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29/1992

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UNIVERSITATIS SCIENTIARUM BUDAPESTINENSIS DE ROLANDO EÖTVÖS NOMINATAE

SECTIO GEOLOGICA

TOMUS XXIX.

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T. BÁLDI
B. GÉCZY
E. VÉGH - NEUBRANDT
M. MONOSTORI (TECHN. ED.)

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REEVALUATION OF THE NEOGENE BRITTLE TECTONICS OF THE MECSEK-VILLÁNY AREA (SW HUNGARY)

by

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(Received: 27th February, 1989)

Abstract

Previous brittle tectonic measurements made in the Mecsek and Villány Mountains (SW Hungary) have enabled us to differentiate 5 paleo-stress-fields of Neogene and unknown ages. Further analyse of the data and of detailed maps have precised the proposed stroy of tectonic events in the Neogene.

These mapping, fracture and sedimentological data suggest that the most intense deformations occur in well known strips i. e. the Northern Thrust Zone, the Southern Mecsek Lineament, and the thrusts of the Villány Mountains. Basins between and around these zones are very probably related to the strike-slip tectonics and they witness the superposition of the different tectonic events.

We suppose a NW-SE directed compression in the Lower Miocene, creating right lateral wrench faults of E-W strike and NNW-SSE oriented left lateral ones in discrete zones (fig.3.). This stress would be followed by N-S compression in the Badenian and by NE-SW compression in the Lower Pannonian. The latter one has created NE-SW trending left lateral and N-S trending right lateral wrench faults and thrusts in the previously existing wrench zones. Because of intense folding of Pannonian sediments, the first mentioned stress-field, the NW-SE compression is very likely to be rejuvenated in the Upper Pannonian (Pontian).

Introduction

The present paper deals with the Mesozoic-Tertiary outcrops of the Mecsek and Villány Mountains, which are part of the South Pannonian (BALLA, 1984) or Tisia (KOVÁCS, 1982) microcontinent. We have studied the microtectonic features of these mountains by measuring the fault related features (like slickenslides, gauges, etc.) and have deduced 5 different stress-fields (BERGERAT and CSONTOS, 1989). Since this work was completed, we have carried on the study of Neogene brittle tectonics in the Pannonian basin, and we have analysed a detailed map of the Mecsek Mountains (HETÉNYI et al., 1982; CHIKÁN et al., 1984). These works enabled us to reevaluate the importance and timing of the main stress-fields affecting the Mecsek-Villány region in the Neogene and to give some ideas on the main deformation zones, limiting the Mesozoic outcrops.

The bigger deformation zones of SE Hungary

The maps of the Mecsek-Villány area *(fig. 1)* reveal three important E-W trending fault zones : the Northern Thrust Zone (WEIN, 1963), the Southern Thrust zone (the Mecsek lineament W from Pécs), and the thrusts of the Villány Mountains (LÓCZY, 1912). In all of these places, we have measured dextral and sinistral strike-slips and oblique thrusts *(figs. 2, 3)*.

Although the NNW-SEE and N-S trending strike-slips are widespread in the Mecsek Mountains, the main location of them seems to be a strike-slip zone between the E- and the W- Mecsek (NÉMEDI-VARGA, 1983), or elsewhere called the Villány-Szalatnak deep fracture zone (KASSAI, 1973). Both sinistral and dextral movements can be measured on these fault surfaces *(figs. 2, 3)*.

The map analyse shows that two major NE-SW trending deformation zones exist in the area : the S-Mecsek Lineament (NÉMEDI-VARGA, 1983), and the Kapos Lineament (NÉMEDI-VARGA, 1977) *(fig. 4)*. They are probably main strike-slip surfaces, functioning at various times, for example in the Pannonian and may be even in the Pleistocene (op. cit.). The microtectonic data *(fig. 2)* reveal intensive sinistral movements on similarly oriented surfaces.

All of the above zones are subject to polyphase deformation. Several generations of slicken-slides, often in opposed directions can be observed in these zones (BERGERAT and CSONTOS, 1989). Naturally, these observations point to longer strike-slip zones functioning at several episodes. The nature of the movement on these surfaces is often changing in time : we can frequently find or deduce dextral or sinistral wrenching followed by oblique reverse faults, resulting in the complexity of these zones.

In the following, we trz to give the main events generating, or rejuvenating the deformation yones, and we will not deal with allt he 5 episodes, differentiated

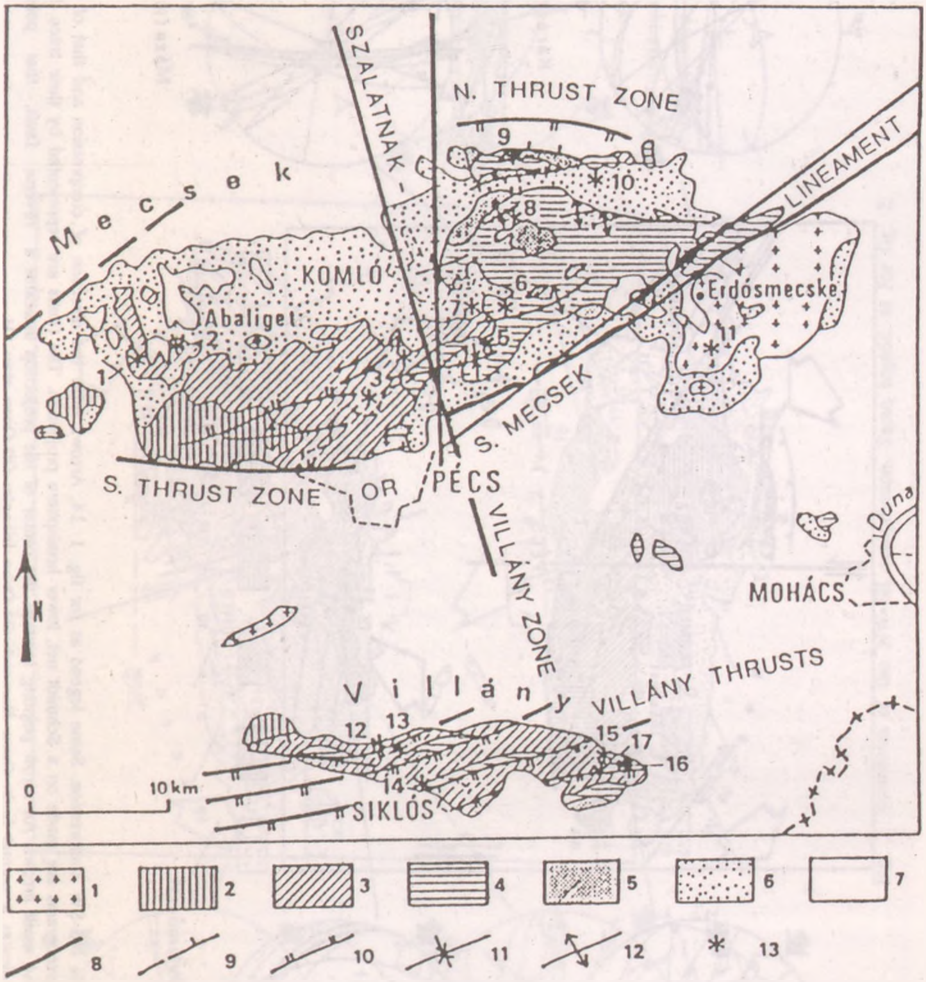

Fig. 1. The main deformation zones of the Mecsek-Villány area.
1. Hercynian granitoids; 2. Permian; 3. Triassic; 4. Jurassic; 5. Cretaceous;
6. Miocene without Lower Pannonian; 7. Lower Pannonian to Quaternary;
8. Main brittle tectonic surfaces and zones (mostly strike-slips);
9. Smaller faults; 10. Thrusts; 11. Sycnlines; 12. Anticlines;
13. Site of microtectonic investigations

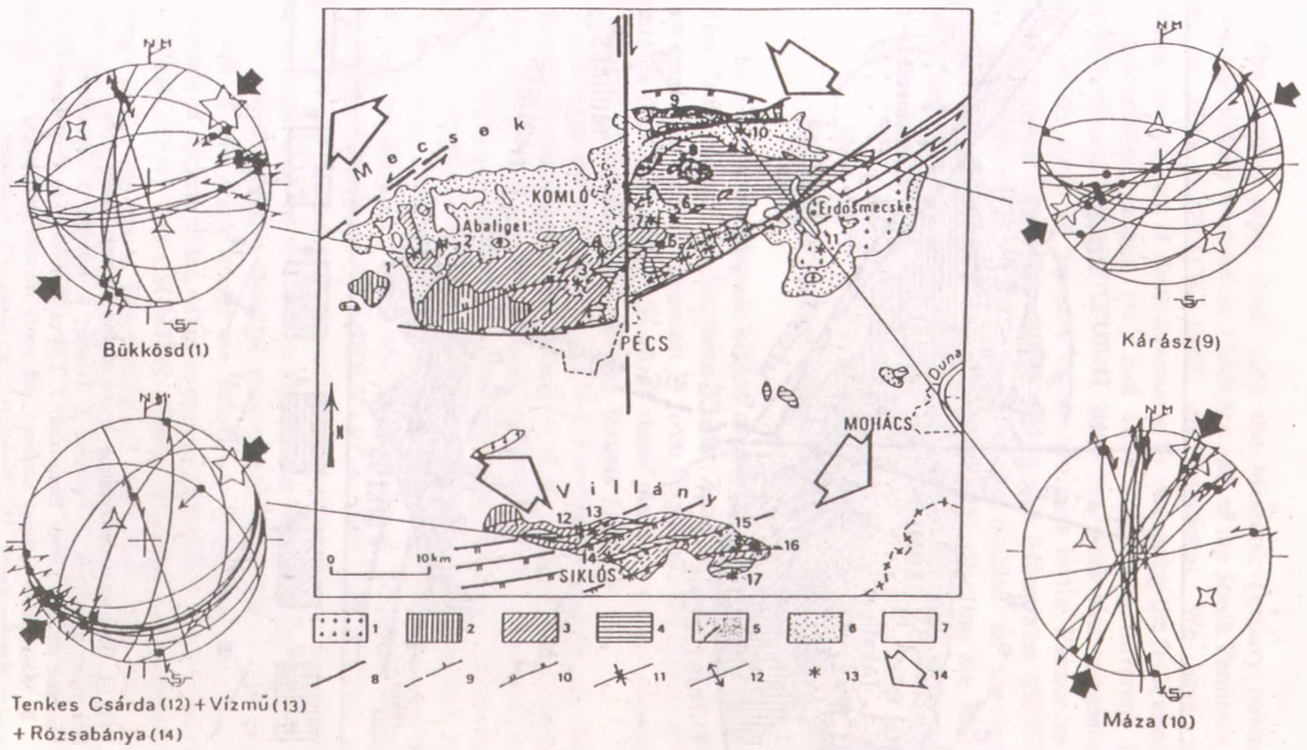

Fig. 2. Structures of the NE-SW compression. Same legend as for fig. 1. 14, Arrows show the direction of compression and that of extension for the whole area. The stereograms are made on a Schmidt net, lower hemisphere projection. The faults are represented by their trace. Movement on them is indicated by the small arrows. An arrow pointing towards the center of the projection indicates a reverse fault, that pointing in the opposite direction indicates a normal fault. Open diamond: O3 Open triangle: O2 Open star: O1

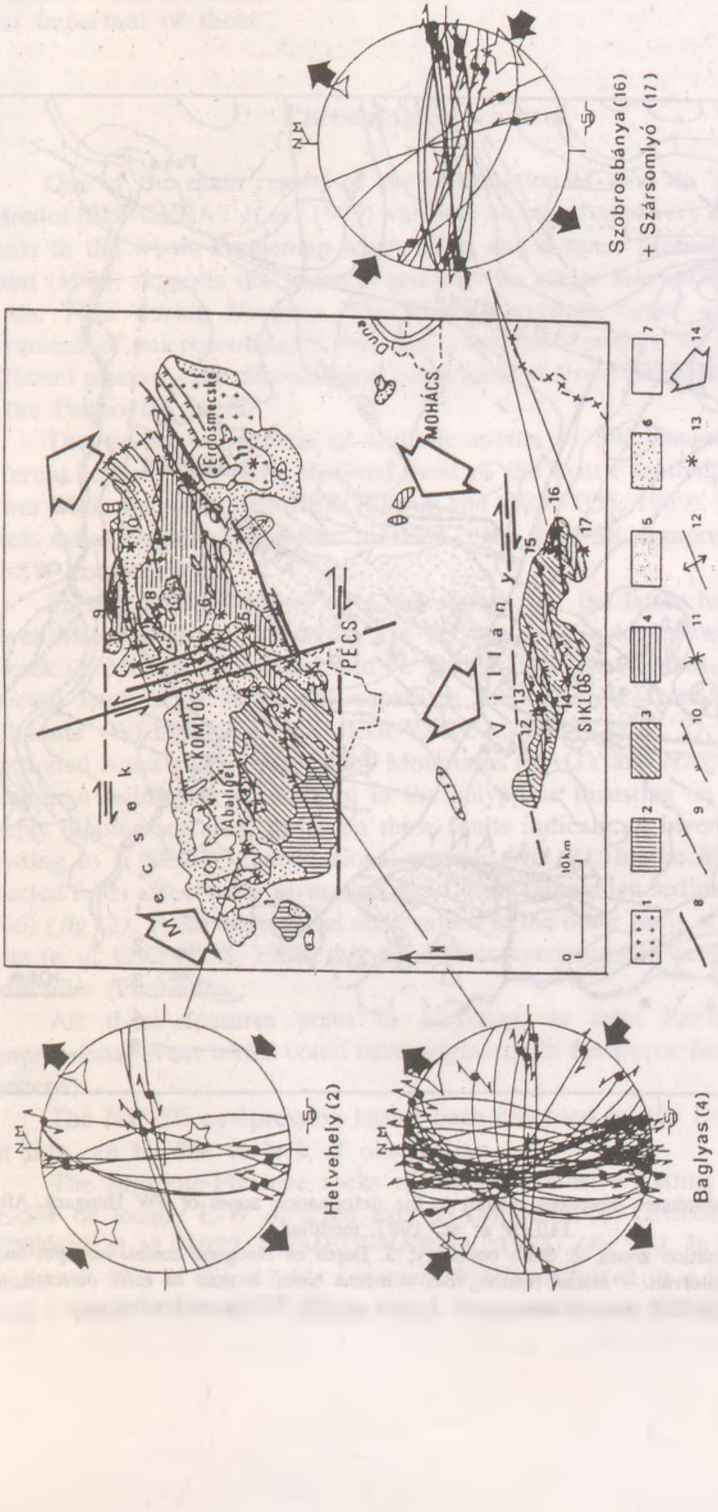

Fig. 3. Structures of the NW-SE compression. Same legend as for fig. 2.

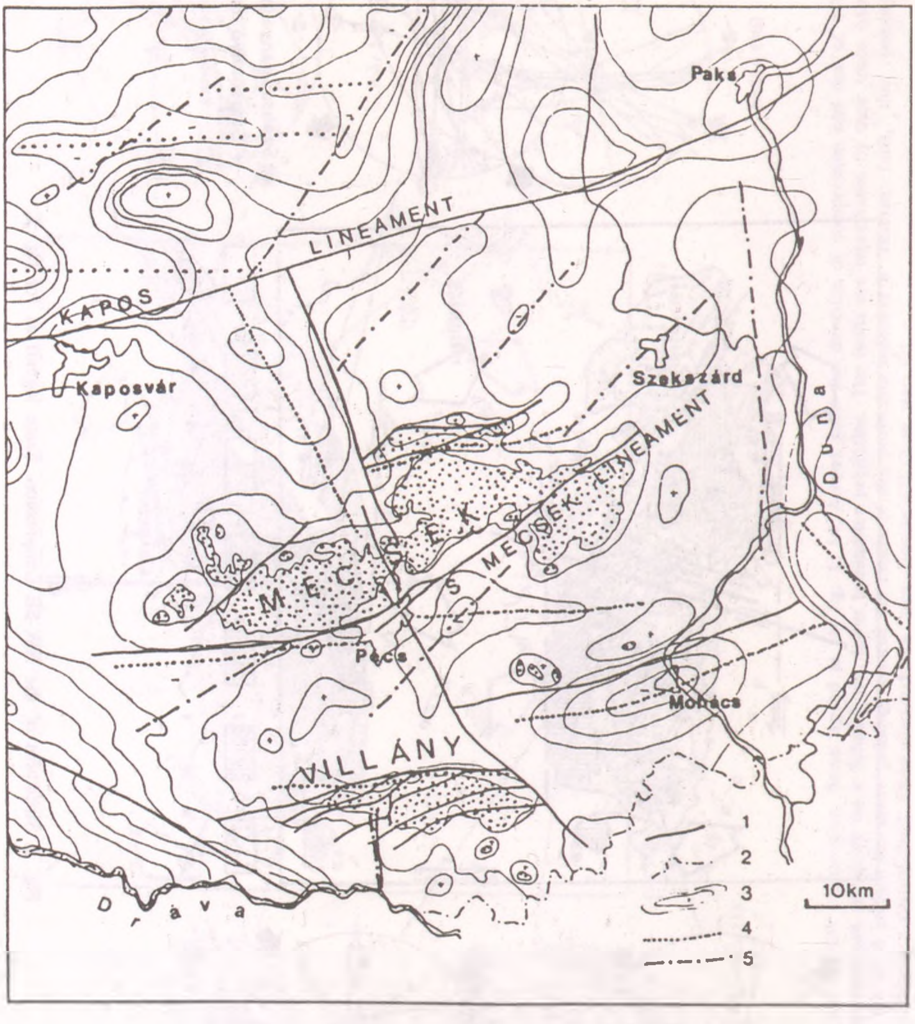

Fig. 4. Basin subsidence directions related to the deformation zones of SW Hungary. After FÜLÖP et al., 1987, modified.

1. Main deformation zones; 2. State boundary; 3. Depth of Neogene basins. isodepth lines are at 500 m intervals. + means relative rise, – means basin. 4. Axis of E-W directed, and of NNW-SSE directed subsidence. 5. Axis of NE-SW directed subsidence.

by earlier work (BERGERAT and CSONTOS, 1989), but we will select the 2 most important of them.

Chronological control

One of the main results of the compilation of data on Tertiary brittle tectonics (BERGERAT et al., 1989) was that we have found very similar tectonic events in the whole Pannonian basin. This, and a space problem in BALLA's model (1984) suggests that there is probably no major microcontinent rotation of the Tisia during Neogene. That doesn't exclude larger scale horizontal movement of microcontinents, but this conclusion enables us to use – with sufficient reserve – the chronological constraints of stress-fields gained elsewhere in the Pannonian basin.

The timing constraints of tectonic events in SW Hungary come from different sources. We have observed most of the brittle tectonic events in the Lower Miocene volcanites (BERGERAT and CSONTOS, 1989). Two important events have remained however undated : the NW-SE compression and the NE-SW compression.

Further analyse of our data has shown that the latter has affected the Lower Miocene strata, hence its age is younger. Geological evidence in the Mecsek (S. Mecsek Lineament and N. Thrust Zone) shows that an ENE-WSW directed large scale strike slip separates the mesozoic from the Pannonian sediments (WEIN, 1963; NÉMEDI-VARGA, 1989) *(fig. 2)*. In the above mentioned zones and in the Villány Mountains (NAGY and NAGY, 1976), even Pannonian sediments are implied in the polyphase thrusting on E-W directed, steeply dipping surfaces. Striae on these faults indicate an inverse oblique slip, pointing to a NE-SW compressional regime *(fig. 2)*. In the Mecsek, NW-SE directed folds affect even Sarmatian and Lower Pannonian sediments (HÁMOR, 1966) *(fig. 2)*. From widespread observation in the other parts of the Pannonian basin (e. g.: CSONTOS, 1988) this NE-SW compression has acted in the Upper Pannonian (Pontian).

All these features point to a young, at least Pannonian NE-SW compressional event which could have originated in the Upper Badenian (Middle Miocene).

The NW-SE compression hasn't been recorded by the Ottnangian rocks but this can be due to lack of observation.

The Miocene-Pliocene rocks record an extensive folding with generally NE-SW or locally E-W directed axis (HÁMOR, 1966, CHIKÁN et a., 1984, HETÉNYI et al., 1982, NÉMEDI-VARGA, 1983) *(fig. 3)*. In the vicinity of Komló the axis of some folds are even slightly distorted in a left lateral way, along a main NNW-SSE fracture zone. These folds are fitting perfectly in a

NW-SE compressional strike-slip type stress-field. That also means that this compression has to be young, i. e. younger than Upper Pannonian.

There is however a timing problem : the same event is calibrated as Karpatian (Lower Middle Miocene) in the Vienna basin (FODOR et al., 1989). The main surfaces of this event are E-W trending wrench faults, which create subsidence of basins of similar strike *(fig. 4)* in the nearby Zala basin at the same age (KŐRÖSSY, 1988).

An early creation of E-W strike dextral faults and NNW-SSE strike sinistral faults in supported by the fact that all the "thrust sheets" in the Mecsek-Villány area are acting as paleogeographic boundaries in the early Neogene. Moreover, they bear oblique sinistral striae on their steeply dipping surfaces *(fig. 2)*. In a NE-SW compression (former paragraph) the E-W directed surfaces are not ideally oriented, they are certainly not created but only rejuvenated as oblique left lateral faults. That is why these zones or at least their root zones must have been created by a former stress-field, not by the NE-SW compression.

Although it is difficult to prove, we suppose, on the base of analogies, that a NW-SE compression has acted first in the Karpatian then in the Upper Pannonian.

There is a further, seemingly much less important strike-slip type stress-field with N-S compression directions. This N-S compression affects the Lower Miocene volcanites, thus its age is younger. We have encountered this type of compression in the Lowermost Miocene and in the Badenian (Middle Miocene) in the Pannonian basin. The one found in the Mecsek is evidently the younger than the Badenian one.

Proposed history of Miocene brittle tectonic events in SW Hungary

Assessing the given data we have compressional stress-regimes of strike-slip type in the Mecsek-Villány area during Miocene-Pliocene with main directions σ_1 and σ_2 changing in time. The σ_1 direction (maximal compression) is seemingly pointing towards the NW-SE in the Lower Miocene. It changes to N-S in the Middle Miocene and to NE-SW in the Upper Miocene. Most probably the NW-SE compression appears once more after the Upper Pannonian (Pontian). We understand quite poorly the reappearence of this latter stress-field. For a detailed analyse we should know the present day stress-field, the basic data of which are being collected by others.

We haven't deal with the various extensions measured in SW Hungary (BERGERAT and CSONTOS, 1989) but we are persuaded that these phenomena, although very important, are only accompanying the basic strike-slip tectonics. Multitude of seismic data (e. g. RUMPLER and HORVÁTH, 1988) acquired in Hungary shows, that the Neogene tectonics are controlled by large wrench faults.

The present day configuration of the major fracture zones and the basins of SW Hungary is in our opinion due to several tectonic events and processes *(fig. 4)*. The early fault zones and basins have been probably formed during the Lower Miocene. These structures generally have an E-W strike. New basin directions of NE-SW direction are overprinted on the older ones probably in the Middle Miocene. The subsidence in these basins is continuing during the Pannonian, when the older structures are rejuvenated. At the end of the Pannonian (Pontian) we experience a drastic change in the compression directions, creating folds even in Lower Pannonian strata, and once more rejuvenating the old E-W directed deformation zones. This polyphase evolution is the probable reason of the curious crescent shape basins and rises and of the complex "thrust zones" of SE Hungary *(fig. 4)*.

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AN UPPER OLIGOCENE MOLLUSC FAUNA FROM KESZTÖLC, HUNGARY

by

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(Received: 6th March, 1989)

Abstract

There are Upper Oligocene beds cropping out in the NW side of Magosi Hill S of village Keszlölc. Clayey-silty sand with thin clay intercalations, sand, and sandstone form the 8 m thick sequence exposed in the 40 m long outcrop.

A typical brackish water fauna of medium preservation was collected from the first bed. It belongs to the *Polymesoda-Tympanotonus* association (after the classification of BÁLDI, 1973). Its most characteristic forms are Polymesoda convexa, *Tympanotonus margaritaceus, Ostrea cyathula,* and *Pirenella plicata.* A molar of a small herbivorous mammal, *Chalicotherium* was found here.

The artificial outcrop ot the 8th bed yielded a mollusc fauna of 30 species. It forms a transition between the associations *Glycymeris latiradiata* and *Pitar polytropa.* Solitary corals were collected in the exposure, too.

Fauna of the Ist bed idicates oscillating salinity between 4-10 %, and up to some metres deep water.

The fauna from the 8th bed indicates a normal saline, oxygen-rich environment in 20-30 m depth.

The fauna was compared to that of some famous Hungarian and foreign localities, and conclusions to its biogeographical relationships were drawn.

Introduction

Several authors have studied the Upper Oligocene sequence of *Magosi Hill* S of village Kesztölc. SCHAFARZIK (1884) described the most important fossils of the *Pectunculus* Beds *(Pectunculus obovatus, Turritella enus).*

SCHRÉTER (1953) listed seven mollusc species from Kesztölc. JASKÓ (1957) stated that the beds with *Pectunculus obovatus* and *Cyrena semistriata* filled flat basins. As these basins were formed among Triassic carbonate blocks, the Upper Oligocene sediments (being the youngest ones in the stratigraphic column) did not form a continuous sedimentary cover in the region.

