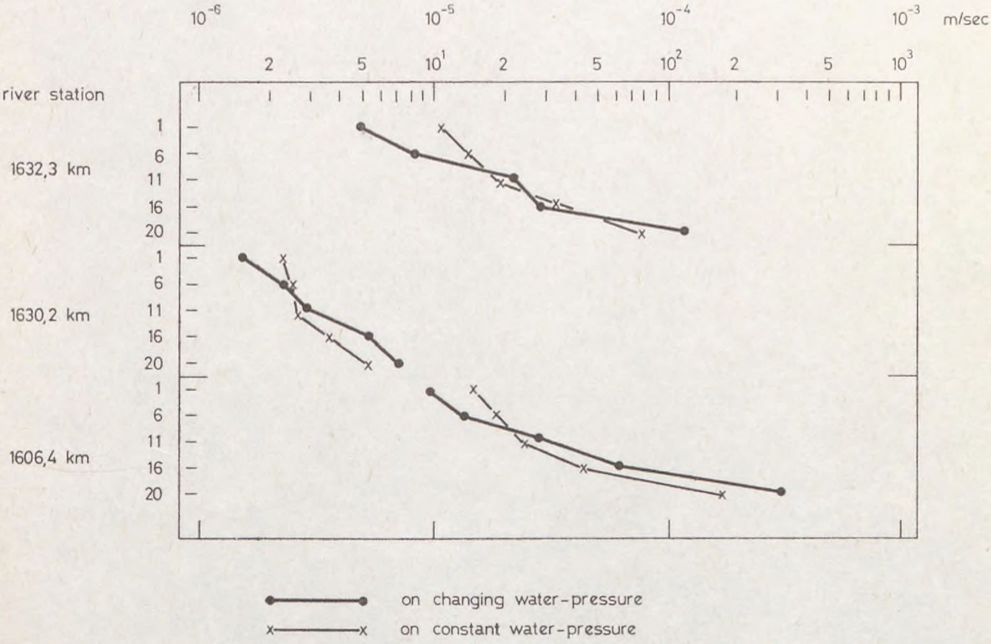

Fig. 1. Change of permeability as a function of depth

In situ investigations

On the actual surfaces tube (110 mm diameter = 78.54 cm²) was set, which was pressed into the sludge in 5 – 10 cm depth, by help of the sharp under border. Both the Danubewater and the ground-water from test wells were used for feed water.

In the draining tests the drain was permanent in time with ground water and was reducing in time with Danube water because of kolmatation similarly to permeameter investigations the measurings were made both with permanent and changeable water-pressure.

In case of permanent 1 m high water pressure the formula is:

$$k = \frac{q}{4 \cdot \pi \cdot r_0 \cdot h}$$

q = drained water discharge
r_0 = radial of test tube
h = pressure of water column

In case of changeable water pressure the formula is:

$$k = \frac{r_0}{h \cdot t} \cdot \ln \frac{h_0}{h_{1;\ 2;\ 3; \dots}}$$

h_0 = pressure of the water column at the beginning of measuring
$h_1; h_2; h_3 \dots$ = in $t_1; t_2; t_3 \dots$ moments

Well marked the values of "k" factor are greater on permanent pressure than on changeable one. (2nd figure).

Limiting conditions of infiltrometer measuring were not realized on the bottom of riverbed, so we had to disregard from application.

There were pumping sampling on water overflood part of the bank, with booth permanent and changeable depression.

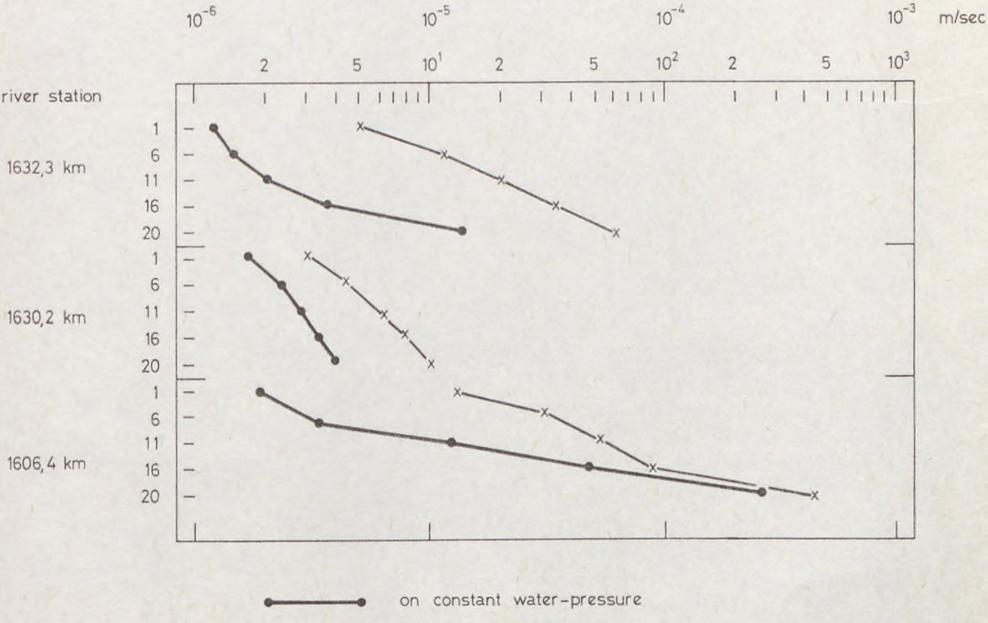

Fig. 2. Change of "k" faktor in "in situ" investigations by draining test

At permanent depression the formula is:

$$k = 3{,}11 \cdot \frac{q}{S \cdot H}$$

q = water discharge
S = depression
H = filtered stratum thickness

As the value of this situation may not be interpreted, therefore "k" factor may not be counted, instead of them (H as regard constant) we represented the specific water discharge. (3th figure).

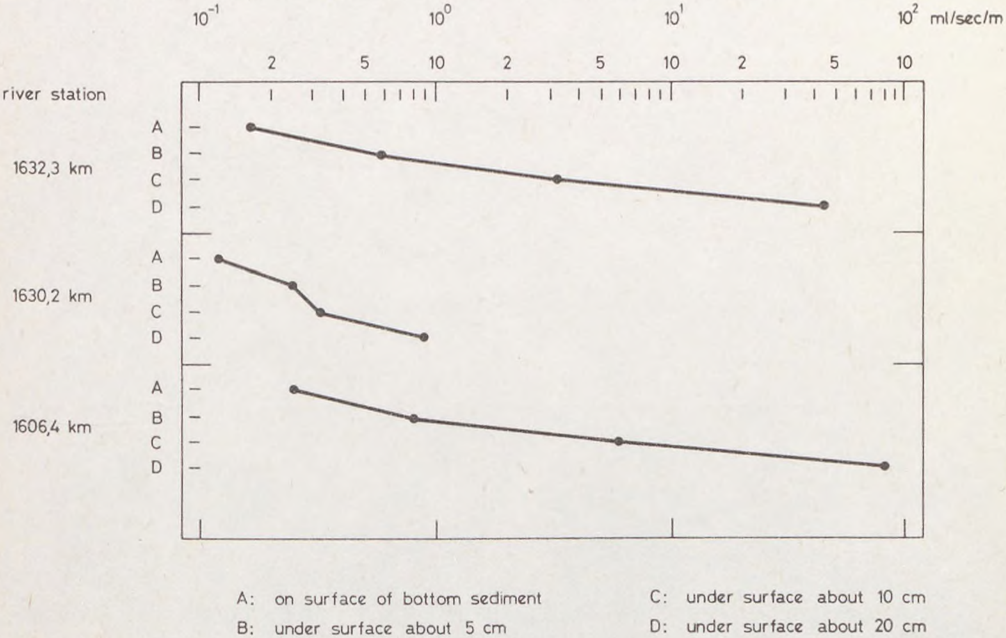

Fig. 3. Change of specific water discharge in "in situ" investigation by pumping at constant depression

Determination of depth under surface is not so exacts as in dry environment, therefore its value is only approximate, we signed them A; B; C; D;.

At changeable depression (backfill) the formula is:

$$k = \frac{r_0}{4 \cdot t} \cdot \ln\left(\frac{s_0}{s_1}\right)$$

s_0 = water table at beginning of investigation
s_1 = water table after t moments

The measurings could be made comparetively correctly. Possibility of quick measuring allowed more repetitions, the diagram showes average of measurings. (4th figure)

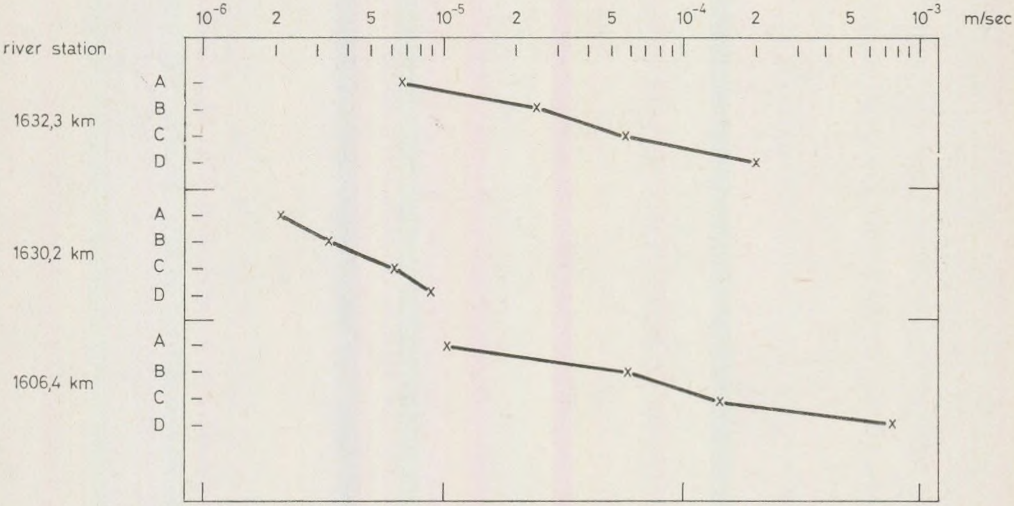

Fig. 4. Change of "k" faktor in "in situ" investigations by backfill

The values of "k" factor increased downwards in all the profils, its degree was in outside profils greater than in middle one. The agreement is remarkable between results of investigations of "in situ" and permeameter, although the two different methods don't measure the same character.

"k" faktor of 5 cm thickness of sludge was measured by permeameter, but in "in situ" investigations the resulting of all subsurface strata was done. The interpretation of this phenomenon is that in every instance of the investigations the nearest stratum to actual surface has the worst permeability, what is determinant the aspect, of "k" faktor. In the deeper strata the permeability is greater nearing order than on surface.

Investigation of kolmatation

Modelling of this nature means the most difficult problem. We couldn't solve the drainage form straming water, therefore the structure of sediment was different from the natural condition.

The testing equipping consists of 10 cm inside diameter, 100 cm lenght tube, its lower part was closed by filtering sand. The surface of sample is free 10 cm above surface is the spillway level. We used Danube-water as feed-water As the kolmatation is influenced by suspended matter of feed-water, the feed-water supply was solved by plunger pump on a small float. The suction pipe was both from surface and bottom leastways 50 cm.

In the sample-holder separated siliceous sand was pat, in E $d < 6$ mm; F $d < 1$ mm; G $d < 0.2$ mm grain size. The permeability was measured for 72 hours in every 4 hours. (5th figure).