PÁLFALVI (1965) described plant fossils from the lower part of the exposure. SIPOSS (1963, 1964a, 1964b) recognized differences between the Esztergom-Dorog and the Buda facies, both being dependent on distance from the shore and the submarine topography.

BÁLDI (1965a, 1973) published the most detailed description of the above mentioned locality. He considered all Upper Oligocene, polyhaline, clastic sedimentary rocks deposited in shallow sublittoral environment as *Pectunculus* Beds; while *Cyrena* Beds constitute of all mesohaline sediments deposited in a tidal lagoon. He published the stratigraphic profile of the locality together with a long list of the fauna. He discussed the lower and middle part of the exposure only; the rich fauna in the upper part was not known at that time. The latter fauna is discussed in the present paper.

The profile

Most of the Magosi Hill south of Kesztölc is made of Upper Oligocene strata. The hilltop is covered by thick loess, outcrops occur only in the NW side, along the creek passing the village from the south *(Fig. 1)*. The Oligocene strata forms minor outcrops in the southern side of the creek valley. There is only a single continuous, long profile in the last exposure downstream. This profile *(Fig. 2)* is the most complete sequence in the Kesztölc region. It is 40 m long, striking 71-251°. Its lowermost strata are covered by ca. 2 m thick slope debris. The sequence is as follows:

1. 3,0 m mollusc sand: monotonous, unbedded, contains much mica flakes. Weakly cemented, forms vertical walls (10-11 % carbonate content). Yellowish grey, medium-grained (BÁRDOSSY, 1961). Very well sorted (FOLK-WARD, 1957). DTA analysis showed montmorillonite in the pelitic fraction. Contains much heavy minerals, including hornblende, tourmaline, and apatite. Crossed by steep fractures (dip: 70-80°, strike: 60-240°, 45-225°, 30-210°). Strong limonitisation along fractures. Frequent pelite pebbles in the sand *(Fig. 3)*, ranging from 1 to 20 cm in diameter. The pebbles are slightly rounded, distributed irregularly, but form thin beds in the upper part of the sequence. Typical brackish water fauna of medium preservation was easily collected from the bed.

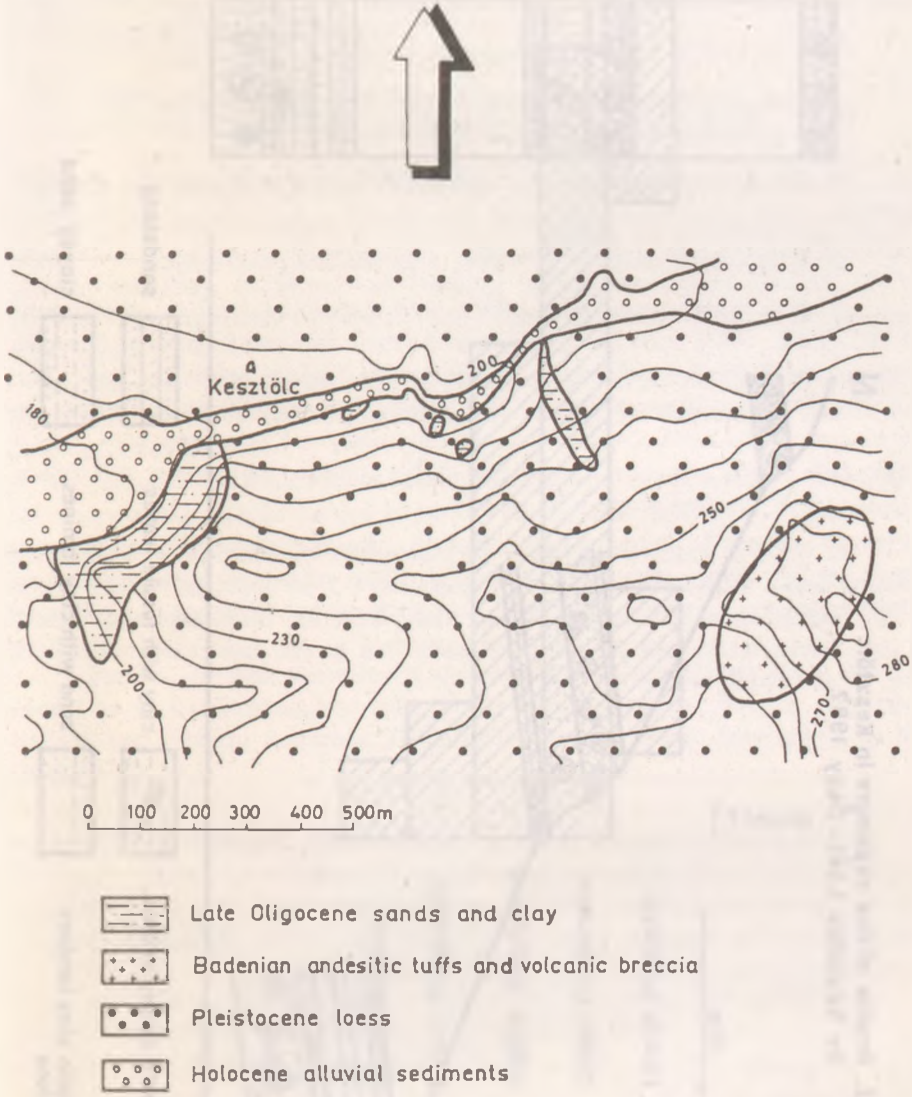

Fig. 1. Geological map of the surroundings of Kesztölc
by Szabolcs Leél-Össy, 1984

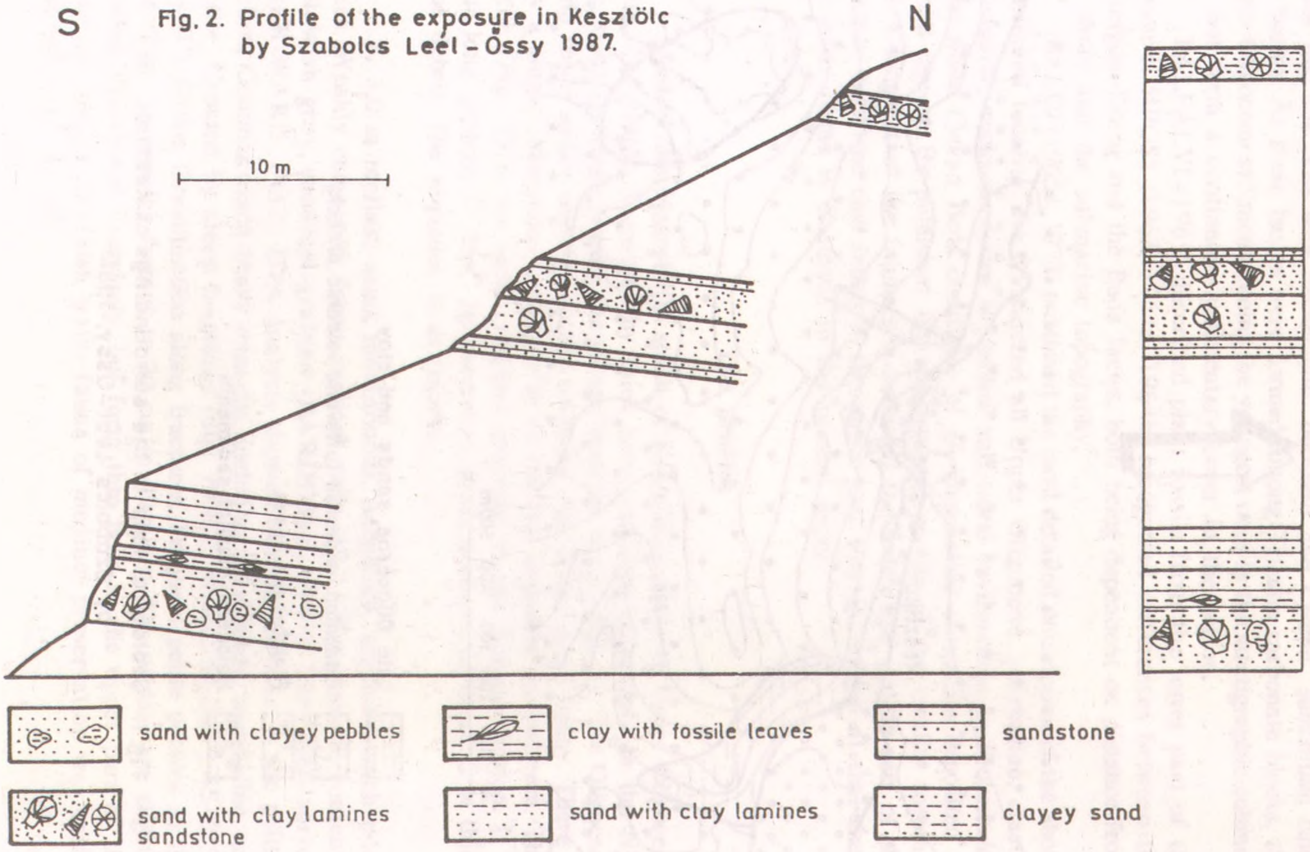

Fig. 2. Profile of the exposure in Kesztölc by Szabolcs Leél-Össy 1987.

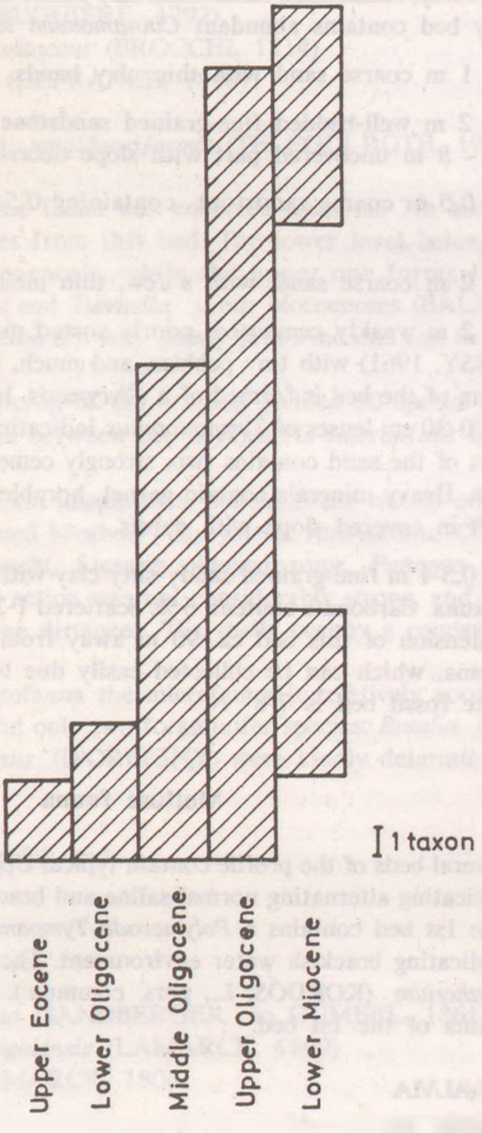

Fig. 3. Chronogram of the mollusc-fauna in Kesztölc

2. Grey, micaceous, calcareous clay bands alternate with sand. A 30 cm thick clay bed contains abundant *Cinnamomum* leave imprints.

3. 1 m coarse sand with thin clay bands.

4. 2 m well-bedded fine-grained sandstone with limonitic tint.
– 8 m uncovered part with slope debris.

5. 0,5 m coarse sandstone, containing 0,5 cm well-rounded quartzite pebbles.

6. 2 m coarse sand, with a few, thin mollusc fragments.

7. 2 m weakly cemented, poorly sorted medium to fine-grained sand (BÁRDOSSY, 1961) with tiny pebbles, and much, but poorly preserved fossils. The bottom of the bed is formed of a *Glycymeris* horizon, while the upper part contains 20-30 cm lenses of *Tympanotonus* indicating brackish environment. The upper part of the sand contains two, strongly cemented sandstone beds, 15 cm thick each. Heavy minerals contain garnet, hornblende, tourmaline, and zircon.
– 8 m covered slope with debris.

8. 0,5-1 m fine-grained sandy-silty clay with species-rich, well-preserved mollusc fauna. Carbonate content: 6 %. Scattered 1-2 cm quartzite pebbles occur. A SW extension of this bed ca. 90 m away from the main exposure yielded a rich fauna, which can be collected easily due to the less cemented matrix. Dip of the fossil bed is 7-8° N.

Mollusc fauna

Several beds of the profile contain typical Upper Oligocene mollusc fauna; fossils indicating alternating normal saline and brackish water conditions occur.

The 1st bed contains a *Polymesoda-Tympanotonus* association (BÁLDI, 1973), indicating brackish water environment. The single mammal molar is of a *Chalicotherium* (KORDOS, L., pers. commun.).

Fauna of the 1st bed:

BIVALVIA
Nucula sp.
Glycymeris latiradiata SANDBERGER in GÜMBEL, 1861
Ostrea cyathula LAMARCK, 1806
Polymesoda convexa (BRONGNIART, 1822)

GASTROPODA
Theodoxus crenulatus (KLEIN, 1853)
Turritella sp.

Melanopsis impressa hantkeni (HOFMANN, 1870)
Pirenella plicata (BRUGUIÈRE, 1792)
Tympanotonus margaritaceus (BROCCHI, 1814)
Terebralia bidentata (DEFRANCE, 1840)
Natica sp.
Babylonia eburnoides umbilicosiformis (TELEGDI-ROTH, 1914)

A typical normal saline fauna was collected from the 7th bed. BÁLDI (1973) described 21 species from this bed. The lower level belongs to the *Glycymeris latiradiata* biocoenosis, while the upper one forms transition between the *Pitar polytropa* and *Turritella venus* biocoenoses (BÁLDI, 1973). Fossils of the *Turritella* horizon are very poorly preserved and can be collected very hardly.

The new artificial outcrop of the 8th bed yielded 30 species (see list). The fauna forms transition between the *Glycymeris latiradiata* and *Pitar polytropa* biocoenoses.

Although the fossils form lumachelles, the shells are weakly eroded, and there are many double-valved bivalves *(Glycymeris latiradiata, Crassatella carcarensis, Pholadomya puschi, Lutraria oblonga soror, Panopea meynardi,* etc.). It indicates that water action was not considerably strong, and the shells were not transported for long distances. The shells occupy a concave-upward position.

Besides the rich macrofauna the microfauna is relatively poor: there is almost no nannoplankton, and only two foraminifer species: *Rotalia propinqua* REUSS and *Florilus boueanus* (D'ORBIGNY) were kindly determined by M. HORVÁTH.

Mollusc fauna of the 8th bed:

BIVALVIA
Nucula sp.
Glycymeris latiradiata (SANDBERGER in GÜMBEL, 1861)
Flabellipecten burdigalensis (LAMARCK, 1809)
Ostrea cyathula (LAMARCK, 1806)
Ostrea sp.
Astarte gracilis degrangei (COSSMANN et PEYROT, 1912)
Crassatella (Eucrassatella) carcarensis (MICHELOTTI, 1847)
Arctica islandica rotundata (BRAUN in AGASSIZ, 1845)
Isocardia subtransversa abbreviata (SACCO, 1890)
Cardium egerense (TELEGDI-ROTH, 1914)
Cardium sp.
Laevicardium cyprium (BROCCHI, 1814)

Venus (Ventricola) multilamella (LAMARCK, 1818)
Pitar (Cordiopsis) polytropa (ANDERSON, 1958)
Angulus (Peronidia) nysti (DESHAYES, 1860)
Dosiniopsis sublaevigata (NYST, 1843)
Lutraria oblonga soror (MAYER, 1867)
Panopea meynardi (DESHAYES, 1828)
Pholadomya puschi (GOLDFUSS, 1837)

GASTROPODA
Turritella (Haustator) venus (D'ORBIGNY, 1852)
Turritella sp.
Tympanotonus margaritaceus (BROCCHI, 1814)
Drepanocheilus speciosus digitatus (TELEGDI-ROTH, 1914)
Polinices catena achatensis (RECLUZ in DE KONINCK, 1837)
Globularia rothi (COSSMANN, 1925)
Zonaria cf. *globosa* (DUJARDIN, 1835)
Cassidaria depressa (BUCH, 1831)
Fusus columballiformis gradatus (GABOR, 1936)
Volutilithes permulticostata (TELEGDI-ROTH, 1914)
Athleta rarispina (LAMARCK, 1811)
Athleta ficulina (LAMARCK, 1811)
Turricula regularis (DE KONINCK, 1837)

SCAPHOPODA
Dentalium kickxi (NYST, 1843)
Fustiaria cf. *taurogracilis* (SACCO, 1897)

ANTHOZOA
Glabellum sp.

Environmental interpretation

Fauna of the lst bed clearly belongs to the *Polymesoda-Tympanotonus* biocoenosis. All characteristic species occur: *Polymesoda convexa, Tympanotonus margaritaceus, Ostrea cyathula, Pirenella plicata, Melanopsis impressa hantkeni.* The associated fossils are: *Theodoxus crenulatus,* and a molar small herbivorous mammal: *Chalicotherium* (KORDOS, L., pers. commun.). The latter genus persisted from Early Oligocene till Badenian time; it is characteristic for the Hungarian Oligocene.

This association indicates oscillating salinity between 4-10 %, characteristic for estuaries.

Water depth was not more than some metres. Strong wave action is indicated by the characteristic rounding of some *Tympanotonus* shells, and by excellent sorting.

Members of the biocoenosis belonged to the epifauna; these were herbivores (or detritus feeders): *Tympanotonus, Pirenella, Theodoxus, Melanopsis.* Suspension feeders were the Ostreas and the infaunal Polymesodas.

Establishment of a brackish water environment indicates humid climate, supported by modern faunas.

The uppermost, 8th level contains a fauna showing transition between the *Glycymeris latiradiata* and *Pitar polytropa* biocoenoses. Large frequency of *Glycymeris latiradiata,* and presence of *Ostrea cyathula, Crassatella carcarensis, Pholadomya puschi, Turritella venus, Panopea meynardi, Polinices catena achatensis,* and *Venus multilamellata* indicates *Glycymeris latiradiata* biocoenosis, while *Pitar polytropa, Laevicardium cyprium, Angulus nysti, Turricula regularis, Drepanocheilus speciosus digitatus, Athleta rarispina, Arctica islandica rotundata,* and *Lutraria oblonga soror* indicates the *Pitar polytropa* biocoenosis. The great species diversity also indiates the latter one.

Extremely large number of suspension-feeders occur in the fauna: coral, *Pecten, Venus, Ostrea, Pitar, Turritella, Laevicardium, Arctica, Panopea, Pholadomya,* and *Isocardia.*

Herbivores were: *Tympanotonus* specimens, which may be redeposited after death. Sediment feeders were members of the following genera: *Angulus, Drepanocheilus, Nucula,* and echinoderms (indicated by echinoid spines in washing residues). Predators were: *Athleta, Turricula, Polinices, Dentalium,* and *Volutilithes.* Distribution of genera according to feeding modes shows no significant differences from the usual distribution. This mollusc fauna – and the relatively large number of solitary corals – indicates normal saline, marine environment. Salinity did not decrease below 30‰ (it is the first occurrence of solitary corals in this biocoenosis in Hungary). Depth may be ranged between 20-30 metres. Concave-upward position of bivalve shells indicate rare wave agitation. Weak sorting indicates slow sedimentation.

The Magosi Hill complex was deposited in a shallow marine, sublittoral environment. The high-diversity fauna needed oxygen-rich water.

The lithology of the sequence does not provide any evidences for contemporaneous surface occurrence of either Traissic of Eocene carbonate rocks, as supposed by JASKÓ, (1957), and SIPOSS (1963).

Paleobiogeographical relations

The collected material was compared to the published lists of the Máriahalom, Törökbálint, and Eger faunas. The following foreign faunas were considered for comparison purposes: Slovenia: ANIC (1952); Alpine molasse:

SCHAFFER (1912); HÖLZL (1957, 1958, 1962); Boreal province: SANDBERGER (1863); GÖRGES (1952); SPEYER et KORENEN (1884); GLIBERT (1957); NEUFFER (1973); Atlantic province: COSSMANN et PEYROT (1909-1932); Mediterranean province: BELLARDI et SACCO (1873-1904) and ROVERETO (1900). Bioprovince relations of the collected fauna were established (following BÁLDI, 1973, 1983): 46 % of the species is cosmopolitan, 20 % Boreal, 10 % Atlantic, 16 % Mediterranean, 4 % endemic. These data fit well the national data of BÁLDI (1983), only the endemic and cosmopolitan values show significant differences.

Comparing the Kesztölc fauna to other Upper Oligocene localities in Hungary, we found especially close relationships to the Kovácov and Eger faunas. Twenty-three taxa determined to the species level (from among 36 ones) can be found in the Kovácov fauna, while 28 in the Eger fauna.

Jaccard coefficient values are very low: e. g. 0.123 compared to the Kovácov fauna, possibly due to the samller number of species at Kesztölc. While the Kovácov fauna contains 158 species (SENES), 1958), the Eger fauna 170 species (BÁLDI, 1973), comparisons applying the Jaccard coefficient provide insufficient results.

Similarities occur with the Törökbálint (16 common species) and Máriahalom (15 species) faunas.

Upper Oligocene age of the Kesztölc fauna is proved by chronograms (BÁLDI, 1976), considering appearances and disappearances of the species. Eighteen species from Kesztölc (more than 50 %) did not live before Late Oligocene, while 13 species did not cross the Oligocene/Miocene boundary.

Geographical position and characteristic facies succession indicates that the Kesztölc fauna belongs to the Kovácov Formation (altogether the Eger fauna contains more common species with the Kesztölc fauna.)

There are several species at Kesztölc which occur in almost all famous Hungarian Upper Oligocene localities: *Glycymeris latiradiata, Ostrea cyathula, Angulus nysti, Pitar polytropa, Panopea meynardi, Pholadomya puschi, Polymesoda convexa, Tympanotonus margaritaceus, Pirenella plicata*, etc., indicating that the Kesztölc fauna may be considered a typical Hungarian Upper Oligocene, Egerian mollusc fauna.

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Plate I.

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Fig. 1–3. *Glycymeris latiradiata* (SANDBERGER in GÜMBEL, 1861)
Fig. 4. *Ostrea cyathula* (LAMARCK, 1809)
Fig. 5. *Pecten (Flabellipecten) burdigalensis* (LAMARCK, 1809)
Fig. 6. *Ostrea cyathula* (LAMARCK, 1809)

Plate II.

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Fig. 1–2. *Crassatella (Eucrassatella) carcarensis* (MICHELOTTI, 1847)
Fig. 3. *Astarte gracilis degrangei* (COSSMANN et PEYROT, 1912)
Fig. 4. *Arctica islandica rotundata* (BRAUN in AGASSIZ, 1845)
Fig. 5. *Crassatella (Eucrassatella) carcarensis* (MICHELOTTI, 1847)
Fig. 6. *Arctica islandica rotundata* (BRAUN in AGASSIZ, 1845)

Plate III.

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Fig. 1. *Polymesoda convexa* (BRONGNIART, 1822)
Fig. 2. *Isocardia subtransversa abbreviata* (SACCO, 1890)
Fig. 3. *Cardium egerense* (TELEGDI-ROTH, 1914)
Fig. 4. *Laevicardium cyprium* (BROCCHI, 1814)
Fig. 5. *Venus (Ventricola) multilamella* (LAMARCK, 1818)
Fig. 6. *Pitar (Cordiopsis) polytropa* (ANDERSON, 1958)
Fig. 7. *Pholadomya puschi* (GOLDFUSS, 1837)
Fig. 8. *Dosiniopsis sublaevigata* (NYST, 1843)

Plate IV.

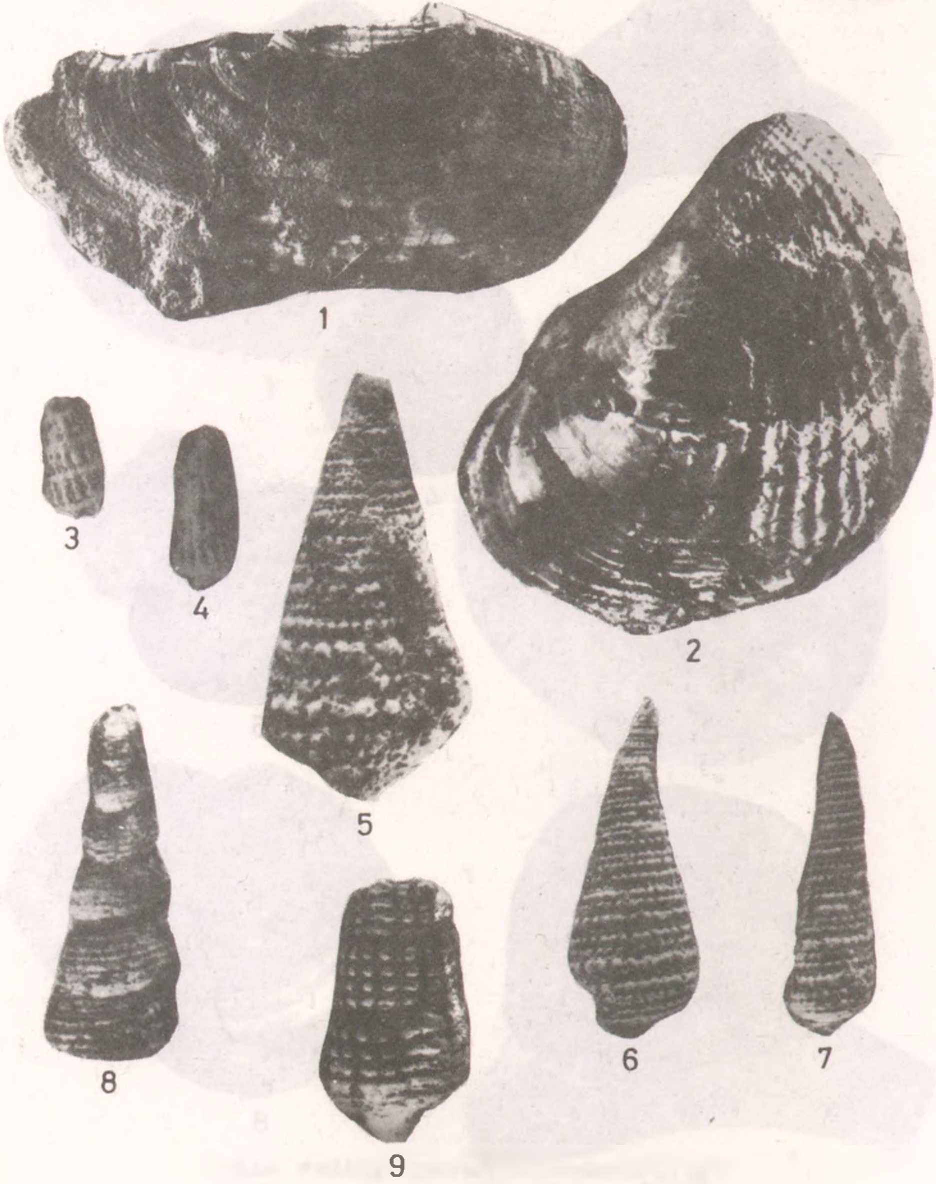

Fig. 1. *Panopea meynardi* (DESHAYES, 1828)
Fig. 2. *Pholadomya puschi* (GOLDFUSS, 1837)
Fig. 3–4. *Pirenella plicata* (BRUGUIÉRE, 1792)
Fig. 5–7. *Tympanotonus margaritaceus* (BROCCHI, 1814)
Fig. 8. *Turritella (Haustator) venus* (D'ORBIGNY, 1852)
Fig. 9. *Terebralia bidentata* (DEFRANCE, 1840)

Plate V.