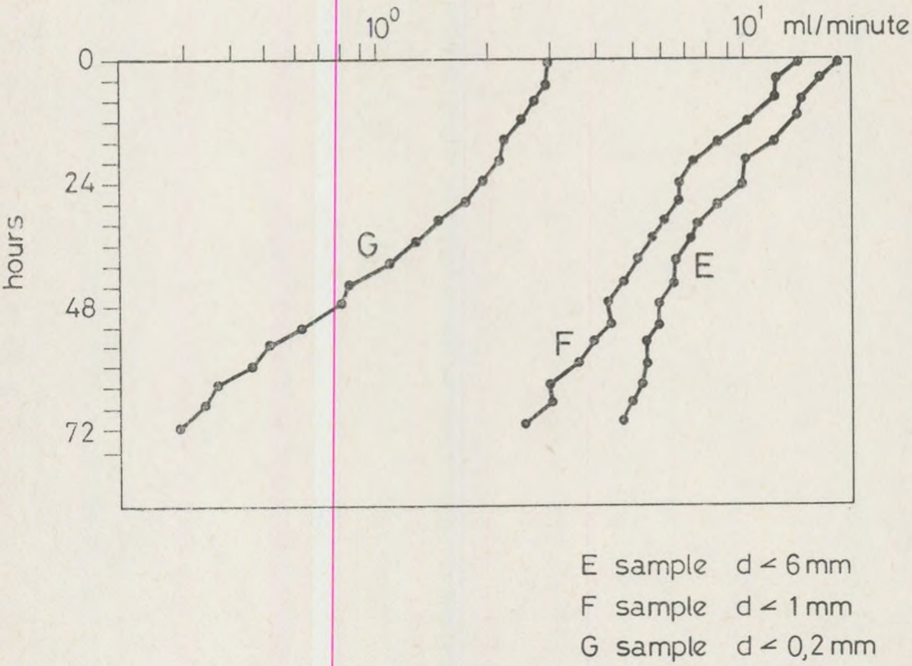

Fig. 5. Laboratory investigation of kolmatation as a function of time

After clearing a way of samples from sample-holder, degree of kolmatation was investigated. We watched kolmatation in E sample cca. 3 mm, in F sample cca. 1 mm deep, and in G sample only surface. This is the explanation to very quick and considerable reduce of permeability.

At the "in situ" investigation after finishing drainage test by groundwater, measuring was continued by Danubewater in A; B; C; D depth (fig. 6, 7, 8 see explanation of 3th figure).

Results of because of technical difficulties shorter test showed, that the experiment reduced the permeability more considerable in deeper strata than at near of surface.

Substantial different was in sedimentation between natural streamwater and stationer-water. Kolmatation from stationer water is only surface phenomenon, but the sludge sediment is very impermeability.

At the natural kolmatation must be taken into consideration out of streamwater the flood wares, which may rip open the consolidated sediment and deeper strata are exposed to effect of kolmatation.

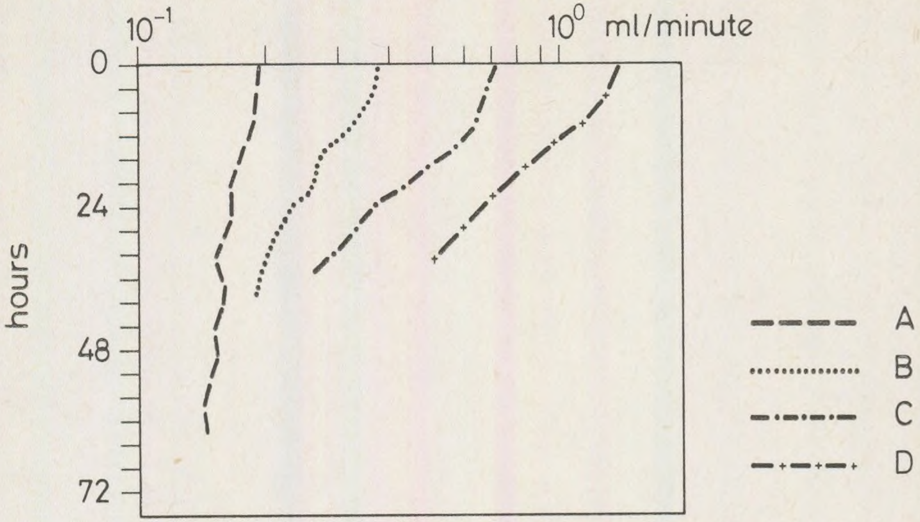

Fig. 6. "In situ" investigation of kolmatation at 1606,4 km river station

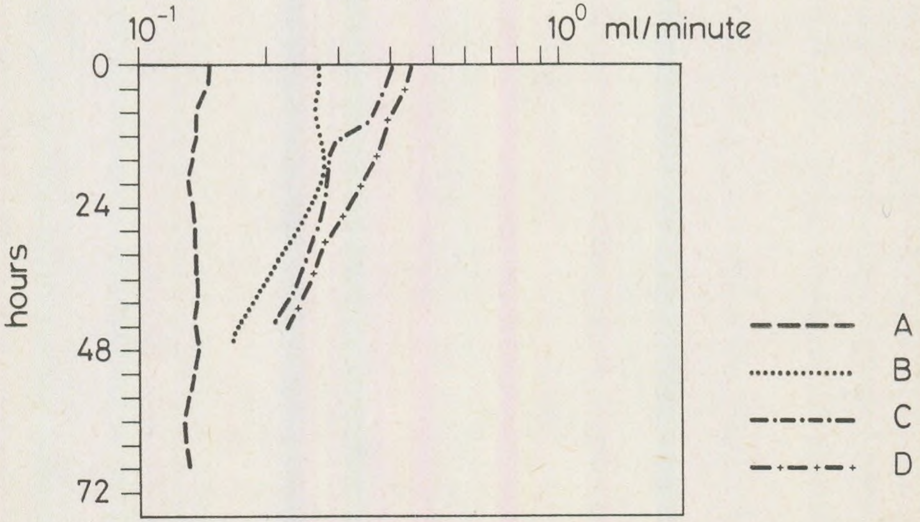

Fig. 7. "In situ" investigation of kolmatation at 1630,2 river station

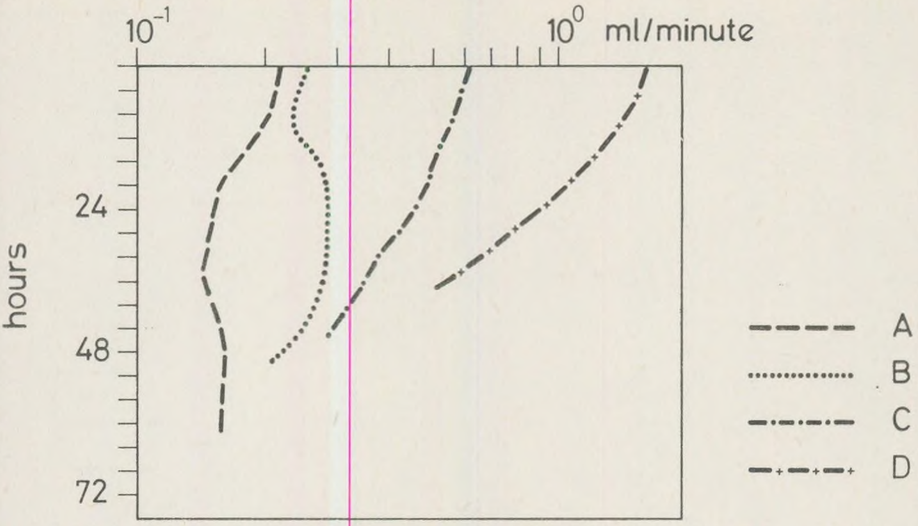

Fig. 8. "In situ" investigation of kolmatation at 1632,3 km river station

Summary

The permeability increases from surface to depth in very great degree and at 20 cm depth approximate same as in gravel apron. The thickness of kolmatation may be several decimeter It is possibility only at streamwater sedimentation, in stationary-water the impermeabily surface stratum by kolmatation prevents the deeper kolmatation.

The impermeabily stratum by kolmatation determines both the quality and quantity of water at bank filtration system.

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CONTRIBUTIONS TO THE ORIGIN OF IRON AND MANGANESE CONTENTS IN BANK-FILTRATION AQUIFERS

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(Received: 30th October 1983)

Abstract

Our study has shown iron and manganese contained by groundwater to be derivable from colloidal substances of Fe and Mn bound by adsorption to clay minerals and solid organic matter which pass reversibly into solution. Other sources mentioned in former studies as well as the weathering of heavy minerals and the solution of pebble incrustations, are neglectable. The decomposition of biotite and hypersthene plays a minor part in supplying iron and manganese to subsurface waters.

Introduction

A difficult problem to be solved regarding water quality in bank-filtration aquifers is given by the high contents of iron and manganese.

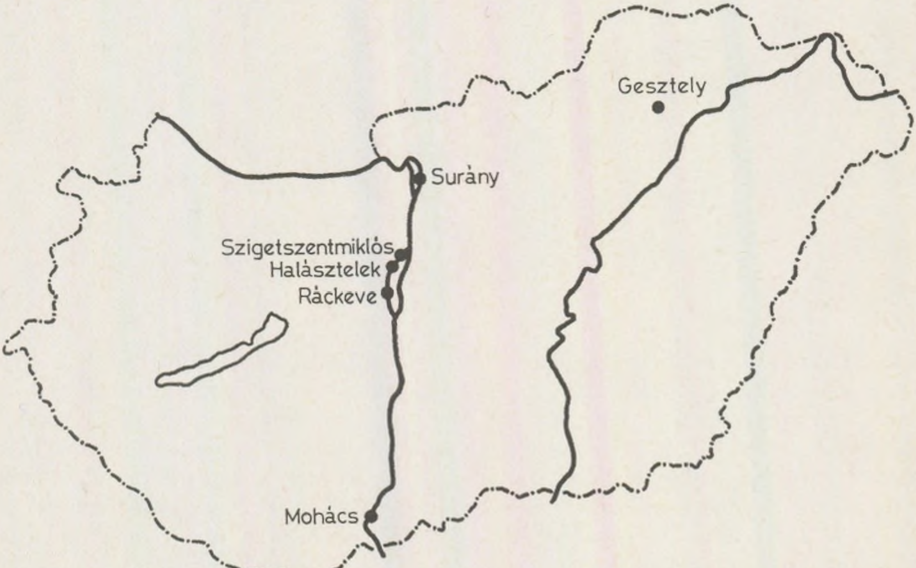


Fig. 1. Sampling localities (Surány, Szigetszentmiklós Halásztelek, Ráckeve, Mohács, Gesztely)

The amount of water recharge and its presumable periodicity is an important factor in the "in situ" or artificial removal of iron and manganese.

As the content of iron and manganese in the just inflowing water is small (0.0 – 0.5 mg/l), there have to be additional sources of these elements. Our investigations have shown such sources as the rock constituents of bank-filtration aquifers and their rare-mineral components, along with the presence of mud fraction as an adsorbing medium and the impermeable underlying sediments.

Investigations on the spot, moreover water and rock sampling were made from the bank-filtration aquifers in a great number of test wells set along the Danube in the zones of Mohács, Ráckeve, Halásztelek, Szigetszentmiklós, Surány, and along the Hernád riverside by Gesztely (Fig. 1.).

Investigations of rock samples

Before testing, the rock samples have to be prepared by separating particle size fractions and mineralogical substances. (see Fig. 2.).