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Fig. 1. *Drepanocheilus speciosus digitatus* (TELEGDI-ROTH, 1914)
Fig. 2. *Polinices catena achatensis* (RECLUZ in DE KONINCK, 1837)
Fig. 3. *Globularia rothi* (COSSMANN, 1925)
Fig. 4–5. *Zonaria* cf. *globosa* (DUJARDIN, 1835)
Fig. 6–7. *Babylonia eburnoides umbilicosiformis* (TELEGDI-ROTH, 1914)
Fig. 8. *Volutilithes permulticostata* (TELEGDI-ROTH, 1914)
Fig. 9. *Athleta rarispina* (LAMARCK, 1811)

Plate VI.

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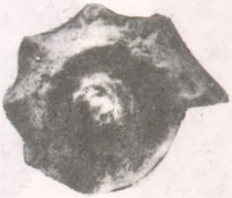

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Fig. 1. Coral colony

Fig. 2. *Chalicotherium* sp.

Fig. 3. Coral colony

Fig. 4. Coral colony

Fig. 5. *Dentalium kickxi* (NYST, 1843)

Fig. 6. *Turricula regularis* (DE KONINCK, 1837)

Fig. 7. *Athleta rarispina* (LAMARCK, 1811)

SARMATIAN FORAMINIFERA OF THE ZSÁMBÉK BASIN, HUNGARY

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Abstract

A Sarmatian foraminiferal zonation is presented on the basis of 3 boreholes from the Zsámbék Basin, which cut a Sarmatian sequence, complete in the Hungarian sense. Three zones could be distinguished: Elphidium reginum, Elphidium hauerinum and Spirolina austriaca zone. These could be correlated with the other foraminiferal zones both of the Western and the Eastern Paratethys, furthermore the boundary of Kozárd and Tinnye Substage could be determined. Systematic descriptions are given of 63 species, including 3 new ones. Previously only 18 of them were described from the Sarmatian formations of Hungary.

Introduction

History of development of the Western and the Eastern Paratethys was different during the Sarmatian. For this reason distinct stratigraphic units are used in these two areas of Paratethys (NEVESSKAJA et al. 1989). The classic stratigraphic divisions were based on the mollusch fauna. In the Eastern Paratethys ANDRUSOV (1902) established the Volhynian, Bessarabian and Chersonian Substages, these correspond to the Lower, Middle and Upper Sarmatian. Starting from the upper part of the Bessarabian Substage in the Western Paratethys lacustrine formations deposited, so this stratigraphic unit is called Pannonian Stage while the lower part is named Sarmatian s.str. (SUESS, 1866) in this region. The Sarmatian s.str. was divided into different units by many authors (FUSCH, 1875; WINKLER, 1913; PAPP, 1956; SENEŠ 1972; JIRICEK, 1972 etc.). The Hungarian Sarmatian biostratigraphic division was made by BODA (1959-74). Studying mollusc fauna of Hungary (from the Zsámbék Basin too) he distinguished the Kozárd and Tinnye Substages. The boundary was defined as the time, when the characteristic specimens of the

	Western Paratethys					Eastern Paratethys									
	POLAND	AUSTRIA		HUNGARY Zsámbék Basin	CZECHO-SLOVAKIA	ROMANIA			NE-BULGARIA	TRANSCAR-PATHIANS		VOLHYN-PODOLIAN	BLACK SEA FOREDEEP	TRANS-CAUCASUS	
	Luczkowska 1967	Grill,1943 Papp,1974		Görög,1992	Jiricek,1972	Ionesi,1968,1986			Darakcieva 1989	Horizont	Venglinski 1962,1975				
	zone		zone		zone		zone				zone				
Bessarabian Substage		Younger Sarmatian	N.granosum	S.austriaca	P.subgranosum with B.sarmatica D.elegans E.hauerinum		N.bogdanowiczi P.subgranosus E.macellum A.beccarii P.subgranosus Q.consobrina	Peneroplidae subzona	P.subgranosum acme zone F.tutkowskii acro zone	Almaschska	P.subgranosus A.problema with N.bogdanowiczi B.sarmatica Caucasina Peneroplidae	P.subgranosus with E.macellum E.subumbilicatum	Q.voloshinovae P.subgranosus	Q.voloshinovae P.subranosus	Middle Sarmatian
Volhynian Substage	E.hauerinum	Older Sarmatian	E.hauerinum	E.hauerinum	E.hauerinum with B.moldavica	Volhynian Substage	E.rugosum Q.reussi Articulina		E.jouckovi interval zone	Lukovska	Q.reussi E.hauerinum with E.rugosum E.reginum	Q.sarmatica Q.reussi	Q.reussi A.sarmatica	P.martkobi Q.reussi	Lower Sarmatian
	V.sarmatica														
	Cy.karreri ovata		E.reginum with E.aculeatum E.hauerinum E.flexuosum grilli	E.reginum	E.reginum with E.aculeatum Q.karreri ovata C.badenenesis		P.regina			Dorobratovska	Q.pseudocostata E.reginum C.badenensis	Q.pseudocostata C.badenensis	Q.costata E.macellum	E.hauerinum	
	An.dividens				C.badenensis with E. subumbilicatum A.sarmatica E.reginum	Buglovian Substage	C.badenensis C.lobatulus								

Table 1. Biostratigraphic correlation of the Sarmatian sediments in Paratethys. An. - Anomalinoides; A. - Articulina; B. - Bolivina; C. - Cibicides; Cy. - Cycloforina; D. - Dendritina; E. - Elphidium; F. - Flintina; N. - Nonion; Pa. - Parrelina (= Elphidium); P. - Porosononion; Q. - Quinqueloculina; S. - Spirolina; V. - Varidentella.

lower substage dissapeared and the species of the upper substage appeared in great numbers.

BOHN-HAVAS (1983) distinguished three characteristic mollusc assemblages in the Zsámbék Basin, but neither of their boundaries coincided with the Kozárd-Tinnye boundary. She proved the presence of the lower part of the Bessarabian Substage and the similarity of mollusca fauna with the different parts of the Eastern Paratethys.

The first foraminiferal zonation was made by GRILL (1943) and PAPP (1956) in the Vienna Basin, distinguishing the *Elphidium reginum* zone, *Elphidium hauerinum* zone and *Nonion granosum* zone, moreover correlating with the mollusc zones. In the Eastern Paratethys VENGLINSKI (1958-1974) established many foraminiferal zones and their connections with the mollusc zones, futhermore distinguished, on the basis of foraminifera, the Dorobratovska, the Lukovska and the Almaschska Horizons in Transcarpathians. In the last twenty years many biostratigraphic divisions were published from the different parts of the Paratethys. A summary of the foraminiferal zonations are presented on *Table 1.*

The Sarmatian foraminifera fauna of Hungary were investigated by some Hungarian paleontologists (SCHRÉTER, 1912, 1941; MAJZON, 1939, 1945; KÓKAY, 1954, BODA, 1959) but usually they published only a fauna list, without descriptions and illustrations. BODA (1971, 1974) found, in connection with the foraminifera fauna, that *Elphidium reginum* D'ORBIGNY, *Elphidium fichtelianum* D'ORBIGNY and *Cibicides lobatulus* WALKER & JAKOB are present only in the Kozárd Substage and *Elphidium aculeatum* D'ORBIGNY occured in great numbers during this time. In the Tinnye Substage *Porosononion granosum* D'ORBIGNY is very abundant and *Spirolina austriaca* D'ORBIGNY occurs only in this level. He correlated the substages with the mollusc and foraminifera zones of the Vienna Basin (GRILL, 1943; PAPP, 1956) and with the Substages of Eastern Paratethys. He established that the Kozárd Substage corresponds to the *Elphidium reginum* zone and the Volhynian Substage while the Tinnye Substage corresponds to the *Elphidium hauerinum* and the *Porosononion granosum* zones of the Vienna Basin and to the lower part of the Bessarabian Substage.

KORECZ-LAKY (1964-82) studied the Hungarian Sarmatian foraminifera fauna in detail, especially in the Mecsek and Tokaj Mountains, regarding the fauna of these areas as Lower Sarmatian *(Fig. 1)*. She distinguished several foraminiferal biofacies (with Miliolidae, *Cibicides, Nodophthalmidium, Rotalia beccarii, Nonion granosum,* Elphididae and *Ammomarginulina-Miliammina*). Moreover she established that these biofacies are connected more with the lithological features than with the age, and a tendency can be ovserved that the Miliolidae biofacies appears in the lower, the *Nodophthalmidium* in the middle and the *Nonion granosum* biofacies in the upper part of the Hungarian Sarmatian formations.

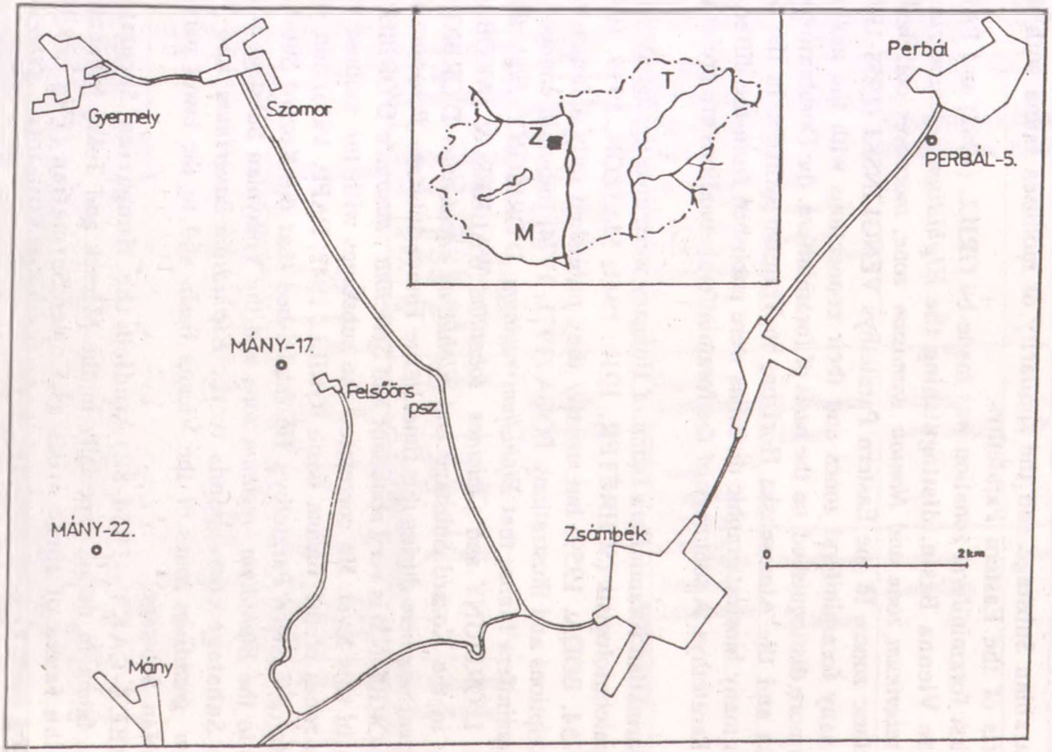

Fig. 1. Chart showing the locations of the studied boreholes. M – Mecsek Mts.; T – Tokaj Mts.; Z – Zsámbék Basin.

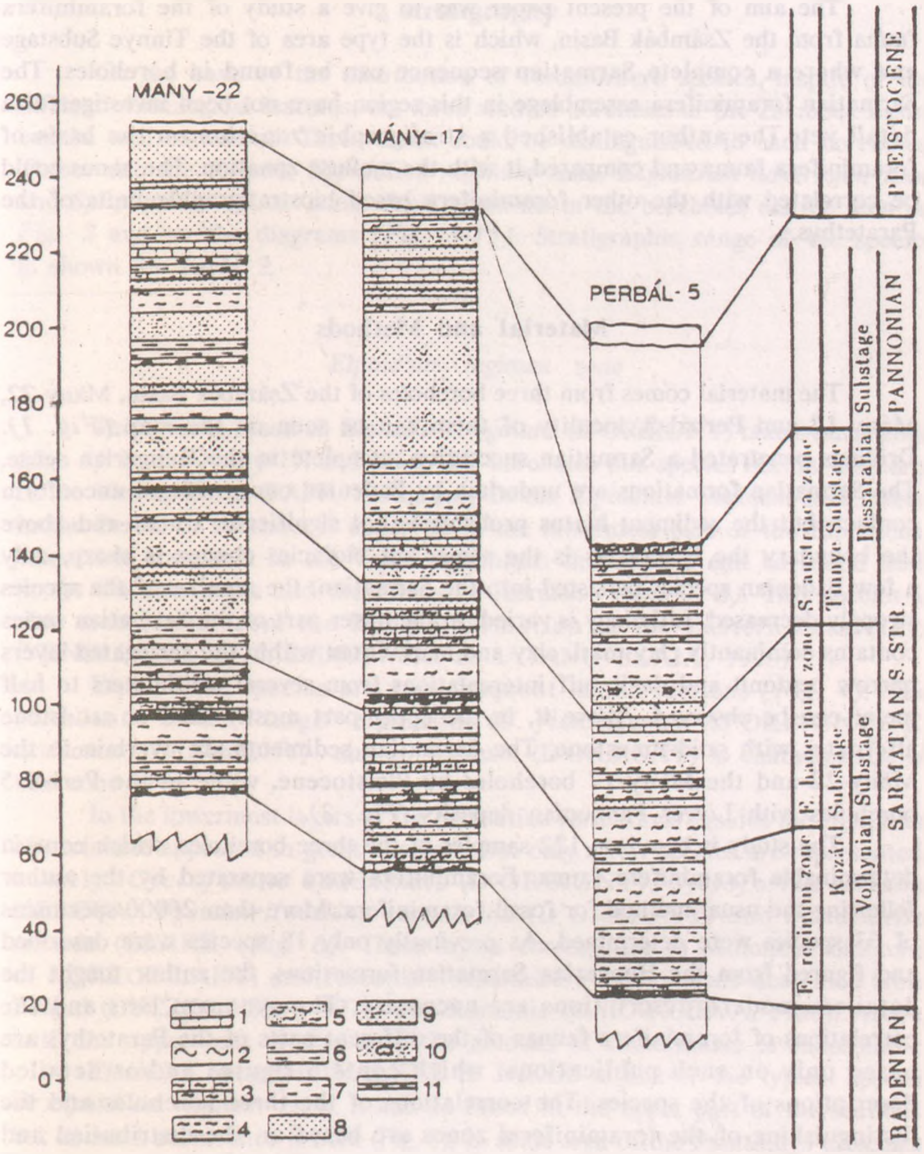

Fig. 2. Comparative profiles of the boreholes with lithological development and stratigraphic subdivision. Depths refer to the sealevel. 1 – limestone; 2 – marl; 3 – calcareous marl; 4 – clay-marl; 5 – silty clay-marl; 6 – aleurit; 7 – clay; 8 – sandstone; 9 – sand; 10 – calcareous sand; 11 – tuff.

The aim of the present paper was to give a study of the foraminifera fauna from the Zsámbák Basin, which is the type area of the Tinnye Substage and where a complete Sarmatian sequence can be found in boreholes. The Sarmatian foraminifera assemblage in this region have not been investigated in detail yet. The author established a stratigraphic zonation on the basis of foraminifera fauna and compared it with the mollusc zonation. The zones could be correlated with the other foraminifera based biostratigraphic units of the Paratethys.

Material and Methods

The material comes from three boreholes of the Zsámbék Basin, Mány-22, Mány-17 and Perbál-5, locality of them can be seen on the map *(Fig. 1)*. Drillings penetrated a Sarmatian succession, complete in the Hungarian sense. The Sarmatian formations are underlain by Badenian ones, with an unconform contact, but the sediment hiatus probably is not significant. Under and above the boundary the lithofacies is the same, but biofacies change is sharp, only a few Badenian species persisted into the Sarmatian, the number of the species strongly decreased. Lithology is varied, in the lower part of the Sarmatian series contains dominantly clay-marl, clay and marl. Often within the variegated layers narrow bentonit and dacit tuff intercalations from several centimeters to half meter can be observed. Above it, in the upper part mostly sand or sandstone alternates with ooid-limestone. The Sarmatian sediments are overlain in the Mány-22 and the Mány-17 boreholes by Pleistocene, while in the Perbál-5 boreholes with Lower Pannonian deposits *(Fig. 2)*.

The study is based on 122 samples of the three boreholes, which contain determinable foraminifera fauna. Foraminifera were separated by the author following the usual method for fossil foraminifera. More than 26000 specimens of 63 species were determined. As previously only 18 species were described and figured from the Hungarian Sarmatian formations, the author tought the detailed, modern descriptions are necessary. The synonym lists and the correlations of foraminifera faunas of the different parts of the Paratethys are based only on such publications, which contain figures and/or detailed descriptions of the species. The correlations of the three boreholes and the distinguishing of the foraminiferal zones are based on the distribution and abundance of the species. The abundance was studied both as percentage of the total foraminiferal assemblage and the number of their specimens in 100 g rocks. The distributions of the most important taxons are illustrated on diagrams. On the horizontal axis the dotted line shows that in the given depth no or undeterminable foraminifera were found. The boundries of the foraminiferal zones are marked by dashed lines.

The photos were made by the author with scanning electron microscope.

Stratigraphy

On the basis of the distribution of foraminifera species, inspite of the different lithological features, the three studied boreholes of the Zsámbék Basin, can be well correlated. Three zones could be distinguished in each boreholes. These are the follows: *Elphidium reginum* zone, *Elphidium hauerinum* zone and *Spirolina austriaca* zone. Their positions in the boreholes can be seen on *Fig. 2* and on the diagrams *(Fig. 3-13)*. Stratigraphic range of the species is shown on *Table 2*.

Elphidium reginum zone

This zone is based on *Elphidium reginum* (D'ORBIGNY) taxon-range zone *(fig. 3)*. In the Mány-17. and Mány-22. boreholes this species occurs, similarly to the Vienna Basin (PAPP, 1956), only in the *Elphidium reginum* zone, while in the Perbál-5. borehole it appeared in the lowermost part of the *Elphidium hauerinum* zone too. In the Transcarpathians this species can be found both in the Dorobratovska and the Lukovska Horizon *(Table 1, 2)*. This species is also mentioned from the Middle Sarmatian of the Eastern Paratethys (VENGLINSKI, 1975; DIDKOWSKI & SATANOVSKAJA, 1970).

Elphidiidae species are very frequent in the sections *(Fig. 4)*. The abundance of the "large" elphidiids (*E. fichtelianum* (D'ORBIGNY), *E. aculeatum* (D'ORBIGNY) and *E. reginum* (D'ORBIGNY) is characteristic of this zone *(Fig. 5)*.

In the lowermost layers of the Sarmatian formations besides the elphidiids Hauerinidae appeared in great numbers, but only a few species are represented, namely *Cycloforina badenensis* (D'ORBIGNY), *Cycloforina toreuma* (SEROVA), *Pseudotriloculina consobrina* (D'ORBIGNY) and *Varidentella rotunda* (GERKE) *(Fig. 6)*. These layers corresponds to Miliolidea biofacies of KORECZ-LAKY, and resemble foraminifera associations described from Poland (LUCZKOWSKA, 1974) and Romania (DARAKCIEVA, 1989). Above, until the upper part of this zone the amount of Hauerinidae is subordinate.

Cibicides lobatulus WALKER & JAKOB is one of the typical species of *Elphidium reginum* zone. It can be found in the upper part of the sections, but its mass occurrence is here (Fig. 8). In some area of the Paratethys *Cibicides* and *Anomalinoides* sp. are used as zone marker species in the Lower Sarmatian (VENGLINSKI, 1962; SENEŠ, 1972; JIRICEK, 1972; LUCZKOWSKA, 1974; VASS et al., 1974; IONESI, 1986) *(Table 1)*.

In the upper part of this zone numerous new hauerinids occur. Some of them is confined only to this short interval and vanished at the end of this zone (e. g. *Nodobaculariella ovalis* VENGLINSKI, *Quinqueloculina buchiana* D'ORBIGNY and a new agglutinated form, *Siphonaperta longidentata* n. sp.), The aim of the present paper was to give a study of the foraminifera fauna from the Zsámbák Basin, which is the type area of the Tinnye Substage and where a complete Sarmatian sequence can be found in boreholes. The Sarmatian foraminifera assemblage in this region have not been investigated in detail yet. The author established a stratigraphic zonation on the basis of foraminifera fauna and compared it with the mollusc zonation. The zones could be correlated with the other foraminifera based biostratigraphic units of the Paratethys.

Material and Methods

The material comes from three boreholes of the Zsámbék Basin, Mány-22, Mány-17 and Perbál-5, locality of them can be seen on the map *(Fig. 1)*. Drillings penetrated a Sarmatian succession, complete in the Hungarian sense. The Sarmatian formations are underlain by Badenian ones, with an unconform contact, but the sediment hiatus probably is not significant. Under and above the boundary the lithofacies is the same, but biofacies change is sharp, only a few Badenian species persisted into the Sarmatian, the number of the species strongly decreased. Lithology is varied, in the lower part of the Sarmatian series contains dominantly clay-marl, clay and marl. Often within the variegated layers narrow bentonit and dacit tuff intercalations from several centimeters to half meter can be observed. Above it, in the upper part mostly sand or sandstone alternates with ooid-limestone. The Sarmatian sediments are overlain in the Mány-22 and the Mány-17 boreholes by Pleistocene, while in the Perbál-5 boreholes with Lower Pannonian deposits *(Fig. 2)*.

The study is based on 122 samples of the three boreholes, which contain determinable foraminifera fauna. Foraminifera were separated by the author following the usual method for fossil foraminifera. More than 26000 specimens of 63 species were determined. As previously only 18 species were described and figured from the Hungarian Sarmatian formations, the author tought the detailed, modern descriptions are necessary. The synonym lists and the correlations of foraminifera faunas of the different parts of the Paratethys are based only on such publications, which contain figures and/or detailed descriptions of the species. The correlations of the three boreholes and the distinguishing of the foraminiferal zones are based on the distribution and abundance of the species. The abundance was studied both as percentage of the total foraminiferal assemblage and the number of their specimens in 100 g rocks. The distributions of the most important taxons are illustrated on diagrams. On the horizontal axis the dotted line shows that in the given depth no or undeterminable foraminifera were found. The boundries of the foraminiferal zones are marked by dashed lines.

The photos were made by the author with scanning electron microscope.

Stratigraphy

On the basis of the distribution of foraminifera species, inspite of the different lithological features, the three studied boreholes of the Zsámbék Basin, can be well correlated. Three zones could be distinguished in each boreholes. These are the follows: *Elphidium reginum* zone, *Elphidium hauerinum* zone and *Spirolina austriaca* zone. Their positions in the boreholes can be seen on *Fig.* 2 and on the diagrams *(Fig. 3-13)*. Stratigraphic range of the species is shown on *Table 2*.