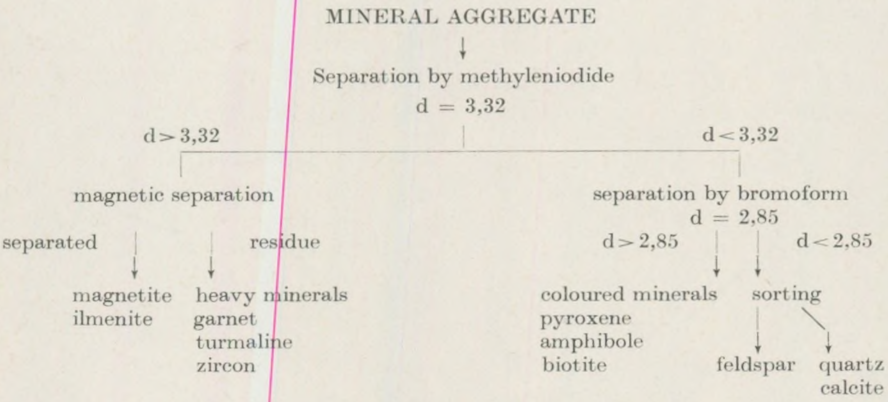


Fig. 2. Pattern of separation

After separation the quantitative determination of the different minerals enables to calculate the theoretical maximum quantity of iron and manganese contents on the basis of the chemical composition of the individual minerals. This method implies, however, fundamental faults. Thus iron and manganese are very rarely found in stoichiometrical quantities bound to silicate minerals. The deviation of the so-obtained data is, in general, extraordinarily great, therefore the much work-and-time-demanding calculation carries fundamental mistakes from the very beginning. Instead of the method of calculation, therefore, we choose a direct mesurement.

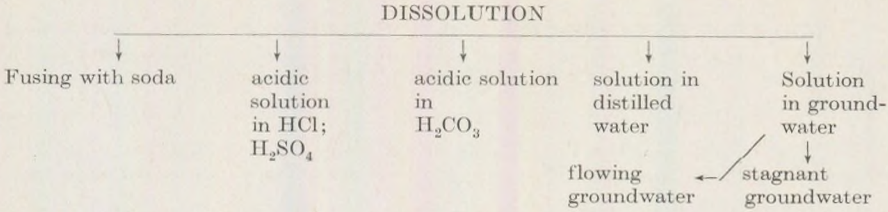


Fig. 3. Pattern of dissolution

The separated "coloured" and heavy minerals fused with soda (Na_2CO_3) turn to be soluble in water and they can be analyzed by usual water analytical methods (Fig. 3.). The results of these analyses is shown in Table 1.

Originally, in the samples the heavy minerals display fresh surface with no marks of attack by solution. The so-salled coloured minerals such as biotite, amphibole, pyroxene ($2.85 < d < 3.32$) are more liable to weathering than heavy minerals ($d > 3.32$).

Large amounts of iron and manganese are bound to andesite pebbles deposited by the Danube. We have applied the described methods in testing pulverized pebbles too.

The resulting data are shown in Table 1. The analysis of the material treated by fusing with soda gives the possible maximum contents of iron and manganese in the samples. As there is no comparable weathering agent in nature as this, so the test results must indicate only the quantitative proportions of iron and manganese which can be dissolved from the rocks.

The next treatment was made by the action of acidic solutions. The separated minerals grains were divided in two parts. One part was dissolved directly, whereas the other one had been pulverized previously.

Methodical note: in solutions the detection limit of iron and manganese is 0.1 mg/l. which is equal to 2 ppm of solid material; so 5 g mineral material was put into 1 l solvent. After evaporating the solution to 100 ml a solution was obtained as containing iron and manganese ions above the detection limit.

For both primary and duplicate samples, the time necessary for the complete solution by hydrochloric and sulfuric acid has been found 1 – 2 hours, on the other hand, the solution by carbonic acid and distilled water needed 5 – 10 hours, and that by water taken from the pertaining aquifer lasted 30 – 50 hours.

In this time 98 – 100% of the solution process is completed. To be sure, the duration of each experimental solving action was extended to as long as 1.000 hours.

It has been found that the iron and mangenese contents of the outer skin of grains attacked by dissolution prior to testing had greatly been removed.

The analysis after solving pulverised samples showed consequently larger amounts of dissolved iron and manganese. It can be explained by the

Results of solution test. The upper two numbers show

	Heavy minerals d > 3,32 garnet, zircon					
	Fusing with soda %	Acidic solution in HCl, H_2SO_4 ppm	Acidic solution in H_2CO_3 ppm	Solution in distilled water	Flowing groundwater	Stagnant groundwater
Fe separated grains		600 – 8 000 2 190,0	40 – 500 141,4	20 – 180 60,0	0 – 30 3,16	0 – 4,5
Fe pulverized	3,8 – 24,7 9,6	9 000 – 63 000 23 811,7	500 – 1 500 866,0	40 – 300 109,5	0 – 20 4,5	0 – 40 6,3
Mn separated grains		50 – 2 500 353,5	40 – 200 89,4	10 – 40 20,0	0	0 – 5 2,2
Mn pulverized	0,3 – 8,1 1,5	1 500 – 4 000 2 449,0	70 – 400 167,0	20 – 90 42,42	0	0 – 10