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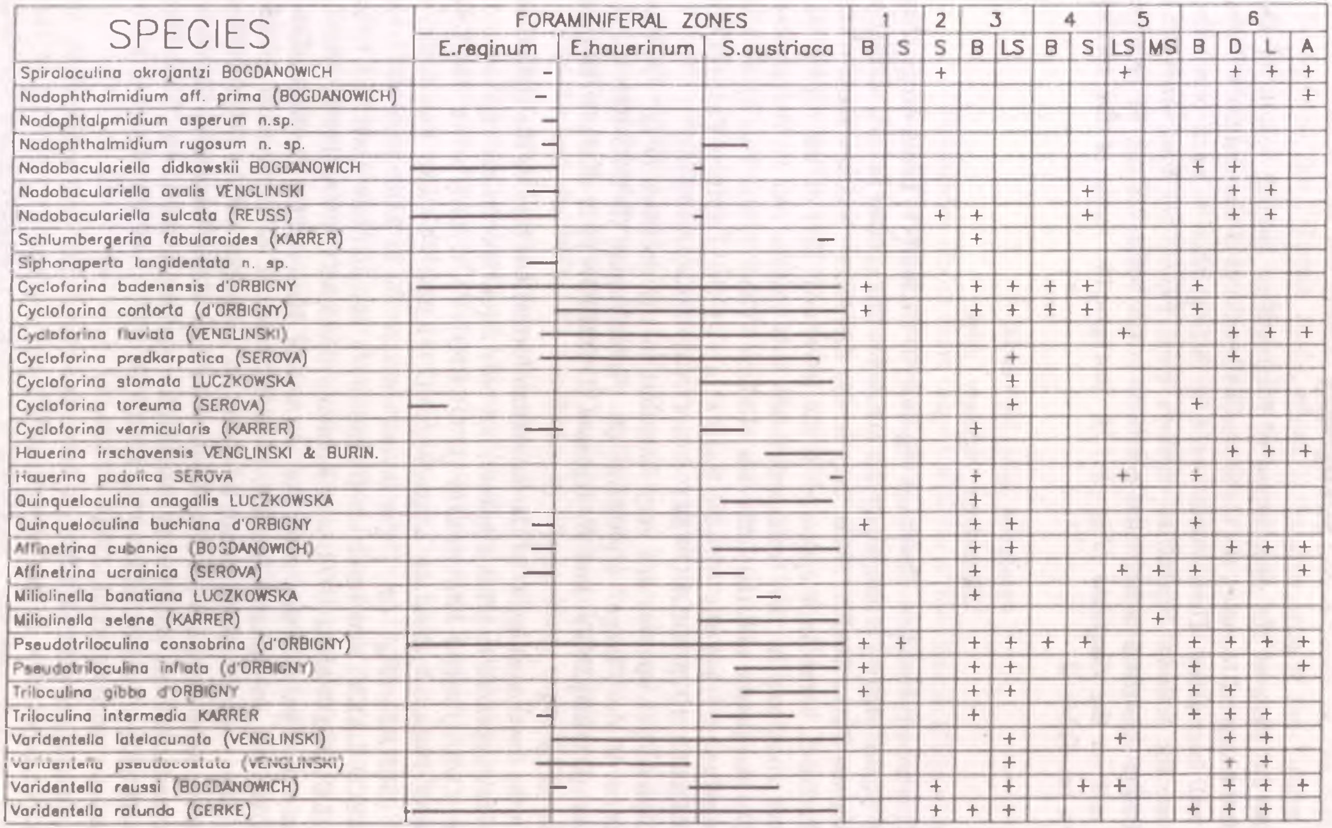
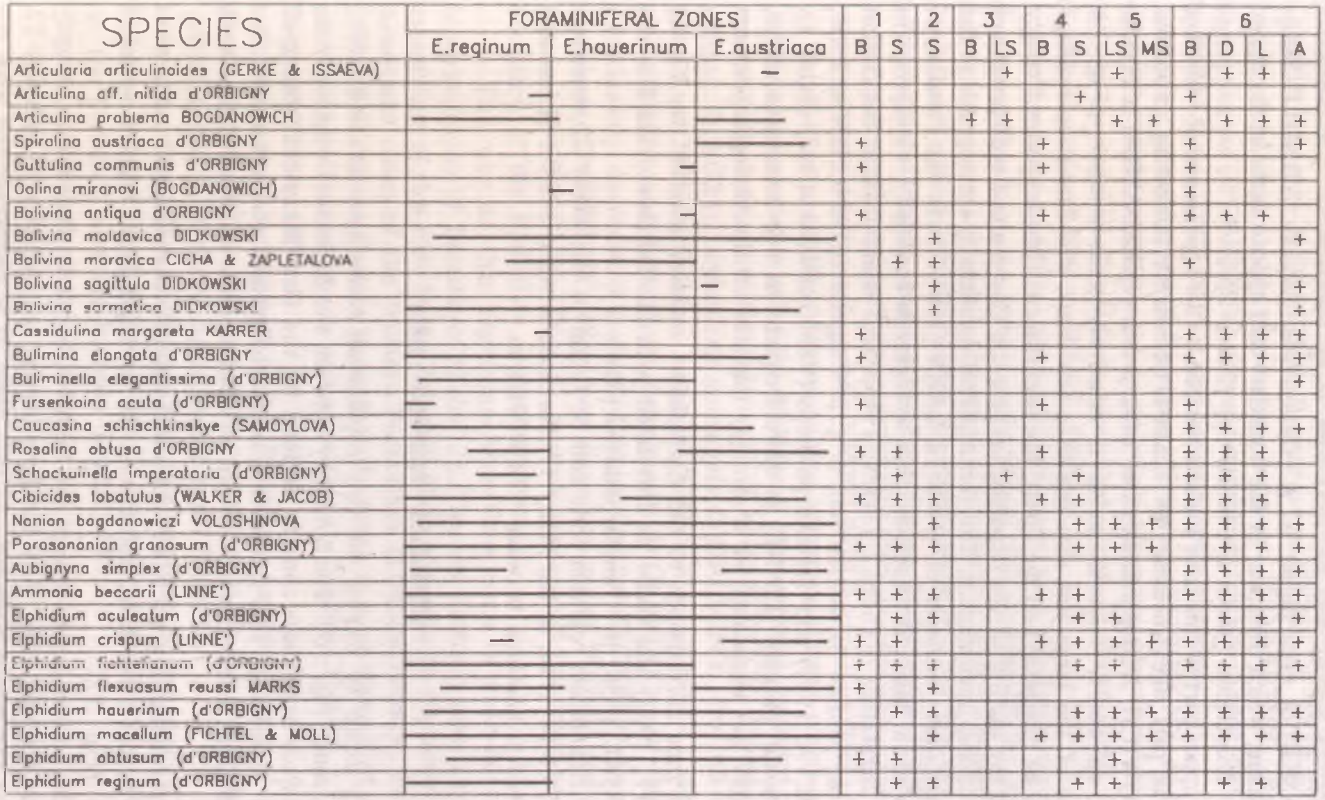


SPECIES	FORAMINIFERAL ZONES			1		2	3		4		5		6			
	E.reginum	E.hauerinum	S.austriaca	B	S	S	B	LS	B	S	LS	MS	B	D	L	A
Spiroloculina okrojantzi BOGDANOWICH	—					+					+			+	+	+
Nodophthalmidium aff. prima (BOGDANOWICH)	—															+
Nodophtalpmidium asperum n.sp.	—															
Nodophthalmidium rugosum n. sp.	—		—													
Nodobaculariella didkowskii BOGDANOWICH	—	—											+	+		
Nodobaculariella ovalis VENGLINSKI	—									+				+	+	
Nodobaculariella sulcata (REUSS)	—	—				+	+			+				+	+	
Schlumbergerina fabularoides (KARRER)			—				+									
Siphonaperta longidentata n. sp.	—															
Cycloforina badenensis d'ORBIGNY	—	—	—	+			+	+	+	+			+			
Cycloforina contorta (d'ORBIGNY)		—	—	+			+	+	+	+			+			
Cycloforina fluviata (VENGLINSKI)	—	—	—								+			+	+	+
Cycloforina predkarpatica (SEROVA)	—	—	—					+						+		
Cycloforina stomata LUCZKOWSKA			—					+								
Cycloforina toreuma (SEROVA)	—							+					+			
Cycloforina vermicularis (KARRER)	—		—				+									
Hauerina irschavensis VENGLINSKI & BURIN.			—											+	+	+
Hauerina podolica SEROVA			—				+				+		+			
Quinqueloculina anagallis LUCZKOWSKA			—				+									
Quinqueloculina buchiana d'ORBIGNY	—			+			+	+					+			
Affinetrina cubanica (BOGDANOWICH)	—		—				+	+						+	+	+
Affinetrina ucrainica (SEROVA)	—		—				+				+	+	+			+
Miliolinella banatiana LUCZKOWSKA			—				+									
Miliolinella selene (KARRER)			—									+				
Pseudotriloculina consobrina (d'ORBIGNY)	—	—	—	+	+		+	+	+	+			+	+	+	+
Pseudotriloculina inflata (d'ORBIGNY)			—	+			+	+					+			+
Triloculina gibba d'ORBIGNY			—	+			+	+					+	+		
Triloculina intermedia KARRER	—		—				+						+	+	+	
Varidentella latelacunata (VENGLINSKI)		—	—					+			+			+	+	
Varidentella pseudocostata (VENGLINSKI)	—	—						+						+	+	
Varidentella reussi (BOGDANOWICH)		—	—			+		+		+	+			+	+	+
Varidentella rotunda (GERKE)	—	—	—			+	+	+					+	+	+	

Table 2. Stratigraphic range of the Sarmatian foraminifera in the Zsámbék Basin and in Paratethys. The foraminiferal zones refer to the Zsámbék Basin. WESTERN PARATETHYS: 1 - Austria, Vienna Basin (D'ORBIGNY, 1846, KARRER, MARKS, 1951, PAPP, 1963, PAPP at SCHMID, 1985); 2 - Czecho-slovakia (Est-Carpathians) (BRESTENSKÁ 1974, CICHA et ZAPLETALOVÁ, 1961); 3 - Poland (LUCZKOWSKA, 1974).



SPECIES	FORAMINIFERAL ZONES			1		2	3		4		5		6			
	E.reginum	E.hauerinum	E.austriaca	B	S	S	B	LS	B	S	LS	MS	B	D	L	A
Articularia articulinoides (GERKE & ISSAEVA)			—					+			+			+	+	
Articulina aff. nitida d'ORBIGNY	—									+			+			
Articulina problema BOGDANOWICH	—		—				+	+			+	+		+	+	+
Spirolina austriaca d'ORBIGNY			—	+					+				+			+
Guttulina communis d'ORBIGNY		—		+					+				+			
Oolina miranovi (BOGDANOWICH)		—											+			
Bolivina antiqua d'ORBIGNY		—		+					+				+	+	+	
Bolivina moldavica DIDKOWSKI	—	—	—			+										+
Bolivina moravica CICHA & ZAPLETALOVA	—	—			+	+							+			
Bolivina sagittula DIDKOWSKI			—			+										+
Bolivina sarmatica DIDKOWSKI	—	—	—			+										+
Cassidulina margareta KARRER	—			+									+	+	+	+
Bulimina elongata d'ORBIGNY	—	—	—	+					+				+	+	+	+
Buliminella elegantissima (d'ORBIGNY)	—	—														+
Fursenkoina acuta (d'ORBIGNY)	—			+					+				+			
Caucasina schischkinskye (SAMOYLOVA)	—	—	—										+	+	+	+
Rosalina obtusa d'ORBIGNY	—	—	—	+	+				+				+	+	+	
Schackoinella imperatoria (d'ORBIGNY)	—				+			+		+			+	+	+	
Cibicides lobatulus (WALKER & JACOB)	—	—	—	+	+	+			+	+			+	+	+	
Nonion bogdanowiczi VOLOSHINOVA	—	—	—			+				+	+	+	+	+	+	+
Porosononion granosum (d'ORBIGNY)	—	—	—	+	+	+				+	+	+		+	+	+
Aubignyna simplex (d'ORBIGNY)	—		—										+	+	+	+
Ammonia beccarii (LINNE')	—	—	—	+	+	+			+	+			+	+	+	+
Elphidium aculeatum (d'ORBIGNY)	—	—	—		+	+				+	+			+	+	+
Elphidium crispum (LINNE')	—		—	+	+				+	+	+	+	+	+	+	+
Elphidium fichtelianum (d'ORBIGNY)	—	—		+	+	+				+	+		+	+	+	+
Elphidium flexuosum reussi MARKS	—	—	—	+		+										
Elphidium hauerinum (d'ORBIGNY)	—	—	—		+	+				+	+	+	+	+	+	+
Elphidium macellum (FICHTEL & MOLL)	—	—	—			+			+	+	+	+	+	+	+	+
Elphidium obtusum (d'ORBIGNY)	—	—	—	+	+						+					
Elphidium reginum (d'ORBIGNY)	—				+	+				+	+			+	+	

4 - Hungary, except the Zsámbék Basin (KORECZ-LAKY, 1964, 1965, 1968, 1973, 1982); EASTERN PARATETHYS: 5 - North-western Bulgaria (STANCHEVA, 1960); 6 - Transcarpathians and Volhyn-Podolian Platform (VENGLINSKI, 1958, 1962, 1975, DIDKOWSKI et SATANAOVSKAJA, 1970); B - Badenian; S - Sarmatian; LS - Lower Sarmatian; MS - Middle Sarmatian; D - Dorobratovska Horizon; L - Lukovska Horizon; A - Almaschska Horizon.

while the others persist into the next zone (e. g. *Varidentella pseudocostata* (VENGLINSKI)) or even higher (e. g. *Cycloforina fluviata* (VENGLINSKI)). There are some, which dissapear at the boundary and appear again in the upper zone (e. g. *Triloculina gibba* D'ORBIGNY) *(Table 2)*.

The upper part of this zone is characterized by the appearance of Miliolina with uniserial part, like *Articulina* aff. *nitida* D'ORBIGNY, *Articulina problema* BOGDANOWICH, *Nodophthalmidium* aff. *prima* (BOGDANOWICH), *N. asperum* n. sp. and *N. rugosum* n. sp. in relatively great numbers *(Fig. 7)*. Making use of the large test size (up to a few mm), this faunal assemblage can already be recognized on the fields. The occurrance of these species strongly depends on the quality of the deposits, favours the fine-grained sediments and quiet depositional environment. This foraminifera community corresponds to the *Nodophthalmidium* biofacies of KORECZ-LAKY (1964-82). In the Paratethys, from the Vienna Basin to Caucasus, this biofacies is especially widespread in the Lower Sarmatian (KORECZ-LAKY, 1973). This characteristic association occurs in the Middle Sarmatian too, e. g. in Bulgaria (STANCHEVA, 1960; DARAKCIEVA, 1989) and Transcarpathians (VENGLINSKI, 1962) (Table 1).

Ammonia beccarii (LINNÉ) is more frequent in this zone than above, but probably the abundance of it strongly depends on the ecological factors *(Fig. 9)*.

This zone corresponds to the *Elphidiuim reginum* zone of the Vienna Basin (PAPP, 1963) and could be correlated with the Dorobratovska Horizon (VENGLINSKI, 1958) in Transcarpathians *(Table 1)*.

The *Elphidium reginum* zone can be found in the Mány-22. borehole between 179.1-141.3 m, in the Mány 17. borehole between 185.6-144.1 m and in the Perbál-5. borehole between 178.4-141.1 m.

Elphidium hauerinum zone

This zone is based on the *Elphidium hauerinum* (D'ORBIGNY) abundance-zone *(Fig. 10)*. The boundary between the *Elphidium reginum* zone and *Elphidium hauerinum* zone is defined by the first mass occurrance of *Elphidiium hauerinum*. This species also occurs below and above this zone, but not in such great numbers and it is not so characteristic element of the fauna as here.

At the boundary (in Mány-22 and Mány-17 boreholes) or somewhat higher (in Perbál-5 borehole, above with 0.4 m) *Elphidium reginum* vanished completely *(Fig. 3)*.

In the bottom layers (except the Perbál-5. borehole) Bolivinidae abruptly became very frequent *(Fig. 11)*. Similar situation can be observed in Mány-17. borehole at the upper boundary of this zone. It is characterized with the predominance of *Bolivina moldavica* DIDKOWSKI, representing more than 80%

of bolivinids. Moreover the next Bolivina species came to daylight from this layers: *B. antiqua* D'ORBIGNY, *B. moravica* CICHA & ZAPLETALOVÁ. Besides the bolivinids *Bulimina elongata* D'ORBIGNY, *Buliminella elegantissima* (D'ORBIGNY), *Caucasina schischkinskye* (SAMOYLOVA) and *Rosalina obtusa* D'ORBIGNY are comparatively abundant here.

This predominance of *Elphidium hauerinum* (D'ORBIGNY) and *Bolivina moldavica* DIDKOWSKI in the foraminifera fauna was also found by JIRICEK (1972) during the *Elphidium hauerinum* zone in Pannonian Basin, in Czecho-Slovakia (PAPP & SEŇEŠ, 1974).

The amount of the Hauerinidae, except in the lowermost and the uppermost layers of the zone is subordinate, the number of the species and their amount is considerably decreased in comparison with the boundary of the *Elphidium reginum* and *Elphidium hauerinum* zone (Fig. 6). The characteristic hauerinids of this zone are *Cycloforina badenensis* (D'ORBIGNY), *Pseudotriloculina consobrina* (D'ORBIGNY), *Varidentella latelacunata* (VENGLINSKI), *V. pseudocostata* (VENGLINSKI) and *V. rotunda* (GERKE).

30-40 m above the lower boundary numeruos species, which come from the Badenian or characterize the *Elphidium reginum* zone, vanished completely – namely *Nodobaculariella didkowskii* BOGDANOWICH, *Nodobaculariella sulcata* (REUSS), *Guttulina communis* D'ORBIGNY, *Oolina mironovi* (BOGDANOWICH), *Bolivina antiqua* D'ORBIGNY, *Buliminella elegantissima* (D'ORBIGNY) and *Elphidium fichtelianum* (D'ORBIGNY) – or their amount significantly decrease e. g. *Elphidium aculeatum* (D'ORBIGNY), *Elphidium hauerinum* (D'ORBIGNY), *Elphidium flexuosum reussi* MARKS and *Elphidium obtusum* (D'ORBIGNY) *(Fig. 5)*. Author recognized this level as the upper boundary of the *Elphidium hauerinum* zone.

The use of the *Elphidium hauerinum* zone is wide-spread in the biostratigraphy of Paratethys *(Table 2)*. The low diversity and poor Miliolina assemblage of this zone in the Zsámbék Basin is similar to the other *Elphidium hauerinum* zones of the Western Paratethys (LUCZKOWSKA, 1974; PAPP, 1956), while in the Eastern Paratethys the fauna is more diversified and species of the Miliolina subordo are significant (VENGLINSKI, 1958, 1962; DARAKCIEVA, 1989).

This zone corresponds to the *Elphidium hauerinum* zone of the Vienna Basin (PAPP, 1956) and could be correlated with the Lukovska Horizon (VENGLINSKI, 1958) in Transcarpathians *(Table 1)*.

The *Elphidium hauerinum* zone can be found in the Mány-22. borehole between 141.3-97.8 m, in the Mány-17. borehole between 144.1-111.6 m and in the Perbál-5. borehole between 141.1-104.8 m.

Spirolina austriaca zone

This zone is based on the *Spirolina austriaca* D'ORBIGNY acro zone, but the lower boundary was defined by the dissapearance of the typical species of the lower two zones (as mentioned above).

Spirolina austriaca D'ORBIGNY is the most characteristic species of this zone, it can be recognized easily even if the preservation is bad. Although it can also be found in Badenian formations, in the Sarmatian it was mentioned only above the *Elphidium hauerinum* zone in the Western Paratethys (BODA, 1971, 1974; JIRICEK, 1972; PAPP & SEÑES, 1974) and in the Middle Sarmatian of the Eastern Paratethys. In the latter area it was especially abundant and together with other *Spirolina*, *Dendritina* and *Peneroplis* species it often occured in masses (VENGLINSKI, 1962; DIDKOWSKI & SATANAOVSKAJA, 1970; IONESI, 1986). The first occurrence of *Spirolina austriaca* D'ORBIGNY coincides with the extinction boundary in the Mány-17. and the Perbál-5. boreholes, and 10 m higher in the Mány-22. borehole *(Fig. 12)*.

Hauerinidae became significant both in the number of species and the amount of specimens. *(Fig. 6)*. Some hauerinids occured only here (e. g. *Quinqueloculina anagallis* LUCZKOWSKA, *Miliolinella banatiana* LUCZKOWSKA, *Pseudotriloculina inflata* (D'ORBIGNY), *Triloculina gibba* (D'ORBIGNY) and on other part of them which disappeared at the end of the *Elphidium reginum* zone or at the lower part of the *Elphidium hauerinum* zone apperared again (e. g. *Affinetrina ucrainica* (SEROVA), *Affinetrina cubanica* (BOGDANOWICH) (see *Table 2*). Varidentella species are especially frequent, namely *Varidentella latelacunata* (VENGLINSKI) and *Varidentella rotunda* (GERKE).

The upper studied strata of the sections are characterized by the presence, in comparatively great numbers (more than 30 % of the total foraminifera assemblage), of species with termathophore aperture as *Hauerina irschavensis* VENGLINSKI et BURINDINA, *H. podolica* SEROVA and *Schlumbergerina fabularoides* (KARRER), which latter is finely agglutinated. Similar association can be found in the Almaschcka Horizon of Transcarpathians (VENGLINSKI, 1962, 1975; VENGLINSKI & BURINDINA, 1965)

In clay beds of this zone (especially in the Mány-22. borehole) *Articularia articulinoides* (GERKE et ISSAEVA) and *Articulina problema* BOGDANOWICH appeared in realtively great numbers *(Fig. 7)*.

Porosononion granosum (D'ORBIGNY) appears in great numbers in these parts of the sections, somewhat more abundant in this zone than in the lower ones, but the difference is not significant *(Fig. 13)*.

The elphidiidae assemblage is characterized by the predominance of *Elphidium macellum* (FICHTEL et MOLL) (see *Fig. 4, 5, 10* and *Table 2*).

Ammonia beccarii (LINNÉ) is abundant in several strata *(Fig. 9)*.

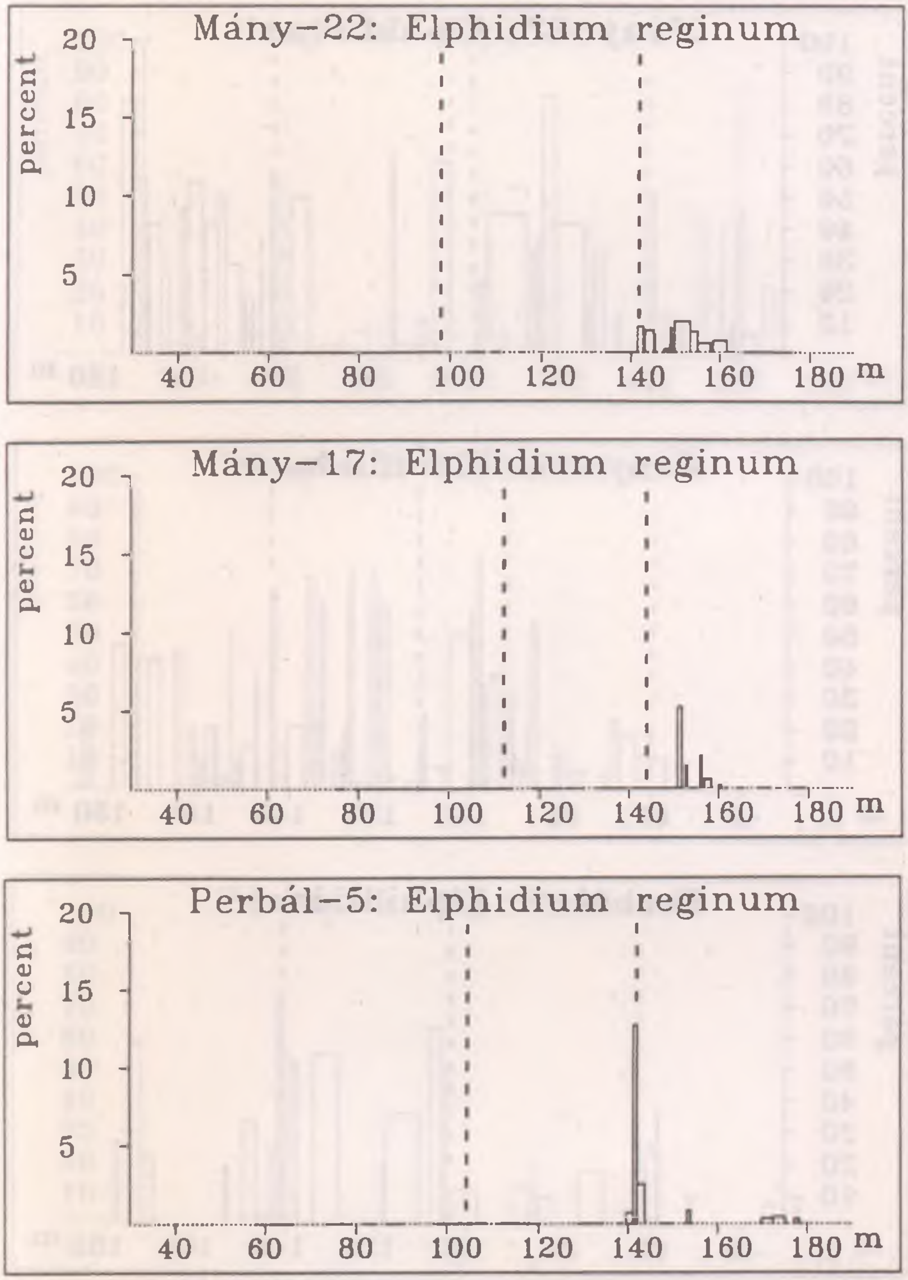


Fig. 3. Distribution of *Elphidium reginum* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