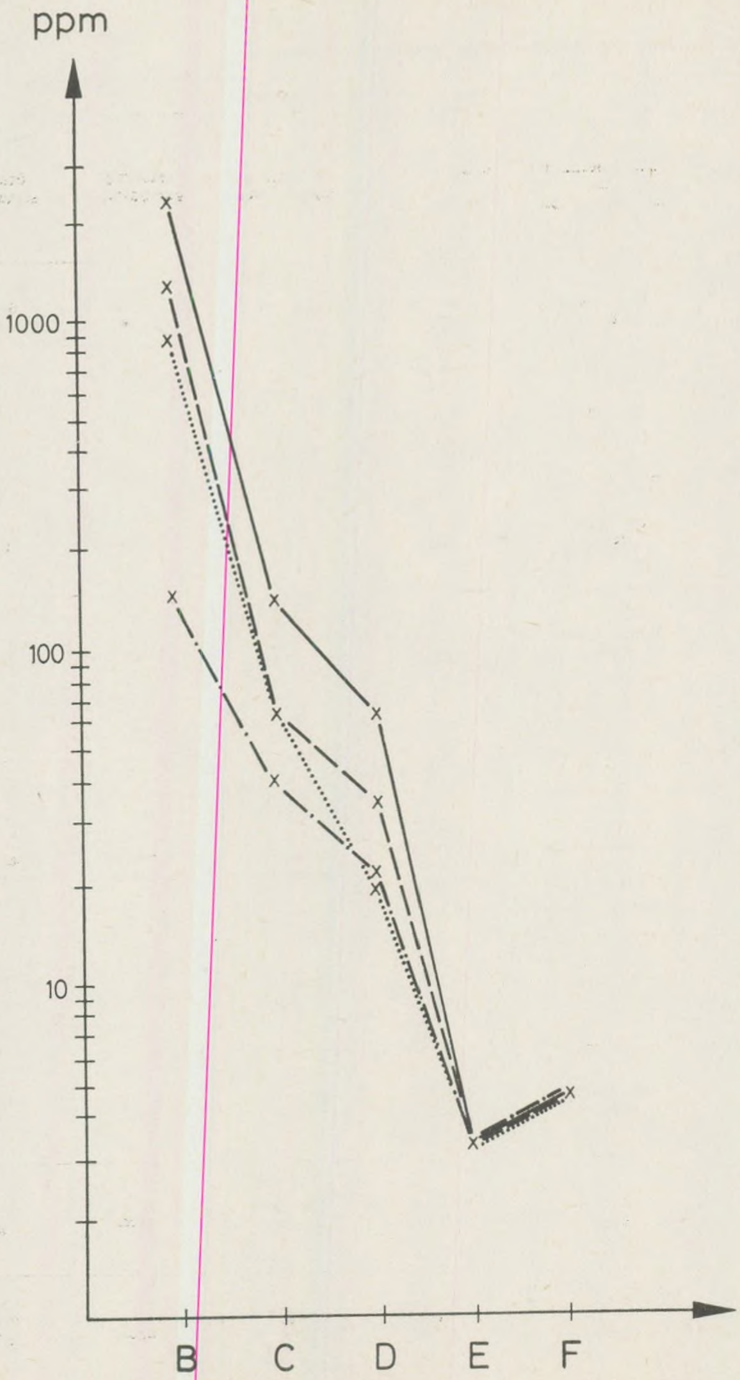
	Coloured minerals pyroxene, amphibole, biotite					
	Fusing with soda %	Acidic solution in HCl, H_2SO_4 ppm	Acidic solution in H_2CO_3 ppm	Solution in distilled water	Flowing groundwater	Stagnant groundwater
Fe separatel grains		500 – 1 500 866,0	40 – 100 63,2	10 – 30 17,3	0 – 10 3,16	0 – 20 4,5
Fe pulverized	0,8 – 2,1 1,29	1 800 – 2 400 2 078,0	60 – 150 91,86	20 – 50 31,62	0 – 20 4,5	0 – 0,13 6,3
Mn separated grains		40 – 600 154,9	20 – 80 40,0	0 – 20 4,5	0 nyom	0 – 5 2,2
Mn pulverized	0 – 0,3 0,1	350 – 1 100 620,48	30 – 150 67,0	10 – 20 14,1	0 nyom	0 – 10 3,16

Table I.

the extreme values, the lower one the weighted average

Magnetite + separable by magnet					
Fusing with soda %	Acidic solution in HCl, H_2SO_4 ppm	Acidic solution in H_2CO_3 ppm	Solution in distilled water	Flowing groundwater	Stagnant groundwater
	200 – 9 000 1 341,6	20 – 200 63,24	20 – 60 34,64	0 – 10 3,16	0 – 20 4,4
56,7 – 70,4 63,17	34 – 660% 47,37	50 – 400 141,4	20 – 80 40,0	0 – 30 5,9	0 – 40 6,3
	50 – 2 100 324,0	20 – 100 44,72	10 – 40 20,0	0 nyom	0 – 5 2,2
0,07 – 1,3 0,3	1 300 – 4 000 2 280,0	40 – 200 89,0	10 – 70 26,4	0 nyom	0 – 0,3 3,16

Felspar					
Fusing with soda %	Acidic solution in HCl, H_2SO_4 ppm	Acidic solution in H_2CO_3 ppm	Solution in distilled water	Flowing groundwater	Stagnant groundwater
	20 – 1 300 161,2	20 – 80 40,0	10 – 40 20,0	0 – nyom	0 – 10 3,16
0,0 – 0,13 0,11	800 – 2 100 1 296,0	40 – 200 89,44	20 – 70 37,4	0 – 10 3,16	0 – 20 4,5
	20 – 120 49,0	70 – 400 167,3	0 – 20 4,5	0 – nyom	0 – 5 2,2
0,0 – 0,05 0,002	70 – 900 250,0	0,0 – 50 7	10 – 30 17,3	0 – nyom	0 – 10 3,16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increase of fresh grain surfaces regarding the individual and total extensions of them, as having been produced by milling. In other part it is due to the greater specific surface of the pulverised material.

Under natural conditions, H_2CO_3. distilled water (rainwater), the groundwater as solution are the most common solvents. Therefore we studied the reversible equilibrium of carbonate – hydrogen carbonate – iron and manganese to obtain the greatest possible solubility by cc H_2CO_3 action.

To test the action of a "pure" solvent on rock material, distilled water was used, as the groundwater itself is regarded as a solution containing agressive and other kind of chemical substance.

When using groundwater as solvent, it was sampled from the one and the same aquiferous rock drilled or from the nearest test well.

Our model experiments reproduced two extreme natural conditions, namely those of stagnant groundwater and flowing groundwater, respectively. Stagnant water accumulations have no direct contact with a river and show a low redox potential. At the same time, the airation displayed by streaming water characterised by high oxygen content i.e. high redox potential was reproduced in lab by means of a small pump, used for the refreshment of aquariums.

The results of analysis are shown in Table 1. and Figs. 4 – 5.

Presumed source of Fe and Mn: pebble incrustations produced by freezing

As a possible source of Fe and Mn, incrustations of pebbles are mentioned in literature. These incrustations are developed by the freezing of groundwater during glacial periods of Pleistocene age showing a concentration of iron and manganese oxides. These can pass into solution again and increase the Fe-Mn concentration of groundwater

These incrustations represent some 1 mm thin layers. they are spotted by oxide and oxihydroxide appearing on the lower sides of the pebble. The contacting interfaces, however, are free of incrustation. Incrusted pebbles are found in large numbers in the deposits of the early Würm period of glaciation and are characteristic of the successive beds of the river terraces II/a and II/b of the Danube.

◀ *Fig. 4.* Solution of mineralgrains: Iron Legend

– – – – – – Heary minerals
– — – – – – Magnetite
. .. Pyroxene, amphibole, biotit
. . . Felspar
A. Fusing with soda
B. Acidic solution by HCL; H_2SO_4
C. Acidic solution by H_2CO_3
D. Solution by distilled water
E. Solution by flowing groundwater
F. Solution by stagnant groundwater

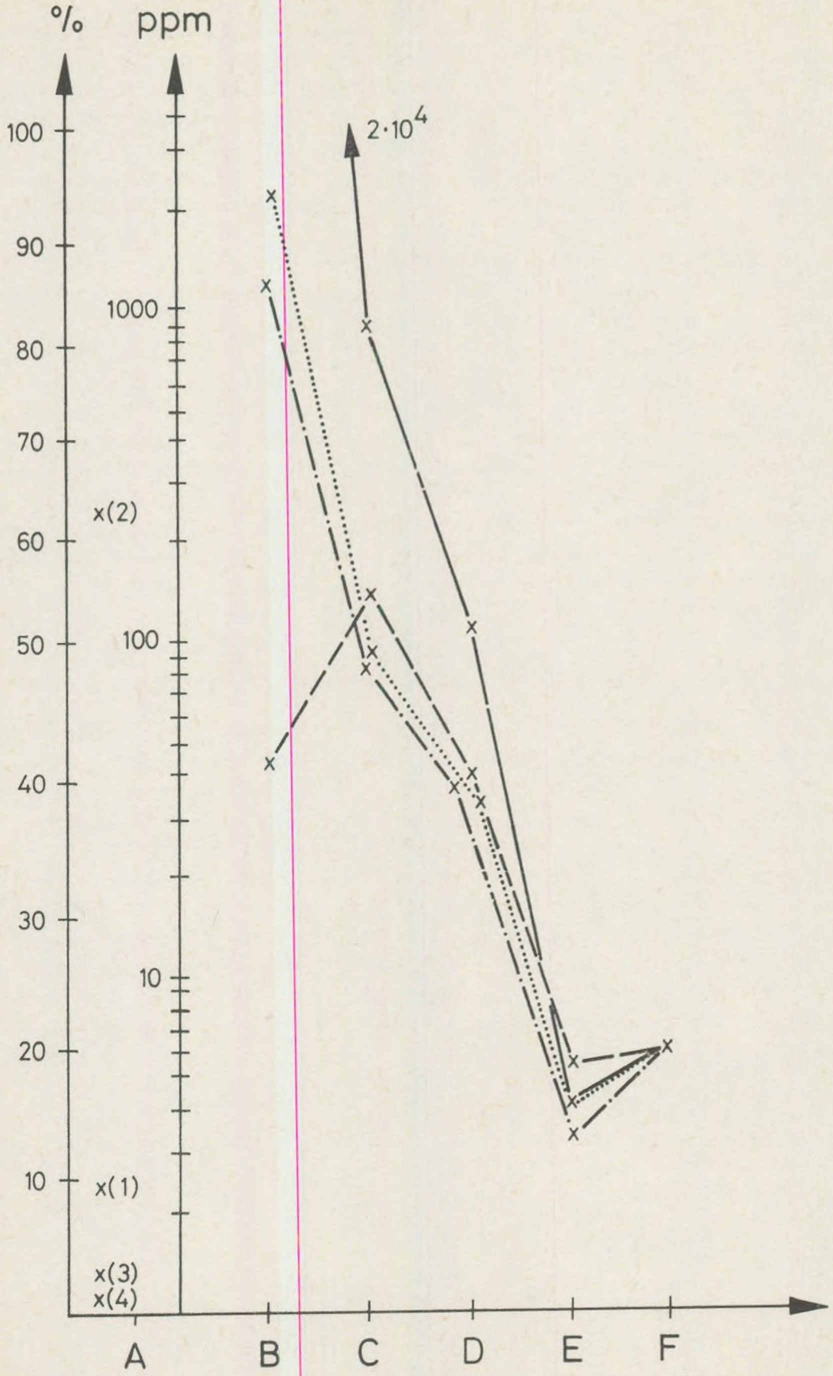

Fig. 5. Dissolution of pulverized minerals: Iron See Legend of Fig. 4.

Their origin is attributable to the segregation by groundwater freezing during the periodically repeated "tundra phases" as taking place parallel with the advancing frost effect. Nevertheless, it should be noted that similar incrustations can be brought about by a full drying out, too.

The conditions for removing the incrustations were tested, and they turned out to be very resistant.

Neither multiple washing by circulating groundwater nor an attack by distilled water was efficient in removing this coat. Nevertheless, an action by stronger acid has been proved successful. 0.1 n ($\cong 0.36\%$) HCl has no effect in 1.000 hours, ln ($\cong 3.6\%$) HCl begins the dissolution and 3n ($= 10\%$) HCl removes the whole crust. Solubility test made under the conditions of low redox potential show just the beginning of solution at $(-300)-(-500)$ mV.

As the previously described testing conditions do not occur in nature, the segregation of the mentioned iron and manganese incrustation can be considered as irreversible.