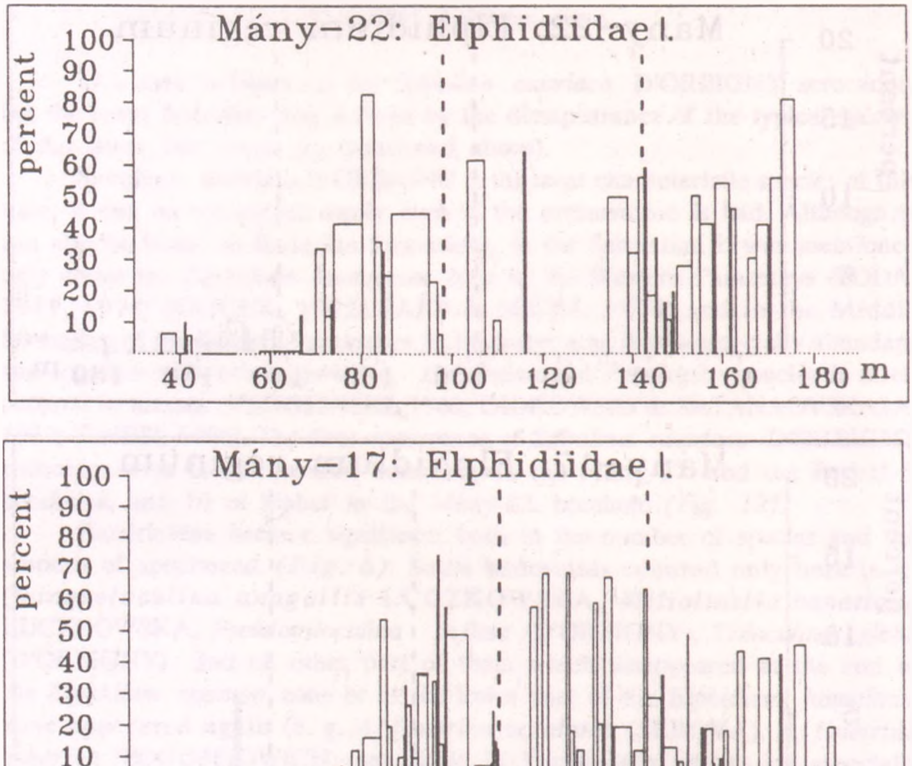


Fig. 4. Distribution of *Elphidiidae I E aculeatum, E. crispum, E fichtelianum, E. flexuosum reussi, E. hauerinum, E. macellum, E. obtusum* and *E. reginum* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

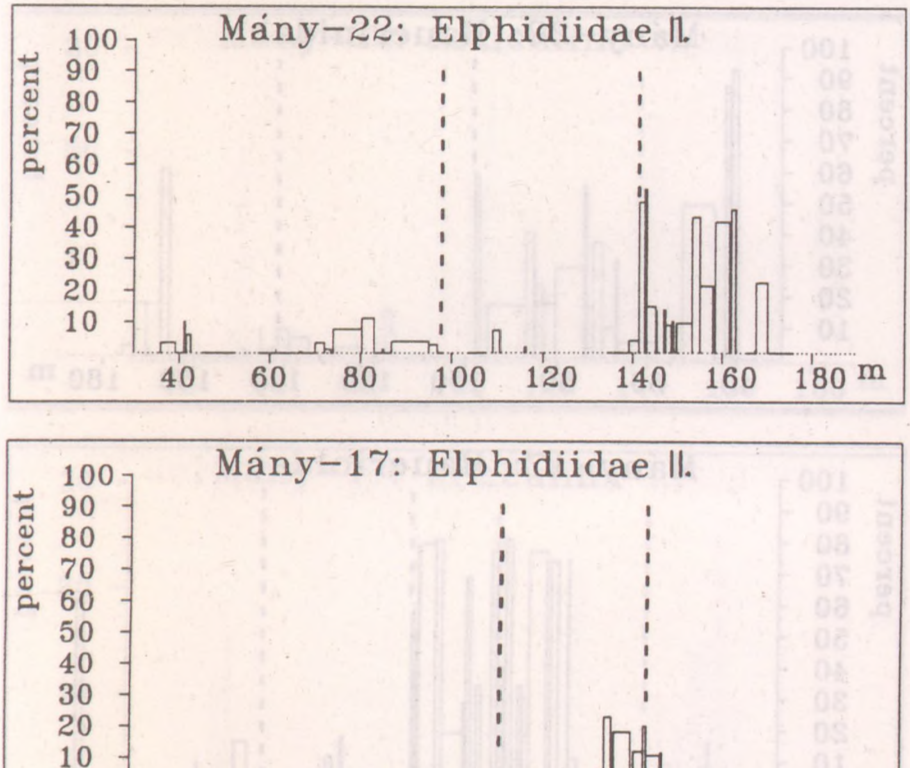


Fig. 5. Distribution of Elphidiidae II. *E. aculeatum*, *E. fichtelianum* and *E. flexuosum reussi* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

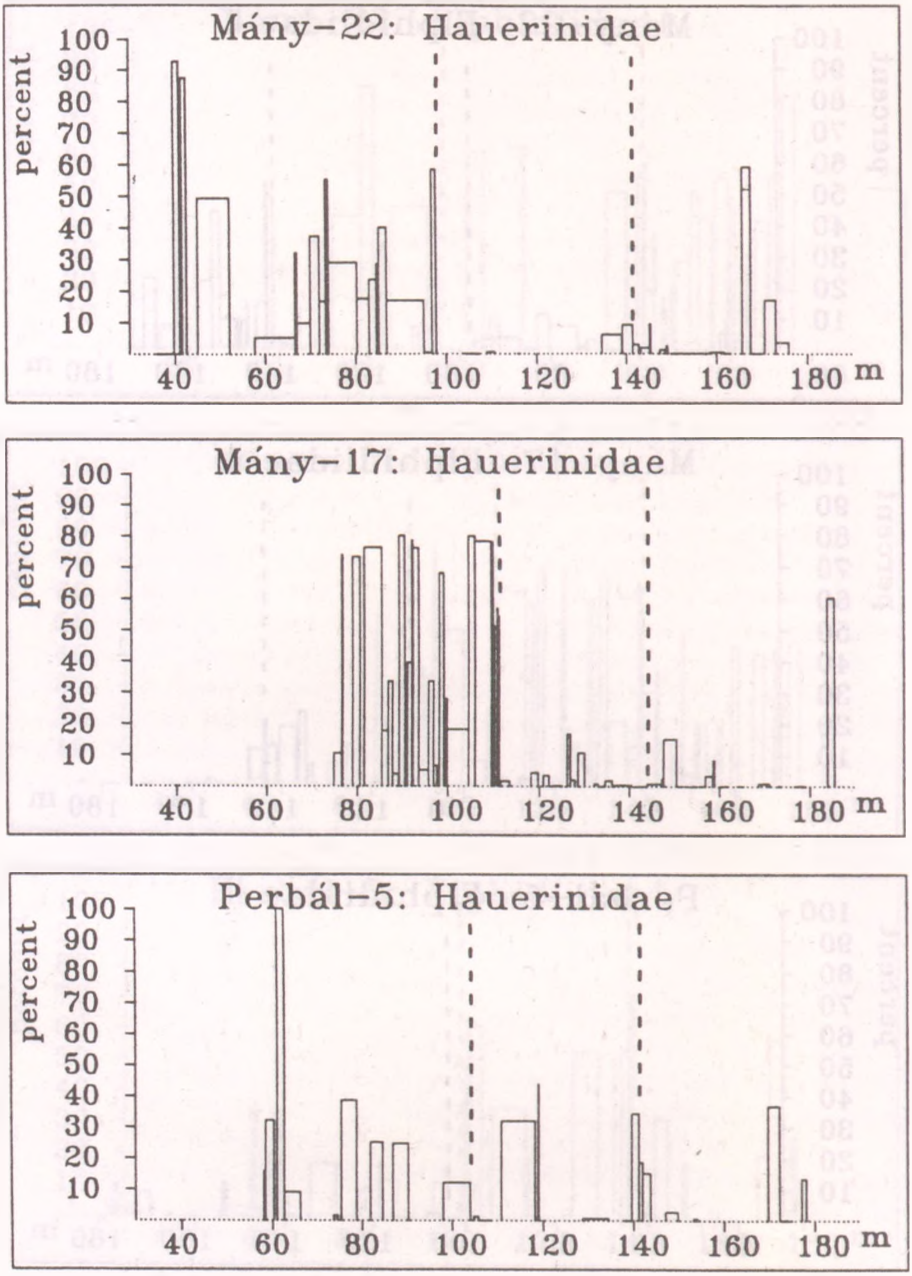


Fig. 6. Distribution of Hauerinidae *Schlumbergerina, Siphonaperta, Cycloforina, Hauerina, Quinqueloculina, Affinetrina, Miliolinella, Pseudotriloculina, Triloculina, Varidentella, Articularia* and *Articulina* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

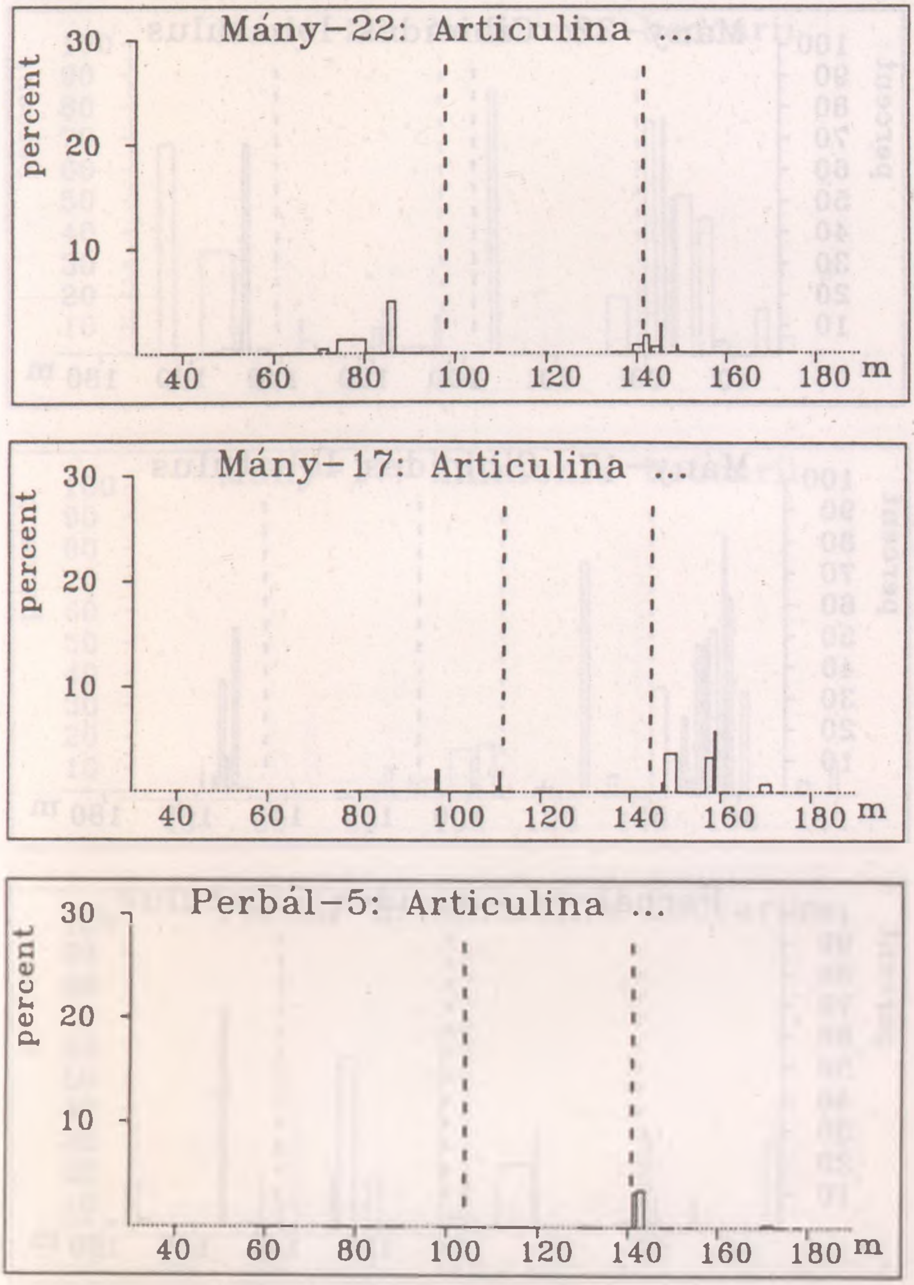


Fig. 7. Distribution of *Articulina*, *Articularia* and *Nodophthalmidium* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

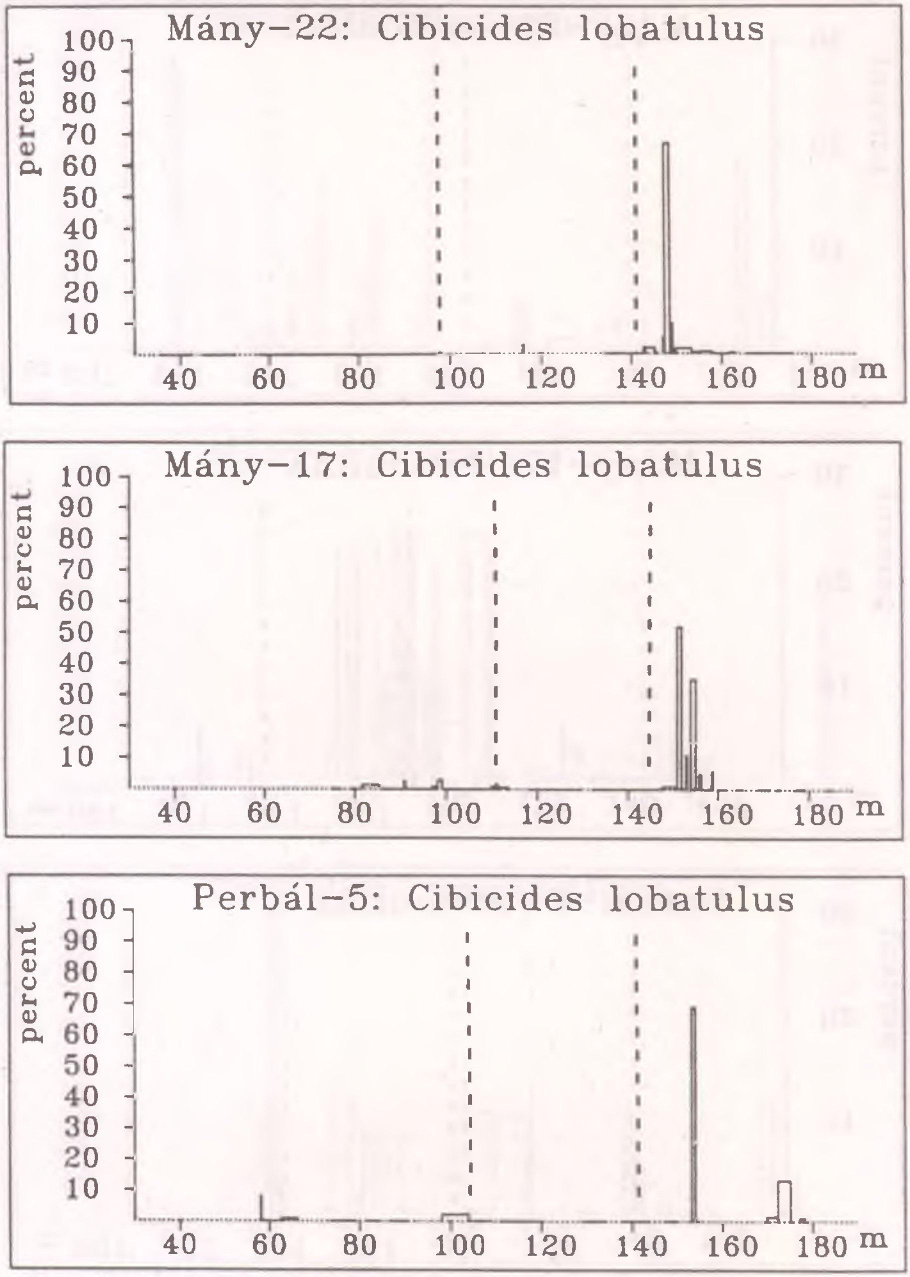


Fig. 8. Distribution of *Cibicides lobatulus* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

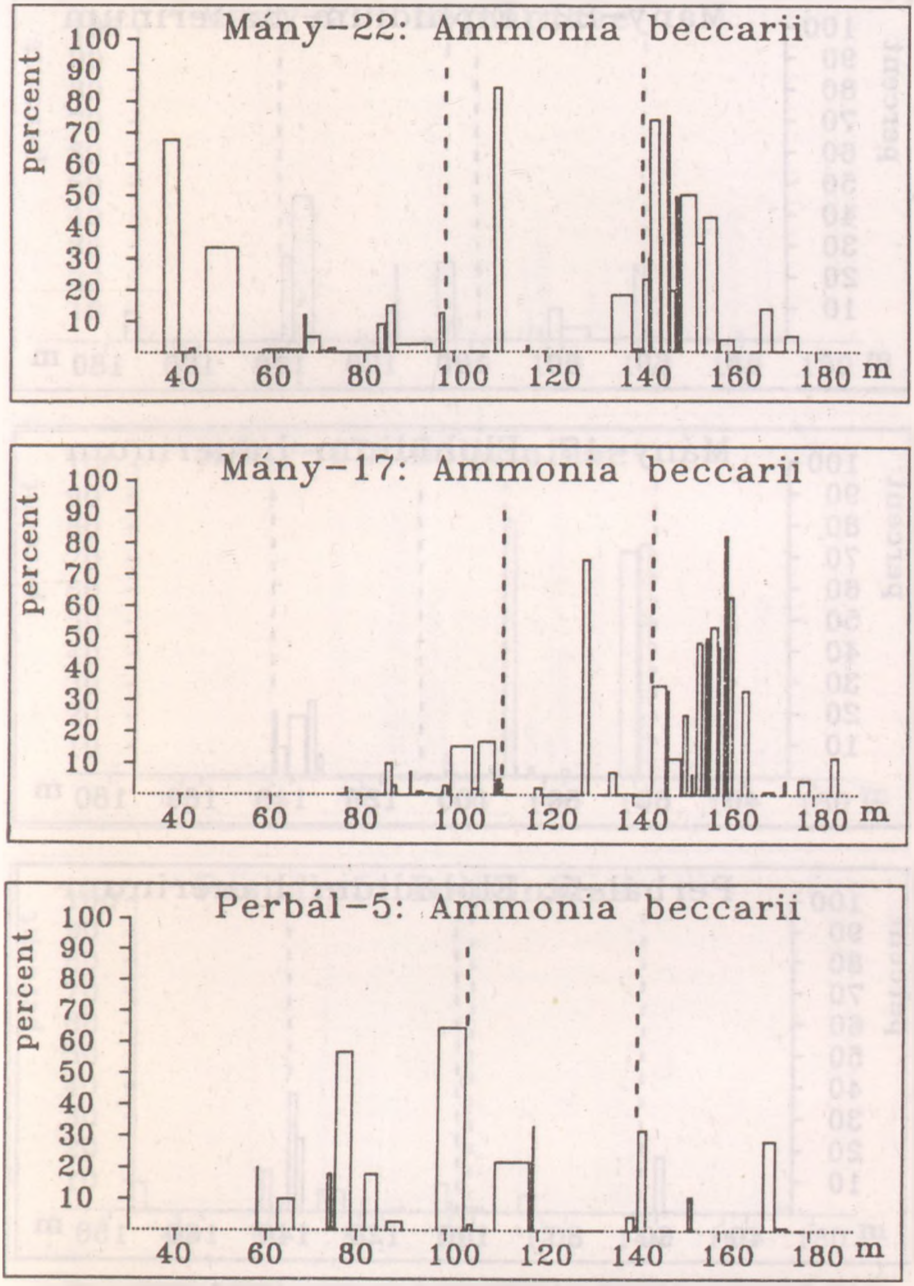
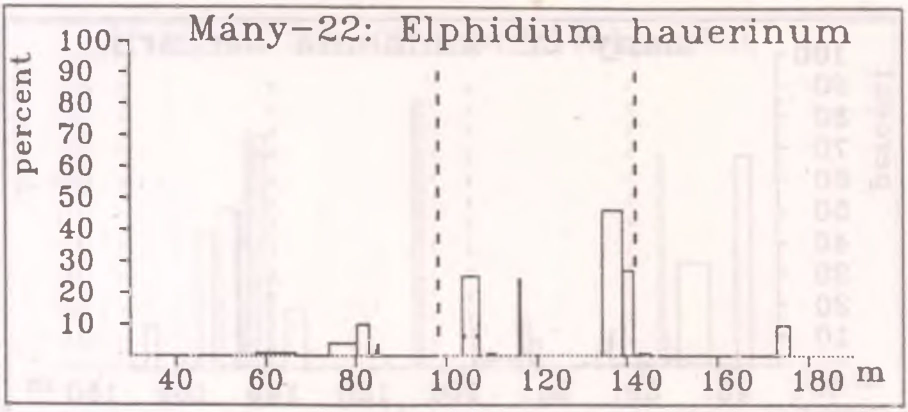
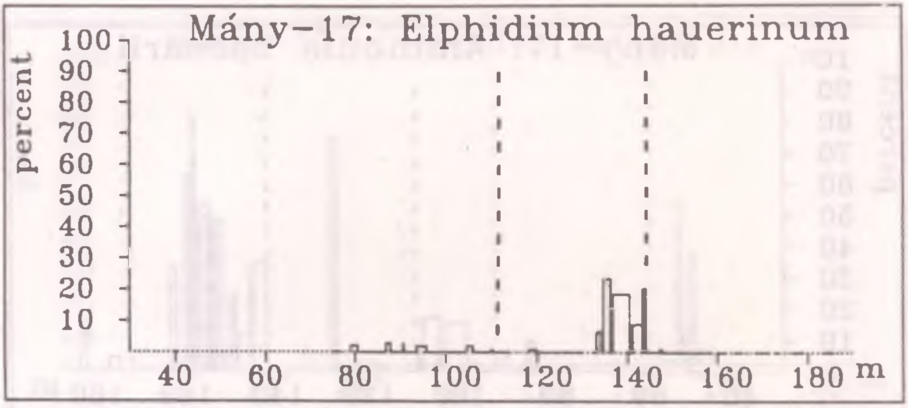


Fig. 9. Distribution of *Ammonia beccarii* inthe boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.





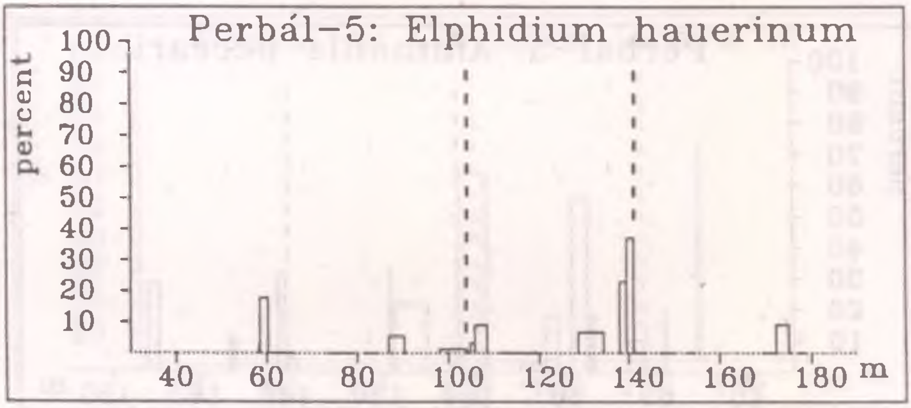
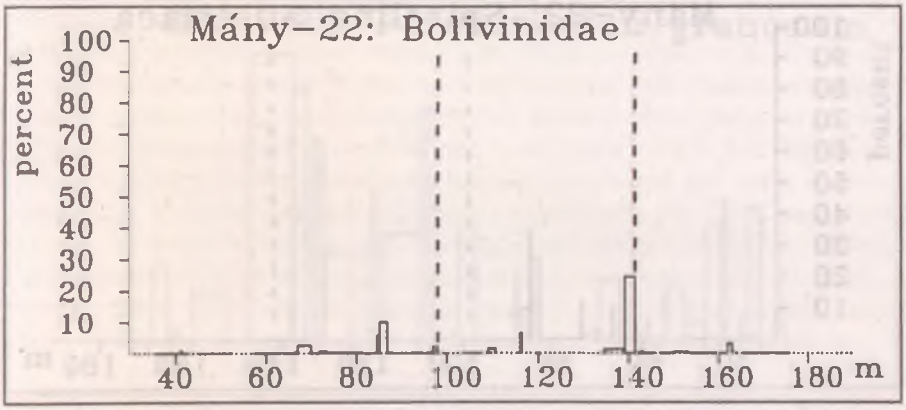
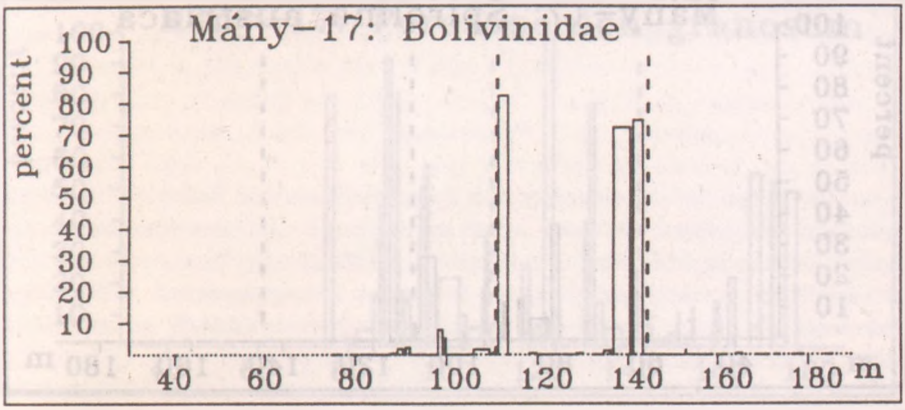


Fig. 10. Distribution of *Elphidium hauerinum* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.