We would stress the importance of one particular occurence found in the Holocene apron II/b of the Danube. This has a good exposure farther from the river in a quarry of bank gravel.

The pebbles studied there have black, friable n × 0.1 mm thin, loosely adhered skins. There are found two types of them:

a) in more arenaceous deposits they form lenses with 1 – 2 mm of horizontal diameter and 0.05 – 0.1 m of thickness, wich intersect the crossbedded structure of the enclosing sands. The fine grains are almost totally missing from these lenses and the whole surface of the pebbles is coated.

b) Sporadically, there are gravels in middle grain-sized sand whose incrustation is similar, but covers a part of the surface only. It doesn't support the theory of origin by freezing, because the incrustation is not resticted to the underside of the pebbles but appears irregularly. The missing parts of the crust cannot be removed by transport, as attested to by their loose powder-like constitution.

The formation of this incrustations took place on the site of their present-time occurrence.

To solve the question of origin of them X-ray examination and spectral analysis were carried out. Vernadite (badly cristallized $Mn(OH)_4$ or $MnO(OH)_2$ and psilomelane can be recognized on the radiograms. The result of spectral analysis proved the presence of Ba, which indicates the mineral psilomelane. Minerals of iron are missing. The spectral analysis gives the following results:

(unit: ppm = 10^{-6}): As 400; B 100; Ga 250; V 250; Ni 1000; Co 600; Cr 400; Pb 250; Ca 1000; Ti 2500.

The vernadite is able to adsorb large-size cations. The presence of relatively large amounts of Ni, Co, Pb, Cu and Ba can be exlpained by this fact.

The solution tests using groundwater applied to samples taken from the crusts gave negative results.

It has to be mentioned that some grains of epigenic limonite are found in the assemblage of separated heavy minerals. The genetic processes must have been very different but with a common result given by the limonite being a product of an irreversible segregation. It can be verified by our remobilisation tests made under natural conditions.

Precipitated iron-manganese adsorbed by clay-minerals and organic substances

On the basis of our investigation the main sources of iron and manganese are the reversibly soluble non-crystallized varieties of Mn^{2+} $-Mn^{3+}$ $-Mn^{4+}$ and Fe^{2+} $-Fe^{3+}$

Among the underlying beds of the terrace depcsits in the investigated areas the Kiscell Clay of middle Oligocene and clays of Pannonian (Pliocene) age contain 0.3 8.7% melnikovite and pyrite (FeS_2). The oxidation of these minerals is a well-known process in connection with the formation of bitter groundwater.

During erosional phases of the riverbed development oxidation is the most characteristic process. The freshly uncovered rock surfaces provide an increased supply of iron and manganese to the river The oxidationprocess is stronger on the surface of the clay bed than in the deeper strata, so iron and manganese can be solved out by rainwater of the river The case of solution by stagnant groundwater can be neglected. However, through the action of oxygen-rich groundwater the intensity and velocity of oxidation and dissolution increases under conditions of slow filtration as well, though oxygen-rich flowing groundwater is very rare in bankfiltration aquifers. Therefore oxidized melnikovite is considered as a supply from fossile sources of iron and manganese. At present this oxidation-solution process is subordinate but in the future it can be accelerated near the water-producing wells by a high flowing velocity of groundwater

By pyrogenic or oxidizing (= cc. H_2O_2) treatment of Fe- and Mn-bearing minerals manganese is released together with iron. Manganese can be determined as a chemical component instead of mineral. Probably it is found in a less crystallized compound than that of the iron Undoubtedly it is not MnS (alabandine).

The quantity of manganese ranges from 3 to 21% of the iron content in rocks.

The mangano (Mn^{2+}) ion is faibly sulfophile, therefore it precipitates together with iron as primary sulfide on the bottom of the sea (see manganese nodules). Iron and manganese have similar ion radii (Fe^{2+} 0.83 Å; Mn^{2+} 0.91 Å) so manganese can be incorporated by different kinds of iron sulfide.

The iron and maganese content of river water is generally limited, as ranging between 0.0 – 0.05 mg/l. We may presume the same conditions to have ruled in Pleistocene time. Though the terrace material deposited since early Pleistocene time contains locally larger quantities of these elements than expected, due to the very long period of accumulation.

The ferro (Fe^{2+}) and mangano (Mn^{2+}) ions get segregated by reversibile oxidization in the upper levels of the groundwater aquifer, because the pH 6 – 7 of the groundwater is low for an irreversible segregation.

Clay minerals and solid organic components of the waterbearing rocks, collect precipitated Mn^{4+} and $Fe(OH)_3$ on their surface, furthermore, iron and manganese can form organic compunds, especially as humates. The iron precipitates can be redissolved by CO_2 in the form of $Fe(HCO_3)_2$ showing a reversible equilibrium in the following way:

$$FeCO_3 + CO_2 + H_2O \rightleftarrows Fe(HCO_3)_2$$

According to our tests the clay fraction and the solid organic matter contain 0.2 – 7.0% iron and 0.13 – 2.8% manganese, or in a respective weighted average 3.4% Fe and 1.15% Mn.

After the analysis-required desiccation of the separated precipitate it goes through a mineralization process and becomes insoluble i.e. soluble only by HCl and H_2SO_4.

Presumbly the precipitation of iron and manganese is simultaneous, and the mud of the river bottom adsorbs the precipitate so it gets separated from the oxygen-rich riverwater. The mud is filling the intergranular pores of the gravel, according to the laws of riverbed-motion and terrace formation.

This first-deposited material cannot be distinguished from the later one precipitated from solutions.

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A kiadásért felelős az Eötvös Loránd Tudományegyetem rektora – A kézirat nyomdába érkezett
1984. augusztus Megjelent: 1985. november – Terjedelem: 23,25 A/5 ív
Példányszám: 500 – Készült monószedéssel, íves magasnyomással,
az MSZ 5601 – 59 és az MSZ 5602 – 55 szabvány szerint
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