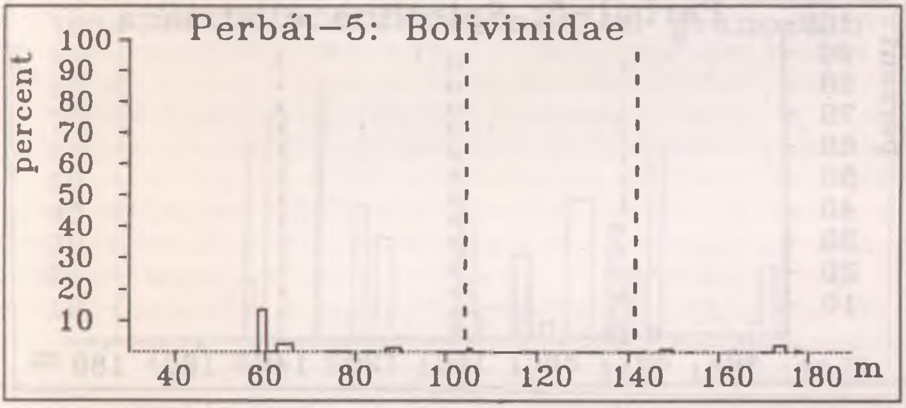


Fig. 11. Distribution of Bolivinidae (*Bolivina antiqua*, *B. moldavica*, *B. moravica* and *B. sagittula*) in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

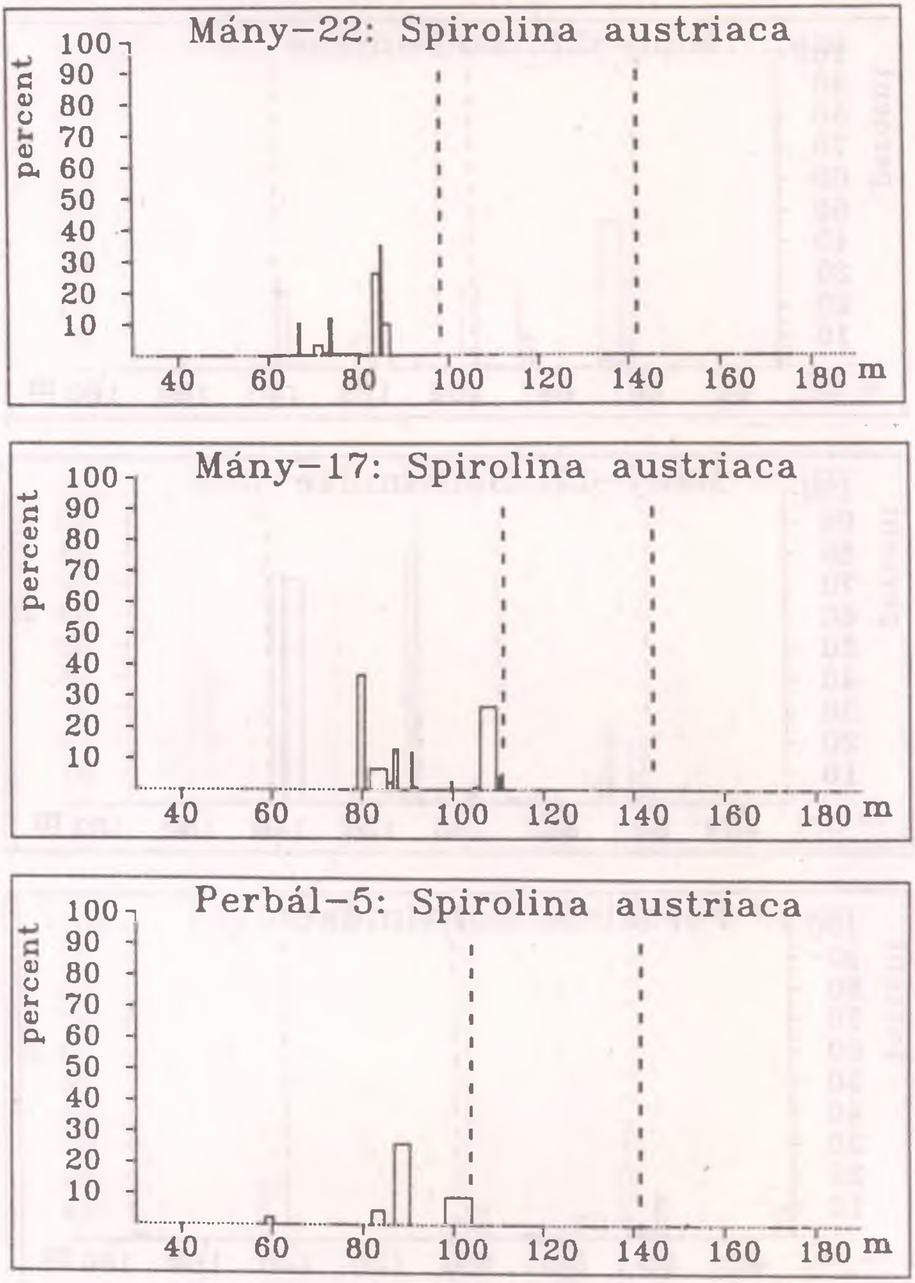


Fig. 12. Distribution of *Spirolina austriaca* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

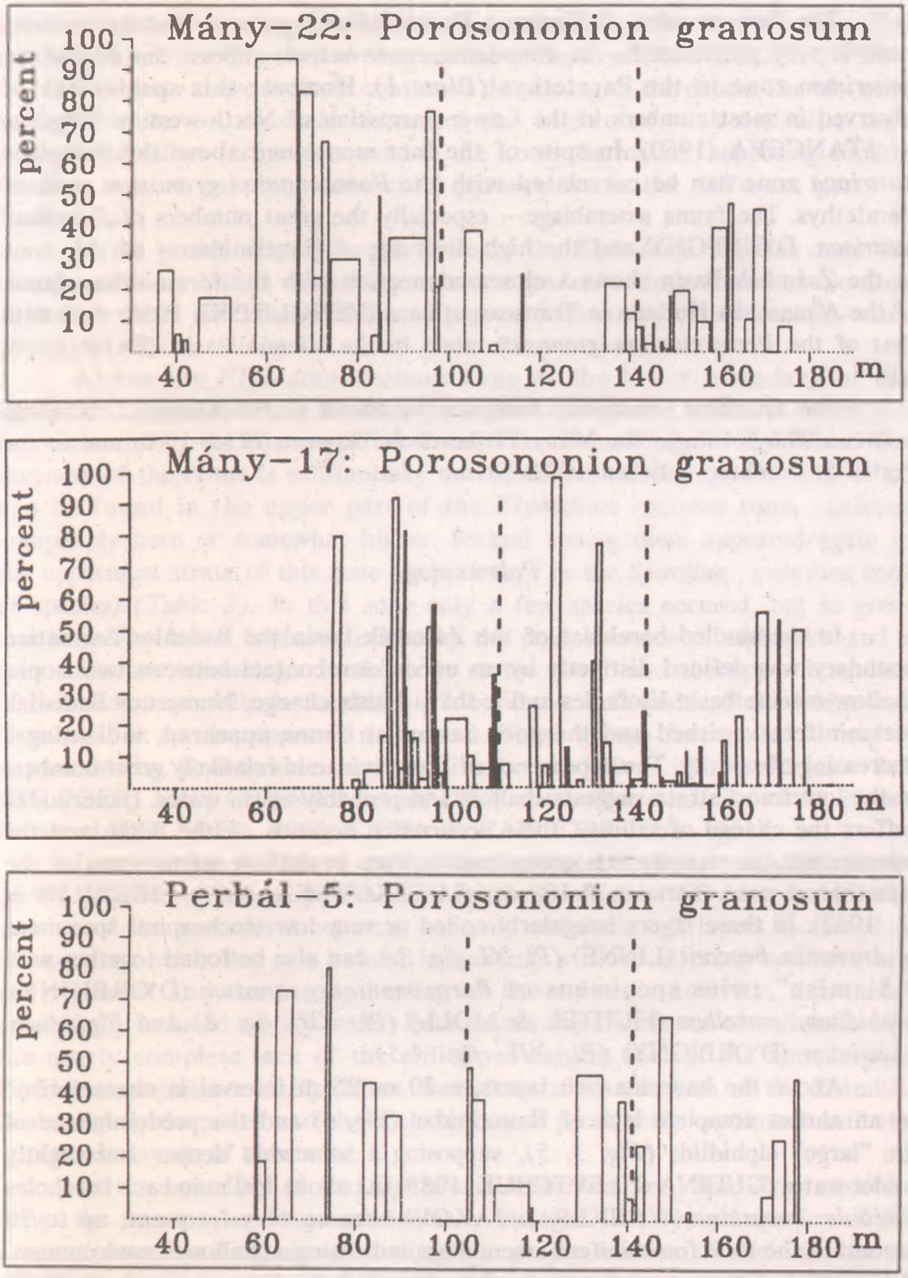


Fig. 13. Distribution of *Porosononion granosum* in the boreholes. Abundance is given as % of the total foraminiferal assemblage. Depths refer to the ground surface.

The *Porosononion (=Nonion= Protelphidium) granosum(=subgranosum)* zone is very much used – in abundance- zone sense – above the *Elphidium hauerinum* zone in the Paratethys *(Plate 1)*. However this species can be observed in most numbers in the Lower Sarmatian of North-western Bulgaria, by STANCEVA (1960). In spite of the fact mentioned above the *Spirolina austriaca* zone can be correlated with the *Porosononion granosum* zone of Paratethys. The fauna assemblage – especially the great numbers of *Spirolina austriaca* D'ORBIGNY and the high diversity of Hauerinidae – of this zone in the Zsámbák Basin shows a closer connection with the foraminifera fauna of the Almaschka Horizon in Transcarpathians (VENGLINSKI, 1958) than with that of the *Porosononium granosum* zone in the Vienna Basin (PAPP, 1956, 63).

The *Spirolina austriaca* zone can be found in the Mány-22. borehole between 97.8-3.4 m, in the Mány-17. borehole between 111.6-10 m and in the Perbál-5. borehole between 104.8-58 m.

Paleoecology

In the studied boreholes of the Zsámbék Basin the Badenian-Sarmatian boundary was defined distinctly by an unconform contact between two isopic, shallow-marine basin litofacies and a sharp fauna change. Numeruos Badenian foraminifera vanished and the poor Sarmatian fauna appeared, indicating a decreasing of salinity. The appearence of Hauerinidae in relatively great numbers in the lowermost strata suggests shallow and probably warm water. Hauerinidae suffers the change of salinity, their occurrence depends on the depth and the temperature, as recently this group mainly lives in shallow-warm-water of the infralittoral zone (between 0-100 m) (LUCZKOWSKA, 1974; CHIERICHI et al., 1962). In these layers irregularly coiled or very low trochospiral specimens of *Ammonia beccarii* (LINNÉ) *(Pl. XI. fig. 3.)* can also be found together with " Siamise" twins specimens of *Porosononion granosum* (D'ORBIGNY), *Elphidium macellum* (FICHTEL & MOLL) *(Pl. XII. fig. 8)* and *Elphidium hauerinum* (D'ORBIGNY) *(Pl. XII. fig. 4-5)*.

Above the hauerina-rich layers, a 20 or 25 m interval is characterized by an almost complete lack of Hauerinidae (Fig. 6) and the predominance of the "large" elphidiids *(Fig. 3, 5)*, supposing a somewhat deeper and slightly colder water (GUDINA & LEVTCHUK, 1989). At about 150 m in each boreholes *Cibicides lobatulus* (WALKER & JAKOV) became very frequent, up to 70 percent of the total foraminifera assemblage, indicating a shallower environment, than earlier. *Cibicides lobatulus* prefers the shallow water, a depth of 40-70 m in Adriatic sea (CHIERICHI et al., 1962). In the uppermost strata of *Elphidium reginum* zone the foraminifera assemblage considerably changes, numerous new – mainly miliolinas (15) and only one *Cassidulina* – species appeared. *Articulina* also occured here in great numbers for the first time. This species favours the very shallow-water, about a depth of 30 m (LUCZKOWSKA, 1974). The facts above indicate continued decreasing of the depth. The biofacies with *Cibicides* or *Anomalinoides* and the biofacies with *Articulina* and *Nodophthalmidium* are wide spread in the Lower Sarmatian, supposing similar, shallow marine paleoenvironmental parameters in the different parts of Paratethys.

In the present-day Zsámbék Basin in the *Elphidium reginum* zone the changes of foraminifera assemblages show a gradual change from not-too-deep to shallow water and less agitated environment with consolidated brackish-water condition with a salinity of about 18 to 25 per thousand.

Above the *Elphidium reginum* zone at the lower boundary of the *Elphidium hauerinum* zone no sharp litological change and sediment hiatus can be observed, but the change of the foraminifera assemblage is significant. The diversity of the fauna is substantially decreased, half of the species (20), which can be found in the upper part of the *Elphidium reginum* zone, vanished completely here or somewhat higher. Several among them appeared again in the uppermost strata of this zone (4 species) or in the *Spirolina austriaca* zone (7 species) *(Table 2)*. In this zone only a few species occured, but in great numbers. The fauna is characterized by the predominance of elphidiids and a poor miliolina assemblage. In the beds at the lower and the upper boundary of this zone, especially in the Mány-17. borehole, Bolivinidae, Buliminidae and Caucasinidae species appeared in masses. These groups favour the somewhat deeper water, Bolivinidae recently live below 100 m in the Adriatic Sea (PHLEGER, 1960; CHIERICI et al, 1962) and suffer a salinity of 18-28 per thousand (PHLEGER, 1960; CICHA & ZAPLETALOVÁ, 1961).

It seems that the fauna change was in close connection with the change of the physico-chemical parameters. In the *Elphidium hauerinum* zone the number of the unconform contacts, bentonit and dacit tuff layers increased in comparison with the one below, indicating a more altering sedimentary environment and the strengthening of the vulcanic activity, this latter episodically induced muddy water. Futhermore the abundance of bolivinids and the nearly complete lack of the miliolinas suggest that at the boundary of *Elphidium reginum* and *Elphidium hauerinum* zones the area of the Zsámbék Basin slightly deepened and these circumtances presumably continued until the uppermost layers of this zone.

At the boundary of the *Elphidium hauerinum* and *Spirolina austriaca* zones the fauna assemblage substancially changes. The typical species of the Lower Sarmatian disappeared completely, or the number of their specimens significantly decreased. The foraminifera fauna became more diversified, because some new species appeared, mainly Haurenidae (10 species). The great numbers both of the species and specimens of this latter group characterizes this zone. In the recent seas miliolinas live in the largest quantities in shallow and warm waters of the infralittoral zone at depths ranging from 30 to 50 m (LUCZKOWSKA, 1974; CHIERICHI et al., 1962). Moreover they are very frequent in the inner turbulent zone at 20-30 m depth (PHLEGER, 1960), which corresponds to that place where the ooid-limestone deposits. The oolit-limestone in the upper part of the sections contains in large quantities miliolinas as the centre of ooids, therefore they could not been determined. The mass occurrence of finely agglutinated species, *Schlumbergerina fabularoides* (KARRER) indicates a shallow-water sand facies at depths 10-30 m (CHIERICHI, 1962; HAIG, 1988).

As it was mentioned above miliolinas, the characteristic group of the *Spirolina austriaca* zone, are not sensitive to change of salinity. Especially in the lower layers of this zone degenerated, irregularly coiled specimens of Hauerinidae species *(Pl. II, fig. 2, Pl. XII, fig. 12-13)* occured. According BOLTOVSKOY & WRIGHT (1976) these pathological phenomena of miliolinas are connection with hypersaline conditions. *Spirolina austriaca* D'ORBIGNY, the typical species of this zone, probably suffered the changes of the salinity, because recently living *Spirolina pertusus* (FORSKÅL) is very abundant in metahaline-hypersalin areas, at water depths 0-30 m (HAIG, 1988).

Considering the above facts one can conclude, that during *Spirolina austriaca* zone there was a shallow-water lagoon in this area, which occasionally became hypersaline. This is also supported by the appearance of evaporite (anhidrit) beds in this stratigraphic level a few kilometres south from the area of the boreholes (JÁMBOR, 1974).

The high salinity and probably the re-occurrence of several Badenian species e. g. *Spirolina austriaca* may indicate an episodical communication with the Tethys during this time.

The layers of this zone contain some redeposited Badenian specimens, e. g. *Spiroplectammina* sp. and *Heterolepa dutemplei* (D'ORBIGNY), with strongly different preservation. They occur in the same stratigraphic level (in the Mány-22. borehole: 73-75 m and 85-87 m; in the Mány-17. borehole: 75-80; in the Perbál-5. borehole: 87-90 m), showing that during this time Badenian formations were on the surface near the Zsámbék Basin. Similar situation was observed by KÓKAY (1983).

Conclusion

In the Sarmatian formations of Zsámbék Basin three foraminiferal zones could be distinguished, the *Elphidium reginum, Elphidium hauerinum and Spirolina austriaca* zones. With the help of them the three studied boreholes could be correlated. Close correspondence could be established with the foraminiferal zones described from the other parts of Paratethys. The similarity is showed much rather in the predominance of the species than in the fauna components.

On the basis of the foraminifera fauna the *Elphidium reginum* zone of the Zsámbék Basin corresponds to the *Elphidium reginum* zone of the Vienna Basin and to the lower part of the Lower Sarmatian in the Eastern Paratethys (see *Table 1*). The author disagrees with the opinion of BODA (1974), that the boundary of the *Elphidium reginum* and *Elphidium hauerinum* zones - both in the Vienna Basin and in the Zsámbék Basin - coincides with the Kozárd-Tinnye boundary, as the typical foraminifera of the Lower Sarmatian, vanished completely or strongly decreased in number later, at the *Elphidium hauerinum - Spirolina austriaca* zone boundary.

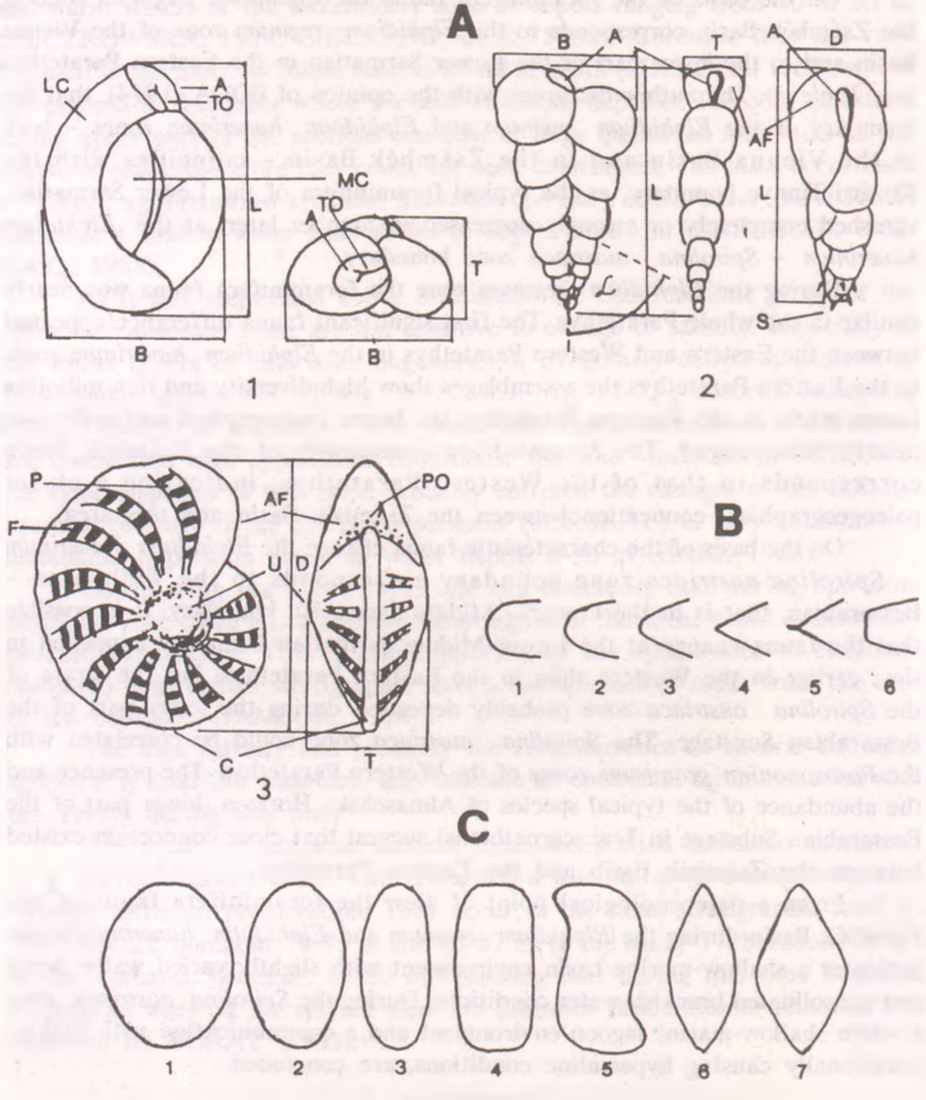
During the *Elphidium reginum* zone the foraminifera fauna was nearly similar in the whole Paratethys. The first significant fauna differance appeared between the Eastern and Western Paratethys in the *Elphidium hauerinum* zone. In the Eastern Paratethys the assemblages show high diversity and rich miliolina fauna, while in the Western Paratethys the fauna impoverished and miliolinas nearly disappeared. The foraminifera community of the Zsámbék Basin corresponds to that of the Western Paratethys, indicating a closer paleogeographical connection between the Zsámbék Basin and this area.

On the basis of the characteristic fauna change the *Elphidium hauerinum - Spirolina austriaca* zone boundary corresponds to the Volhynian - Bessarabian, that is to the Lower - Middle Sarmatian boundary. It is possible that the fauna change at the Lower-Middle Sarmatian boundary happened in time earlier in the Western than in the Eastern Paratethys, but the strata of the *Spirolina austriaca* zone probably deposited during the lower part of the Bessarabian Substage. The *Spirolina austriaca* zone could be correlated with the *Porosononion granosum* zones of the Western Paratethys. The presence and the abundance of the typical species of Almaschska Horizon (lower part of the Bessarabian Substage in Transcarpathians) suggest that close connection existed between the Zsámbék Basin and the Eastern Paratethys.

From a paleoecological point of view the foraminifera fauna of the Zsámbék Basin during the *Elphidium reginum* and *Elphidium hauerinum* zones indicates a shallow-marine basin environment with slightly varied water depth and consolidated brackish-water conditions. During the *Spirolina austriaca* zone a warm shallow-marine lagoon environment and a communication with Tethys, occasionally causing hypersaline conditions, are concluded.

Acknowledgements

I am indepted to my colleague M. MONOSTORI for sparing me so much time for discussions and consultations. Sincere thanks are due to J. BODA for his suggestions and advices. Special thanks are extended to the staff of the Electron Microscope of Eötvös Unviersity, Budapest, for their help in my using of the scanning elektron microscope. This work was supported by the OTKA foundation, contract number 3400313.



Text-fig. 1. Test morfology of important groups of the studied foraminifera. A. Dimensions and chamber arrangement: 1 – Miliolinacea, 2 – Bolivinacea, Caucasinidae and 3 – Elphidiidae. A. – aperture; AF – apertural face; B – breadth; C – carinae; D – diameter; F – fossette; L – length; LC – last chamber; MC – middle chamber; P – ponticuli (= septal bridge); PO – pores; S – spine; T – thickness; TO – tooth; U – umbilicus; α– angle betwwen the suture and the longitudinal axis of the test. B. Outline of the periphery: 1 – rounded; 2 – subrounded; 3 – subacute; 4 – acute; 5 – carinate or keeled; 6 – angular. C. shape of the test: 1 – broad-oval; 2 – oval; 3 – elongate or slender; 4 – quadrangular; 5 – sigmoid; 6 – lenticular; 7 – rhomboid.

Systematic descriptions

The material studied is deposited in the Micropaleontological Collection of Hungarian Natural History Museum, Budapest.

Terminology. The terminology used int he descriptions is elucidated in text-fig. 1.

After LOEBLICH and TAPPAN, 1990.

Phylum Protista
  Subphylum Sarcodina SCHMARDA, 1871
    Classis Rhizopodea VON SIEBOLD, 1845
      Subclassis Lobosia CARPENTER, 1861
        Ordo Foraminiferida EICHWALD, 1830
          Subordo Miliolina DELAGE et HÈROUARD, 1896
            Superfamily Milionicea EHRENBERG, 1839
              Family Spiroloculinidae WIESNER, 1920
                Genus Spiroloculina D'ORBIGNY, 1826

Spiroloculina okrojantzi BOGDANOWICH, 1947
(Pl. I, fig. 1)

1947. *Spiroloculina okrojantzi* BOGDANOWICH; BOGDANOWICH, p. 27, Tabl. 3, fig. 4a, b. fide Catalogue Ellis et Messina.
1960. *Spiroloculina okrojantzi* BOGDANOWICH; STANCHEVA, p. 15, Tabl. II. fig. 1.
1970. *Spiroloculina okrojantzi* BOGDANOWICH; DIDKOWSKI et STANOVSKAJA, p. 46, Tabl. 26, fig. 3a, b.
1974. *Spiroloculina okrojantzi* BOGDANOWICH; BRESTENSKÁ, p. 246, Taf. 2, Fig. 1.

Material. 4 slightly eroded specimens.

Description. Test large, nearly circular or broad-oval, slightly tapering at both end, strongly flattened; periphery rounded; six to nine tubular and arcaute chambers are visible from the outside; middle chambers depressed; sutures distinct and depressed; wall porcelanous, thin; surface dull and ornamented with extremely fine, oblique, longitudinal costae; aperture rounded, placed more or less obliquely at the apertural end of the last chamber, surrounding with a thin lip, bearing a low simple or bifid tooth.

Dimensions. Length: 0.6-1.0 mm; breadth: 0.5-0.8 mm; thickness 0.15-0.2 mm.

Variability. The number of the visible chambers is variable. The ornamentation may be more or less distinct.

Remarks. The specimens from Zsámbék Basin can be well identified with the type described and figured by BOGDANOWICH, 1947, which however differs in its smaller size, only 0.45-0.6 mm in lenght.

This species differs from the other *Spiroloculina* species in its nearly circular test shape, rounded periphery and surface ornamentation.

Distribution. Russia: Caucasus – Lower and Middle Sarmatian; Ukraine: Krime – Lower and Middle Sarmatian; North- Western Bulgaria: Vladimirovo and Dimovo – Lower Sarmatian; Czecho-Slovakia – Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Superfamily Cornuspiracea SCHUTTZE, 1854
Family Fischerinidae MILLETT, 1898
Subfamily Nodophthalmidiinae CUSHMAN, 1940
Genus Nodophthalmidium MACFADYEN, 1939

Nodophthalmidium aff. prima (BOGDANOWICH, 1952)

(Pl. I, fig. 2)

1970. *Sarmatiella prima* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 44, Tabl. 25, fig. 1.

Material. 2 specimens.

Description. Initial part elongated-oval, somewhat compressed; periphery rounded; three chambers visible from the outside; the last two chambers tubular, one-half coil in lenght, planispirally enrolled; sutures slightly depressed.

The uncoilled part consits of a few elongate chambers, increasing in size, inflated at the base, tapering and depressed at the aperture; sutures depressed; wall porcelanous thick and dull; surface smooth; aperture slit-like, somewhat bends down at both ends, without a tooth.

Dimensions. Initial part: length: 0.22-0.27 mm; breadth: 0.10.0.14 mm; thickness 0.07-.10 „; Uniserial part: length: 0.26-0.30 mm; maximum diameter: 0.15-0.18 mm.

Variability. The uniserial part may have anoblique position to the coiling axis.

Remarks. Our specimens much resemble the type of *Sarmatiella prima* BOGDANOWICH figured by BOGDANOWICH, 1952, the original figure published in DIDKOWSKI et SATANOVSKAJA, 1970.

Distribution. Ukraine (Black Sea Foredeep) and Azerbaidjan - Middle Sarmatian; Hungary: Zsámbék Basin - Sarmatian, *Elphidium reginum* zone.

Nodophthalmidium asperum n. sp.
(Pl. I, fig. 5)

Holotypus: Pl. I, fig. 5.
Locus typicus: Perbál-5. borehole, depth 142-144 m, Zsámbék Basin, Hungary.
Stratum typicum: Sarmatian, upper part of the *Elphidium reginum* zone.
Derivatio nominis: asperum (latin) - rough surface.

Material. 2 specimens.

Diagnosis. Initial part planispirally enrolled; chambers of uniserial part are conical shape, compressed at the apertural end; slit-like aperture; surface covered with short spine-like ornamentation, forming a rough texture.

Description. Initial part oval, planispirally enrolled; periphery rounded; three chambers visible from the exterior; the last chambers one-half coil in length; chambers elongated somewhat broader at the base; middle chambers elongated, slightly convex; sutures depressed; aperture more or less rounded, with a tooth.

Uniserial part long, consists of a few conical-shape chambers, gradually increasing in size; chambers broad and inflated at the suture, narrowed and slightly compressed at the upper one-third part; sutures strongly depressed.

Wall of test relatively thick; surface rough, caused by small irregular spines; aperture slit-like and somewhat broader at both ends, surrounding with a smooth, more or less thickened lip, which inclined at both ends, without a tooth.

Dimensions. Holotype: initial part: length: 0.30 mm; breadth: 0.27 mm; thickness: 0.12-0.15. The last chamber of the uniserial part: length: 0.42 mm; maximum diameter: 0.22 mm.

Remarks: The distictive feature of this species is the rough surface. This species does not resemble any form known to the author from literature.

Distribution. Hungary: Zsámbék Basin - Lower Sarmatian, *Elphidium reginum* zone.

Nodophthalmidium rugosum n. sp.
(Pl. I, figs. 3-4)

Holotypus: Pl. I, fig. 4.
Paratypus: Pl. I, fig. 5.
Locus typicus: Mány-17. borehole, depth 147.1-147,5 m, Zsámbék Basin, Hungary.
Stratum typicum: Sarmatian, upper part of the *Elphidium reginum* zone.
Derviatio nominis: rugosa (latin) - wrinkled.

Material. 10 specimens (2 complete).

Diagnosis. Convex middle chamber in the planispirally coiled part; in the uniseral part chambers are elongated, with slit-like aperture, bordered with a smooth thickened lip; surface ornamented fine irregular grooves.

Description: Initial part oval; periphery rounded; three or four chambers visible from the outside; the fourth chamber poorly or not visible; chambers tubular, one-half coil in lenght, planispirally enrolled, last chamber strongly curved at the base; middle chambers elongated and convex; sutures depressed; aperture rounded, surrounded with a thickened rim, without a tooth.

The uniserial part consists of a few long, slender chambers, slightly inflated at the base, tapering and somewhat depressed at the aperture; sutures depressed. Wall porcelanous, thick and dull; surface covered with fine irregular, longitudinal grooves, often bifurcated or anastomosed; aperture slit-like, somewhat bends down at both ends, without a tooth.

Dimensions. Holotype: initial part: length: 0.29 mm; breadth: 0.18 mm; thickness 0.11 mm; Uniserial part: length: 0.34 mm; maximum diameter: 0.15 mm; Paratype: initial part: length: 0.34 mm; breadth: 0.24 mm; thickness 0.12 mm.

Variability: The intensity of the ornamentation is variable.

Remarks: This species is close to *Nodophthalmidium moldawiensis* BOGDANOWICH, 1952, which however differs in its narrower aperture, in the bent down at both ends and in oramentation, the distinctly longitudinal striae.

This species differs from *Nodophthalmidium aff. prima* (BOGDANOWICH, 1952) in its more slender chambers of uniserial part and the ornamentation.

Distribution. Hungary: Zsámbék Basin - Sarmatian, upper part of the *Elphidium reginum* zone to the lower part of the *Spirolina austriaca* zone.

Subfamily Nodobaculariinae CUSMAN, 1927
Genus Nodobaculariella CUSMAN et HANZAWA, 1937

Nodobaculariella didkowskii BOGDANOWCH, 1952
(Pl. I, fig. 6)

1970. *Nodobaculariella didkowskii* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 52, Tabl. 30, fig 6a, b.

Material. 7 specimens.

Description. Test nearly circular, strongly depressed; periphery rounded or slightly subacute; six to eight chambers visible from the outside; last two chambers large, uniform in width, oval in cross-section; middle chambers small, depressed in both sides; sutures depressed, distinct; wall porcelaneous, thick; surface smooth, dull; aperture large, oval, with an everted lip, without a tooth.

Dimensions. Length: 0.45-0.6 mm; breadth: 0.38-0.56 mm; thickness 0.17-0.24 mm.

Variability. The number of the visible inner chambers is variable.

Remarks. This species is determined on the basis of original figures of BOGDANOWICH published by DIDKOWSKI and SATANOVSKAJA (1970). The distinctive features of this species are the nearly circular test shape and the large oval aperture.

Distribution. Ukraine: Volhyn-Podolian Platform – Upper Badenian and Lower Sarmatian; Russia: Eastern Precaucasus – Konka Horzint: Zsámbék Basin – Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone.

Nodobaculariella ovalis VENGLINSKI, 1958
(Pl. I, figs. 7-9)

1958. *Nodobaculariella ovalis* VENGLINSKI; VENGLINSKI, p. 91, Tabl, 18, fig. 1.
1962. *Nodobaculariella ovalis* VENGLINSKI; VENGLINSKI, Tabl. VII, fig. 5.
1965. *Nodobaculariella ovalis* VENGLINSKI; KORECZ-LAKY, p. 354, Taf. II. fig. 2.
1970. *Nodobaculariella ovalis* VENGLINSKI; DIDKOWSKI et SATANOVSKAJA, p. 52, Tabl. 31, fig. 4.

1973. *Nodobaculariella ovalis* VENGLINSKI; KORECZ-LAKY, Pl. III. fig. 2.
1974. *Nodobaculariella ovalis* VENGLINSKI; BRESTENSKÁ, p. 247, Taf. 1, Fig. 2.

Material. About 30 specimens.

Description. Test oval, flattened; periphery rounded; three or four chambers visible from the exterior; chambers one-half coil in length and tubular, in the lower part strongly inflected, middle chamber large, convex; fourth chamber poorly visible or lacking; sutures distinct; wall porlelaneous, relative thick; surface smooth, dull; aperture circular to oval, bordered by a thick rim, without a tooth.

Dimensions. Length: 0.34-0.6 mm; breadth: 0.22-0.36 mm; thickness 0.13-0.20 mm.

Variability. The test shape ranges from oval to nearly rounded.

Remarks. Morfologically this species is close to *Nodobaculariella sulcata* (REUSS), but the characteristic remarks are the smooth surface and the rounded periphery.

Distribution. Ukraine: Transcarpathians - Lower Sarmatian; Hungary: Tokaj Mountains, Zsámbék Basin - Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone.

Nodobaculariella sulcata (REUSS, 1849)
(Pl. I, fig. 10-12)

1849. *Articulina sulcata* REUSS; REUSS, p. 383, Taf. IV, Fig. 13-17.
1958. *Nodobaculariella sulcata* (REUSS); VENGLINSKI, p. 89, Tabl. XVII. fig. 4a, b, c.
1964. *Nodobaculariella sulcata* (REUSS); KORECZ-LAKY, Taf. III, Fig. 5.
1970. *Nodobaculariella sulcata* (REUSS); DIDKOWSKI et SATANAOVSKAJA, p. 53, Tabl. 31, fig. 6.
1974. *Nodobaculariella aff. sulcata* (REUSS); BRESTENSKÁ, p. 247, Taf. 1, Fig. 1.

Material. About 50 specimens.

Description. Test oval, flattened; periphery subacute; three or four chambers visible from the exterior; chambers one-half coil in length, thick tubular, in the lower part strongly inflected, middle chamber small, elongated, forth chamber usually poorly visible or lacking; sutures distinct; wall calcareous, porcelaneous, relative thick; surface dull, covered with irregular longitudinal ribs; aperture oval at the end of a neck or lacking, with thin rim, without a tooth.

Dimensions. length: 0.35-0.6 mm; breadth: 0.32-0.42 mm; thickness 0.11-0.20 mm.

Variability. Test more or less elongated. Variable features are the length of the final chamber and the intensity of the ornamentation.

Remarks. The test shape is the same as the description and illustration of the type described by REUSS, 1849, but the latter specimens differ in their regular, longitudinal striae.

VENGLINSKI (1958) figured specimens with broad-rounded periphery, but described sometimes that may be subacute. The more distinctive remarks of this species are the longitudinal ornamentation and the oval aperture at the end of a longer or shorter neck, surrounded by a thickened rim.

Distribution. Eocene – Recent. Recently lives in the oceans and seas between 72 to 790 m (DIDKOWSKI, 1970). In Lower Sarmatian, in the large *Elphidium* zone this species wide-spread in Central-Paratethys (BRESTENSKÁ, 1974).

Original description of REUSS from Felső-Lapugy, Romania and Wieliczka, Poland from Miocene. Ukraine: Transcarpathians – Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone.

Family Hauerinidae SCHAWAGER, 1876

Subfamily Siphonapertinae SAIDOVA, 1975

Genus Schlumbergerina MUNIER-CHALMAS, 1882

Schlumbergerina fabularoides (KARRER, 1865)
(Pl. II, fig. 1-4)

1865. *Quinqueloculina fabularoides* KARRER; KARRER, p. 704, Taf. 1, Fig. 3.
1865. *Quinqueloculina transilvaniae* KARRER; KARRER, p. 704, Taf. 1, Fig. 4.
1974. *Miliola fabularoides* (KARRER); LUCZKOWSKA, p. 96, Pl. XIV, figs. 1-3, test-fig. 34/1.

Material. Over 500 specimens.

Description. Test large, quadrangular- oval or oval; subtriangular to oval in cross-section; periphery rounded; five chambers visible from the outside, chambers elongated, tubular, one-half coil in length in quinqueloculine arrangement; middle chambers long, convex and more or less elevated; sutures depressed; wall finely agglutinated; surface slightly rough and dull; aperture nearly circular to subtriangular and convex, somewhat prominent or flush with the periphery, trematophore, with numerous rounded openings.

Dimensions. Length: 0.5-1.8 mm; breadth: 0.3-0.95 mm; thickness 0.27-0.55 mm.

Variability. The test shape is variable, often appeared irregular-shape chambers. Frequently six chambers can be seen. Sometimes the last chambers do not reach the top of the test, forming a lateral position of the aperture. The aperture is surrounded with crenulate border and bearing a low simple tooth if the termatophore damaged.

Remarks. In our specimens the quadrangular test shape is more common, in contrast to description of LUCZKOWSKA. The irregular chambers appeared frequently. This species occured in only one sample (Mány-22. borehole, 40-43 m), but in large quantities (about 8000 specimens in 100 g rocks) and amounts over 30% of the total foraminifera fauna.

Distribution. Romania: Lapugy in Transylvania - Badenian; Poland: Niskowa - Upper Badenian; Hungary: Zsámbék Basin - Sarmatian, *Spirolina austrica* zone.

Genus Siphonaperta VELLA, 1957

Siphonaperta longidentata n. sp.

(PL. II, figs. 5-8)

Holotypus: Pl. II, fig. 8.
Paratypus: Pl. II, figs. 5-7.
Locus typicus: Mány-17. borehole, depth 147.1-147.5 m, Zsámbék Basin, Hungary
Stratum typicum: Lower Sarmatian, *Elphidium reginum* zone.
Derivatio nominis: longidentata (latin) - long tooth.

Material. 33 speciemens.

Diagnosis. Sigmoid test shape; surface covered with fine sand grains; aperture oval with a long simple tooth.

Description. Test sigmoid or sometimes oval; periphery rounded; three to five chambers visible from the outside; chambers tubular; the last chamber strongly inflected in the lower part, usually has short extension at the base end and longer, distinct extension at the aperture; middle chambers long, elongated and more or less elevated; sutures slightly depressed, indistinct; wall calcareous, agglutinated with fine sand grains; surface rough; aperture oval, somewhat boardered at the upper end, surrounded with a smooth porcelaneous, slightly inclined rim, bearing a long, slender simple tooth.

Dimensions. Holotype: length: 0.39 mm; breadth: 0.27 mm; thickness 0.25 mm. Paratypes: length: 0.33-0.42 mm; breadth: 0.24-0.33 mm; thickness 0.12-0.18 mm.

Variability. The shape of the test and the length of the extensions of both ends of the last chamber are variable.

Remarks. This species somewhat resembles to *Siphonaperta mediterranensis* BOGDANOWICH, 1950, but the latter species differs in its small round aperture, equipped with a short simple tooth.

Distribution. Hungary: Zsámbék Basin – Sarmatian, upper part of the *Elphidium reginum* zone.

Subfamily Hauerininae SCHWAGER, 1876

Genus Cycloforina LUCZKOWSKA, 1972

Cycloforina badenensis D' ORBIGNY, 1846

(Pl. II, fig. 9-11)

1846. *Quinqueloculina Badenensis* D'"ORBIGNY; D'ORBIGNY, p. 299, Taf. 20, fig. 10-12.
1958. *Miliolina badenensis* D'ORBIGNY; VENGLINSKI, p. 76, Tabl. 13, fig. 3.
1968. *Quinqueloculina badenensis* D'ORBIGNY; KORECZ-LAKY, p. 148, Taf. 12, Fig. 10.
1970. *Quinqueloculina badenensis* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 18, Tabl. 8, fig. 2 a, b.
1974. *Cycloforina badenensis* D'ORBIGNY; LUCZKOWSKA, p. 73, Pl. 11, fig. 5.
1985. *Cycloforina badenensis* D'ORBIGNY; PAPP et SCHMID, p. 105, Pl. 101, fig. 6-10.

Material. Over 500 specimens.

Description. Test broad-oval; periphery angular; five chambers visible from the outside, chambers one-half a coil in lenght in cycloforina arrangement, chambers uniform in width, in cross-section trapezoid, slightly inflated, only on the last two chambers visible two ridges; large, elevated middle chambers with a visible ridge; sutures distinct, depressed; wall calcareous, imperforate, thick; surface dull; aperture circular, with a short, bifid tooth.

Dimensions. Length: 0.60–1.10 mm; breadth: 0.40–0.75 mm; thickness: 0.26-0.60 mm.

Variability. The test may sometimes be more elongated and edges of the chambers more or less acute.

Remarks. In our material the specimens are not so keeled as the ones figured by PAPP et SCHMID (1985) on plate 101, figs. 7, 10.

Distribution. Austria: Baden, Vienna Basin – Badenian; Poland: Benczyn, Bogoria, Karsy, Korytnica – Badenian and Lower Sarmatian; Ukraine: Transcarpathians, North Caucasian, Southern part of the Russian Platform – Miocene; Hungary: Mecsek Mts. – Badenian and Lower Sarmatian; Zsámbék Basin – Sarmatian.

Cycloforina contora (D'ORBIGNY, 1846)
(Pl. III, fig. 1-3)

1846. *Quinqueloculina Juelana* D'ORBIGNY; D'ORBIGNY, p. 298, Taf. 20, Fig. 1-3.
1846. *Quinqueloculina contorta* D'ORBIGNY; D'ORBIGNY, p. 298, Taf. 20, Fig. 4-6.
1846. *Quinqueloculina Rudolphina* D'ORBIGNY; D'ORBIGNY, p. 299, Taf. 20, Fig. 7-9.
1964. *Quinqueloculina contorta* D'ORBIGNY; KORECZ-LAKY, p. 478. Taf. 2, Fig. 10.
1968. *Quinqueloculina contorta* D'ORBIGNY; KORECZ-LAKY, p. 59, Taf. 4. Fig. 4.
1968. *Quinqueloculina juleana* D'ORBIGNY; KORECZ-LAKY, p. 59.
1970. *Quinqueloculina contorta* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 22, Tabl. 9, fig. 6.

1974. *Cycloforina contorta* (D'ORBIGNY); LUCZKOWSKA, p. 74, part 1. Pl. 12, fig. 3, part 2, Pl. 11, figs. 2, 3, Text-fig. 26.
1985. *Cycloforina contorta* (D'ORBIGNY); PAPP et SCHMID, p. 104-105, Pl. 100, figs. 1-11, Pl. 101, figs. 1-5.
1991. *Cycloforina contorta* (D'ORBIGNY); CIMMERMAN and LANGER, p. 32,pl. 27, figs. 7-11.
1991. *Cycloforina juleana* (D'ORBIGNY); CIMERMAN and LANGER, p. 33, pl. 28, figs. 1-2.

Material. About 350 specimens.

Description. Test narrowly-oval; periphery angular; in cross-section flattened or triangular; five chambers visible from the outside, chambers one-half a coil in lenght in cycloforina arragement, in the lower part strongly inflected and sometimes reach the last one, chambers long, narrow, uniform in width, sides flattened, two carinae run wide apart on the periphery, may be slightly depressed between the keels; elevated middle chambers, long, with a visible ridge; sutures distinct, depressed; wall calcareous, imperforate, thick; surface dull; aperture circular, with a short, bifid tooth.

Dimensions. Length: 0.6-1.1 mm; breadth: 0.3-0.7 mm; thickness 0.25-0.45 mm.

Variability. The shape of the test may be more slender and in cross-section has more or less parralel siedes or triangular shape. Sometimes two ridges run along the largest middle chamber. The carinae ranges from blunt to sharp. The aperture may be produced on a short neck.

Remarks. In our material the axe of the test often curved. Inspite of description of LUCZKOWSKA the rough streakly surface is not a characteristic feature, it appeared very rarely.

Distribution. Eocen to Recent. Recently lives in Mediterranean Sea (CIMERMAN and LANGER, 1991). Austria: Vienna Basin – Badenian; Ukraine – Upper Eocen-Miocen; Poland: Benczyn, Bogoria, Korytnica, Gliwice Stare, Niechobrz, Rybnica, Wieliczka – Badenian and Lower Sarmatian; Hungary: Mecsek Mts. – Badenian and Lower Sarmatian, Zsámbék Basin – Sarmatian, *Elphidium hauerinum* and *Spirolina austriaca* zone.

Cycloforina fluviata (VENGLINSKI, 1958)
(Pl. II, figs. 4-6)

1958. *Miliolina fluviata* VENGLINSKI; VENGLINSKI, p. 82, Tabl. 15, fig. 4, 5.
1960. *Miliolina fluviata* VENGLINSKI; STANCHEVA, p. 10, Tabl. 1, fig. 7.
1962. *Quinqueloculina fluviata* (VENGLINSKI); VENGLINSKI, p. 73, Tabl. 4, fig. 2.
1970. *Quinqueloculina fluviata* (VENGLINSKI); DIDKOWSKI et SATANOVSKAJA, p. 23, Tabl. 11. fig. 2.
pars 1974. *Cycloforina fluviata* (VENGLINSKI); LUCZKOWSKA, p. 76, Pl. 13, fig. 4, text-fig. 27/2.

Material. About 100 specimens.

Description. Test quadrangular-oval, elongated, flattened in cross-section; periphery rounded; five chambers visible from the outside; chambers one-half coil in length in cycloforina arrangement, broad tubular, in the lower part inflected, middle chamber long, fifth chamber usually poorly visible; sutures slightly depressed; wall thin; surface covered with longitudinal ribs; aperture circular, with a short, bifid or quadrate and slightly bifid tooth.

Variability. Variability expressed in the visible size of the fifth chamber and in the strong or weak development of ribs.

Dimensions. Length: 0.28-0.42 mm; breadth: 0.13-0.19 mm; thickness 0.09-0.18 mm.

Remarks. The specimens are same the as the original description of VENGLINSKI. Specimens of LUCZKOWSKA differ from it in the ornamentation ("surface longitudinal thick protuberences accumulated at the bottom of chambers and dissappearing towards the end"), in the broad oval-quadrangular shape of the test, and the aperture bearing a quadrate tooth.

Distribution. Ukraine: Transcarpathians – Lower and Middle Sarmatian; Northwestern Bulgaria: Vladimirovo, Pelovo – Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, from the upper part of the *Elphidium reginum* zone to the *Spirolina austriaca* zone.

Cycloforina predkarpatica (SEROVA, 1955)
(Pl. III, figs. 7-9)

1970. *Cycloforina predkarpatica* (SEROVA); DIDKOWSKI et SATANOVSKAJA, p. 30, Tabl. 18, fig. 1.
1974. *Cycloforina predkarpatica* (SEROVA); LUCZKOWSKA, p. 83, Pl. 13, figs. 8, 9, text-fig. 27/4.

Material. 46 specimens.

Description. Test quadrangular-oval to oval; subtriangular in section; periphery rounded; four or five chambers visible from the outside; chambers tubular, in the lower part inflected, straightened at the aperture; middle chambers long, convex; sutures depressed; wall thin; surface smooth, polished; aperture small, circular with a low quadrate, somewhat bifid tooth.

Dimensions. Length: 0.4-0.8 mm; breadth: 0.3-0.5 mm; thickness 0.1-0.3 mm.

Variability. The shape of the test varies from elongated oval to quadrangular-oval. Often the fourth and the fifth chambers are very narrow and poorly visible. The periphery sometimes covered with faint and irregular longitudinal grooves.

Remarks. The specimens from Zsámbék Basin are similar to the original illustration of SEROVA, 1950, and have larger test, than specimens of LUCZKOWSKA, 1974.

This species differs from *Cycloforina stomata* LUCZKOWSKA in its more quadrangular test shape, smaller aperture and lower, quadrate tooth.

Distribution. Ukraine: Precarpathian Foredeep - Lower Sarmatian; Poland: Budy, Dwikozy, Grzybów, Miechocin, Mielec, Niwka, Rytwiany, Zrecze - Loser Sarmatian; Hungary: Zsámbék Basin - Sarmatian.

Cycloforina stomata LUCZKOWSKA, 1974
(Pl. III, fig. 10-11)

1974. *Cycloforina stomata* LUCZKOWSKA; LUCZKOWSKA, p. 85, Pl. 13, fig. 5, text-fig. 27/1.

Material. 32 specimens.

Description. Test oval, tapering at both ends; periphery rounded; five chambers visible from the exterior; chambers one-half coil in length, broad tubular, middle chambers large and convex, fifth chamber narrow and usually poorly visible; sutures slightly depressed; wall thin; surface smooth, shiny; aperture large, circular or semicircular, with an everted border, bearing a short, bifid tooth.

Dimensions. Length: 0.4-0.6 mm; breadth: 0.25-0.35 mm; thickness 0.17-03 mm.

Variability. The test shape may be more or less elongated. The size of the fifth chamber is variable. The tooth ranges from narrow to quadrate.

Remarks. LUCZKOWSKA remarked, that "some specimens covered with longitudinal, irregular wrinkles", in our material such specimens did not appeare. Except of this, our specimens corresponds to Cycloforina stomata LUCZKOWSKA, 1974.

Distribution. Poland: Budy, Grzybów, Mielec, Niwka, Rytwiany - Lower Sarmatian; Hungary: Zsámbék Basin - Sarmatian, *Spirolina austriaca* zone.

Cycloforina toreuma (SEROVA, 1955)

(Pl. IV. figs. 1-2)

1970. *Quinqueloculina toreuma* (SEROVA); DIDKOWSKI et SATANOVSKAJA, p. 35, Tabl. 20, fig. 4.

1974. *Cycloforina toreuma* (SEROVA); LUCZKOWSKA, p. 87, Pl. 13, fig. 3 a-c, text-fig. 29/2, 31.

Material. 22 specimens.

Description. Test nearly circular in outline; subtriangular in section; periphery rounded; four or five chambers visible from the exterior; fifth chamber usually poorly visible; chambers broad, arcaute, middle chamber large, prominent; sutures distinct, depressed; wall porcelaneous, thin; surface polished and covered with longitudinal striae, which may be bifurcated or dissappeared, stronger on the periphery and often missing from the sides of the chambers; aperture large, rounded, bearing with a low, quadrate, slightly bifurcated tooth.

Dimensions. Length: 0.3-0.46 mm; breadth: 0.24-0.36 mm; thickness 0.15-0.26 mm.

Variability. Often the fourth chamber is very small, and poorly visible and the fifth invisible. The intensity of the ornamentation is variable.

Remarks. Our specimens are very close to the description of Luczkowska, but differ in their less number of the visible chambers. This species differs from *Cycloforina vermicularis* (KARRER) in its smaller size, sharp and thinner striae. From *Cycloforina karreri ovata* (SEROVA) it differs in having aperture flush with the periphery and having irregular grooves placed only on the periphery. This species differs form *Varidentella pseudocostata* (VENGLINSKI) in its smaller size of the test, having stronger ornamentation and circular shape of the aperture.

Distribution. Ukraine: Volhyn-Podolian Platform, West Ukraine-Upper Badenian; Poland: Rytwiany, Zrecze – Lower Sarmatian; Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Cycloforina vermicularis (KARRER, 1868)
(Pl. IV, fig. 3-5)

1868\. *Quinqueloculina vermicularis* KARRER; KARRER, p. 150, Taf. 3, Fig. 1.

1974\. *Cycloforina vermicularis* (KARRER); LUCZKOWSKA, p. 88, Pl. 13, fig. 10, text-fig. 32.

Material. 31 specimens.

Description. Test, broad-oval, tapering at both ends; periphery subrounded or subacute; five chambers visible from the outside; chambers arcuate, uniform in width; middle chambers eleveted; sutures slightly depressed, distinct wall thick,dull surface covered by longitudinal or sometimes irregular, bifurcated and interrupted striae aperture circular, with a short tooth widening at the end.

Dimensions. Length: 0.4-0.9 mm breadth: 0.25-0.7 mm thickness 0.28-0.63 mm.

Variability. The shape of the test ranges from oval to nearly circular. In the section may be subrounded or more or less angular. The ornamentation varies from regular to irregular longitudinal striae. The aperture may be produced on a short neck.

Remarks. Dimorphism and ontogeny are discussed in detail by LUCZKOWSKA (1974). In the studied material specimens with regular, longitudinal ornamentation are more common than specimens with irregular, acuted one, such as figured by KARRER, 1868.

Distribution. Romania: Kostej in Banat, Lapugy in Transylvania – Badenian; Poland: Benczyn, Korytnica – Lower Badenian; Hungary: Zsámbék Basin – Sarmatian.

Genus Hauerina D'ORBIGNY, 1839

Hauerina irschavensis VENGLINSKI et BURINDINA, 1965
(Pl. IV, figs. 6-9)

1965. *Hauerina irschavensis* VENGLINSKI et BURINDINA; VENGLINSKI et BURINDINA, p. 72, Tabl. 1, fig. 1a, b.

pars 1965. *Hauerina subcompressa* VENGLINSKI et BURINDINA; VENGLINSKI et BURINDINA, p. 74, Tabl. 1, fig. 3a, b.

pars 1965. *Hauerina confusa* SEROVA sarmatica VENGLINSKI et BURINDINA; VENGLINSKI et BURINDINA, p. 75, Tabl. 1, fig. 5a, b.

1975. *Hauerina irschavensis* VENGLINSKI et BURINDINA; VENGLINSKI, p. 166, Tabl. 17, fig. 1-3.

1975. *Hauerina confusa sarmatica* VENGLINSKI et BURINDINA; VENGLINSKI, p. 166, Tabl. 18, fig. 6-9.

Material. About 80 species.

Description. Test circular to oval, flat, outline irregular; periphery rounded; early chambers show a quinqueloculina arragement, later planispiral with three or four chambers per whorl, chambers slightly inflated, middle chambers small, oval; sutures depressed, indistinct; wall calcareous, porcelanous; surface smooth, dull; aperture circular to triangular, large, tremathophore.

Dimensions. Length: 0.36-0.73 mm; breadth: 0.22-0.71 mm; thickness 0.09-0.16 mm.

Variability. The shape of the test ranges from circular to oval. Chambers in the last whorl may have irregular arrangement.

Ontogeny. The juvenile specimens have rounded or triangular aperture and the middle chambes are convex and clearly visible, as in *Hauerina confusa sarmatica.* In adult stage the aperture is triangular and the middle chambers flat and poorly visible, as in *Hauerina irschavensis.*

Remarks. The valid figure in the original description of the *Hauerina confusa sarmatica* VENGLINSKI et BURINDINA, 1965 is fig. 3. The valid figure of *Hauerina subcompressa* VENGLINSKI et BURINDINA, 1965 is fig. 4., 5. is *Peneroplis sarmaticus* DIDKOWSKI *besarabica* VENGLINSKI, 1965. VENGLINSKI (1958) and VENGLINSKI and BURINDINA (1975) designated *Hauerina irschavensis* VENGLINSKI et BURINDINA and *Hauerina confusa sarmatica* VENGLINSKI et BURINDINA from the same stratigraphic level, they occured together. According to the description of VENGLINSKI and BURINDINA (1965) *H. irschavensis* is larger than *H. confusa sarmatica.* According to the morfologycal features and their stratigraphic distribution *Hauerina confusa sarmatica* is the juvenile stage of *Hauerina irschavensis.*

Distribution. Ukraine: Transcarpathian - Lower and Middle Sarmatian; Hungary: Zsámbék Basin - Sarmatian, *Spirolina austriaca* zone.

Hauerina podolica SEROVA, 1955
(Pl. IV. figs. 10-12)

1960. *Hauerina podolica* SEROVA; STANCHEVA, p. 15, Tabl. 1, fig. 5.
1970. *Hauerina podolica* SEROVA; DIDKOWSKI et SATANOVSKAJA, p. 50, Tabl. 29, fig. 6.
1974. *Hauerina podolica* SEROVA; LUCZKOWSKA, p. 92, pl. 18, figs. 3,4.

Material. 38 specimens.

Description. Test round in outline, lenticular in cross-section; three or four chambers visible from the exterior; The two outer ones are broad, with early chambers show a quinqueloculina arragement, later planispiral with two chambers per whorl, chambers slightly inflated, middle chambers small, poorly visible; sutures indistinct; wall calcareous, porcelanous; surface smooth, dull; aperture triangular, large, tremathophore.

Dimensions. Length: 0.26-0.38 mm; breadth: 0.22-0.33 mm; thickness 0.15-0.24 mm.

Variability. The shape of the test ranges from circular to broad oval.

Distribution: Ukraine: Volhyn-Podolian Platform – Upper Torton; Bulgaria: Vladimirovo (North-western Bulgaria) – Lower Sarmatian; Poland: Gliwice Stare, Ligota Zabrska, Niskowa Weglinek – Upper Badenian; Hungarian: Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

Genus Quinqueloculina D'ORBIGNY, 1826, emend LUCZKOWSKA, 1972.

Quinqueloculina anagallis LUCZKOWSKA, 1974
(Pl. V. figs. 1-3)

1974. *Quinqueloculina anagallis* LUCZKOWSKA; LUCZKOWSKA, p. 40, Pl. I, figs. 1a-c, 2a, b, 3a-c, text-fig. 7-9, 11/1, 4.

Material. About 80 specimens, only in quinqueloculine stage.

Description. Test large oval, somewhat tapering at both ends, triangular in cross-section; periphery acute; five chambers visible from the exterior, usually the fifth chamber very narrow; chambers broad, more or less acute, with slightly convex or flat sides; middle chambers large and acute; sutures distinct; wall relatively thick; surface more or less covered with strong or weak longitudinal striae; aperture large, oval,places in slightly oblique position, surrounded with thickened rim, bearing, a long, distally bifid tooth.

Dimensions. Length: 0.52-1.2 mm; breadth: 0.32-0.78 mm; thickness: 0.4-0.8 mm.

Variability. The periphery may be more or less acute, but not carinate. The ornamentation varies from weak longitudinal wrinkles along the edges to distinct striae, covering the hole surface of the test.

Variability and ontogeny are discussed in detail in LUCZKOWSKA, 1974.

Remarks. The test shape of these specimens much resembles Quinqueloculina pseudobuchiana LUCZKOWSKA, which differs in its smooth polished surface.

Distribution. Poland: Chomentów, Grabki Duze, Karsy, Korytnica, Leki Dolne – Lower Badenian; Hungary: Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

Quinqueloculina buchiana D'ORBIGNY, 1846
(Pl. V, figs. 4-7)

1846. *Quinqueloculina buchiana* D'ORBIGNY; D'ORBIGNY, p. 289, Taf. 18, Fig. 10-12.
1964. *Quinqueloculina buchiana* D'ORBIGNY; KORECZ-LAKY, p. 478, Taf. 3, Fig. 3.
1970. *Quinqueloculina ungeriana* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 36, Tabl. 21, fig. 2a-c.
1974. *Quinqueloculina buchiana* D'ORBIGNY; LUCZKOWSKA, p. 45, Pl. 4, figs. 1-4, text-fig. 11/2, 3, 12-14.
1985. *Quinqueloculina buchiana* D'ORBIGNY; PAPP et SCHMID, p. 99, Pl. 93, figs. 1-7, text-plate 14, fig. 4, text-plate 15.

Material. 25 specimens in quinqueloculine stage, 4 in massiline stage.

Description. Quinqueloculine stage: Test large, broad-oval, triangular in cross-section; periphery acute and keeled; five chambers visible from the exterior, often the fifth chamber visible as a ridge; chambers broad, more or less keeled, with flat sides; strongly elevated middle chambers large and acute; sutures distinct, flat; wall relatively thick; surface smooth, shiny; aperture large, oval, places in slightly oblique position, bordared with thickened rim, equiped with a long, distally bifurcated tooth.

Massiline stage: nearly circular, flattened; periphery sharply angled and keeled; chambers broad, slightly inflated; middle chambers large, bearing ridge, somewhat prominent; sutures distinct, flat; wall relatively thick; surface covered with fine longitudinal striae, accumulated at the outer part of the chambers near the edges; aperture large, oval, parallel with the periphery, with a simple distally bifurcated tooth.

Dimensions. Quinqueloculine form: length: 0.6-10.8 mm; breadth: 0.4-1.33 mm; thickness: 0.35-0.7 mm.

Variability. The shape of the test is characteristic and constant. The periphery may be more or less keeled. Surface of quinqueloculine forms sometimes covered with fine longitudinal grooves along the edges of the chambers.

Variability and ontogeny are discussed in detail in Luczkowska, 1974.

Remarks. The specimens from Zsámbék Basin are identical in detail with the descriptions and figures of LUCZKOWSKA, 1970 and PAPP et SCHMID, 1985; difference is in the appearance of the ornamentation on quinqueloculine forms.

Distribution. Austria: Vienna Basin – Badenian; Russia: Tchokrak Horizont (Middle Miocene); Poland: Brzeznica, Benczyn, Chomentów, Gliwice Stare, Karsy, Korytnica – Badenian and Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Subfamily Miliolinellinae VELLA, 1957
Genus Affinetrina LUCZKOWSKA, 1972

Affinetrian cubanica (BOGDANOWICH, 1947)
(Pl. V, figs. 8-10)

non 1958. *Miliolina aff. cubanica* BOGDANOWICH; VENGLINSKI, p. 83, Tabl. 15, fig. 2.
non 1960. *Miliolina aff. cubanica* BOGDANOWICH; STANCHEVA, p. 13, Tabl. 2, fig. 3.
1970. *Triloculina cubanica cubanica* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 55, Tabl. 32, fig. 3.
1974. *Affinetrina cubanica* (BOGDANOWICH); LUCZKOWSKA, p. 108, Pl. 26, fig. 4, text-fig. 38/5.

Material. About 70 specimens.

Description. Test small, broad oval to nearly circular, slightly tapering towards the aperture; periphery rounded; three chambers visible from the outside, in triloculina arragement; chambers broad, more inflated and somewhat curved at the base, narrowed towards the end; middle chamber narrow, somewhat elevated and oblique; sutures distinct, slightly depressed; wall calcareous, imperforted and thin; surface smooth and polished; aperture high, narrow, with arcuate border, which is bent somewhat to the back, placed slightly oblique to the penultimate chamber and filled with a long simple tooth, often jutting out over the plan of the aperture.

Dimensions. Length: 0.20-0.38 mm; breadth: 0.22-0.33 mm; thickness: 0.11-0.2 mm.

Variability. The morfology of the test is unvaried. The early chambers show a cryptoquinqueloculina arrangement.

Remarks. The arcute boarder and the oblique position of the aperture and the near circular and not flattened test shape are the major distinguishing features between this species and *Affinetrina ucrainica* (SEROVA, 1952).

The species described by VENGLINSKI (1958) and STANCHEVA (1960) has an elongated test shape and the aperture perpendicular or nearly perpendicular to the penultimate chamber, as in *Affinetrina ucrainica* (SEROVA, 1952).

Distribution. Russia: North and West Caucasus – Lower and Middle Sarmatian; Ukraine: Black sea Depression – Lower and Middle Sarmatian; Poland: Gliwice, Stare, Grabowiec, Grzybów, Weglinek, Zrecze – Upper Badenian and Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Affinetrina ucrainica (SEROVA, 1952)
(Pl. VI. figs. 1-3)

1958. *Miliolina aff. cubanica* BOGDANOWICH; VENGLINSKI, p. 83, Tabl. 15, fig. 2.
1960. *Miliolina aff. cubanica* BOGDANOWICH; STANCHEVA, p. 13, Tabl. 2, fig. 3.
1962. *Triloculina ucrainica* (SEROVA); VENGLINSKI, Tabl. 8, fig. 5 a, b, c.
1970. *Triloculina ukrainica ukrainica* SEROVA; DIDKOWSKI et SATANOVSKAJA, p. 63, Tabl. 38, fig. 8 a, b.
1974. *Affinetrina ucrainica.* (SEROVA); LUCZKOWSKA, p. 111, Pl. XXVI, figs. 3a-c, text-fig. 38/4.
1975. *Triloculina ucrainica siwaschica* DIDKOWSKI; VENGLINSKI, p. 168, Tabl. 19, fig. 4. 5.

Material. 34 specimens.

Description. Test elongated oval, flattened; periphery rounded; three chambers visible from the exterior, in triloculina arrangement; chambers broad, somewhat inflated in the lower part, straightened and narrowing towards the aperture; middle chamber small and narrow; sutures slightly depressed; wall calcareous, imperforate; surface smooth and polished; aperture high, narrow slit-like, filled with a long simple tooth, often jutting out over the plan of the aperture.

Dimensions. Length: 0.3-0.55 mm; breadth: 0.2-0.3 mm; thickness: 0.16-0.2 mm.

Variability. Sometimes the fourth chamber is visible. The test may be more or less flattened.

Remarks. The distinctive features between this species and *Affinetrina cubanica* (BOGDANOWICH) are presented in the description of the latter species.

Distribution. Ukraine: Transcarpathians, Volhyn-Podolian Platform – Upper Badenian – Middle Sarmatian; Bulgaria: Vladimirovo, Dobrusa, Krividol, Staroselci, Staverci, Orjahovina and Deleina in Moldavian Platform (Nortwestern Bulgaria) – Lower and Middle Sarmatian; Poland: Boguvice, Ligota Zrabska, Rytwiany, Weglin – Upper Badenian; Hungary: Zsámbék Basin – Sarmatian.

Genus Miliolinella WIESNER, 1931, emend. LUCZKOWSKA, 1972

Miliolinella banatiana LUCZKOWSKA, 1974
(Pl. VI, figs. 4-5)

1974. *Miliolinella banatiana* LUCZKOWSKA; LUCZKOWSKA, p. 103, Pl. 29, figs. 1-5, text-fig. 35.

Material. 24 specimens.

Description. Test ovate in outline, usually broader than longer, flattened; periphery rounded; three to five chambers visible from the outside; early chambers small, in quinqueloculine arrangemenet, two chambers in the final whorl broad, inflated, in planispiral arrengement; sutures depressed, distinct, with narrow strip along the sutures; wall calcareous, imperforate, thin; surface smooth and polished; aperture large, semicircular, with a broad and low apertural flap.

Dimensions. Length: 0.4-0.57 mm; breadth: 0.36-0.6 mm; thickness: 0.2-0.38 mm.

Variability. The test shape is variable, as the last chamber may be more or less inflated and have flattened sides. Sometimes slightly evolut. Centrally more or less depressed.

Remarks. The specimens from Zsámbék Basin can be well identified with the type described by LUCZKOWSKA, 1974.

Distribution. Poland: Ligota Zabrska, Wegline, Wierczhowika – Upper Badenian; Romania: Kostej in Banat – Badenian; Hungary: Zsámbék Basin – Sarmatian. *Spirolina austriaca* zone.

Miliolinella selene (KARRER, 1868)
(Pl. VI, figs. 6-8)

1868. *Triloculina selene* KARRER; KARRER, p. 138, Taf. 1, Fig. 12.
1970. *Quinqueloculina selene* (KARRER); DIDKOWSKI et SATANOWSKAJA, p. 32, Tabl. 18, fig. 9.
1974. *Miliolinella selene* (KARRER); LUCZKOWSKA, p. 105, Pl. 20, figs. 1, 2, text-fig. 36.

Material. 76 specimens.

Description. Test small, oval, subtriangular in cross-section; periphery rounded; three to five chambers visible from the outside, usually the fourth and fifth chambers are small, or invisible; chambers broad, widest at the base, tapering towards the aperture; elevated middle chamber placed slightly oblique; sutures somewhat depressed; wall calcareous, imperforte and thin; surface smooth and polished; aperture semicircular to low and broad arch, bearing a flap or low, tape-shape tooth.

Dimensions. Length: 0.25-0.5 mm; breadth: 0.2-0.4 mm; thickness: 0.2-0.36 mm.

Variability. Usually three chambers are visible from the exterior. The shape of the aperture and the tooth is variable.

Remarks. The shape of the aperture and the tooth are the major distinguishing features between *Miliolinella selene* (KARRER) and *Miliolinella valvularis* (REUSS).

The specimens from Zsámbék Basin can be well identified with the type described by KARRER, 1868.

Distribution. Romania: Kostej in Banat – Badenian; Russia: West-Precaucasian region. Georgia, Crimea – Middle Miocene: Ukraine: Volhyn-Podolian Platform – Lower Badenian; Hungary: Zsámbék Basin – Sarmatian. *Spirolina austriaca* zone.

In Paratethys: Oligocene – Miocene.

Genus Pseudotriloculina CHERIF, 1970 (= Sinuloculina LUCZKOWSKA, 1972)

Pseudotriloculina consobrina (D'ORBIGNY, 1846)
(Pl. VI. figs. 9-10)

1846. *Triloculina consobrina* D'ORBIGNY; D'ORBIGNY, p. 277, Taf. 17, Fig. 10-12.
1951. *Triloculina consobrina* D'ORBIGNY; MARKS, p. 40.
1958. *Miliolina consobrina* (D'ORBIGNY); VENGLINSKI, p. 80, Tabl. XV, fig. 3 a-c.
1958. *Miliolina consobrina* (D'ORBIGNY) var. nitens REUSS; VENGLINSKI, p. 82, Tabl. XV, fig. 1 a-c.
1960. *Miliolina consobrina* (D'ORBIGNY) var. nitens REUSS; STANCHEVA, p. 11, Tabl. I, fig. 1 a.
1960. *Miliolina consobrina* (D'ORBIGNY) var. sarmatica BOGDANOWICH; STANCHEVA, p. 11, Tabl. I, fig. 6.
1968. *Triloculina consobrina* D'ORBIGNY; KORECZ-LAKY, p. 67, Taf. I, fig. 12.
1970. *Triloculina consobrina consobrina* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 21, Tabl. 10, fig. 10-12.
1973. *Triloculina consobrina* D'ORBIGNY; KORECZ-LAKY, Pl. I, fig. 12.
1974. *Sinuloculina consobrina* (D'ORBIGNY); LUCZKOWSKA, p. 123, Pl. XXV, figs. 5-7, text-fig 40.
1975. *Quinqueloculina consobrina* (D'ORBIGNY); VENGLINSKI, p. 157, Tabl. XV, fig. 2.
1985. *Sinuloculina consobrina* (D'ORBIGNY); PAPP et SCHMID, p. 95, Pl. 88, Fig. 5-10, text-plate 14, fig. 2.

Material. About 500 specimens.

Description. Test slender, flattened, tapering at the aperture; periphery rounded, three or five chambers visible from the exterior, chambers one-half coil in lenght, broader at the base, the last chamber often extended forming a short neck, middle chambers long, narrow and oblique, usually the fourth and fifth chambers poorly or not visible; sutures indistinct; wall thin; surface smooth, polished; aperture small, circular, bearing a short, bifid tóoth.

Dimensions. Length: 0.5-1,0 mm; breadth: 0.2-45 mm; thickness: 0.2-0.3 mm.

Variability. Variable features are the length of the extension of the last chamber, which occasionally dissappeares, producing a more or less quadrangular shape of the test. The periphery may be subacute.

Remarks. This is a very well-known and common species. It differs from *Sinuloculina nitens* (REUSS, 1950) in broader oval test and oblique position of the middle chamber.

Distribution. Austria: Nussdorf, Baden, Vienna Basin – Badenian and Sarmatian; Poland: Regions of Wadowice, Wieliczka, Chmielnik – Badenian and Lower Sarmatian; Ukraine: Transcarpathians – Lower Sarmatian, Krim – Miocene; North Caucase – Miocene; Hungary: Mecsek Mts. – Badenian and Lower Sarmatian, Zsámbék Basin – Sarmatian.

In Lower and Middle Sarmatian this species were cosmopolitan in Paratethys.

Pseudotriloculina inflata (D'ORBIGNY, 1826)
(Pl. VI, figs. 11-13)

1826. *Triloculina inflata* D'ORBIGNY; D'ORBIGNY, p. 300,in Catalogue Ellis et Messina.
1846. *Triloculina inflata* D'ORBIGNY; D'ORBIGNY, p. 278. Taf. 17, Fig. 13-15.
1970. *Tirloculina inflata inflata* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 57, Tabl. 34, fig. 4.
1974. *Sinuloculina inflata* D'ORBIGNY; LUCZKOWSKA, p. 126, Pl. XXIV. fig. 6.
1985. *Triloculina inflata* D'ORBIGNY; PAPP et SCHMID, p. 95, Pl. 89, Fig. 1-3.

Material. 28 specimens.

Description. Test broad, quadrangular-oval, oval in section; periphery rounded; three chambers visible from the outside; chambers broad, tubular, in the lower part strongly inflected, straightened toward the aperture; sutures slightly depressed; wall calcareous, relative thick; surface smooth, polished; aperture large, circular, with a robust, bifid tooth.

Dimensions. Length: 0.6-1.2 mm; breadth: 0.4-0.72 mm; thickness: 0.34-0.52 mm.

Variability. Sometimes only two chamber are visible from the exterior.

Remarks. Our specimens are similar to the original description and illustration of this species published by D'ORBIGNY in 1846, having a broad-oval shape of the test. In contrast to the specimens described and figured by LUCZKOWSKA (1974) they have slenderer shape, but the other features are the same.

Distribution. Austria: Nussdorf, Vöslau, Vienna, Basin – Badenian; Poland: Bogoria, Grabowiec, Niskowa, Rybnica, Weglinek, Wieliczka – Badenian and Lower Sarmatian; Ukraine: Volhyn-Podolian Platform, Predcarpathian Foredeep, Black Sea Depression – Upper Badenian; South Ukraine – Pliocene; Hungary: Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

In the Upper Badenian this species was cosmopolitian in Paratethys. Recently lives in Medierrenean Sea (LUCZKOWSKA, 1974).

Genus Triloculina D'ORBIGNY, 1826, emend. LUCZKOWSKA, 1972

Triloculina gibba D'ORBIGNY, 1846
(Pl. VII. figs. 1-2)

1826. *Triloculina gibba* D'ORBIGNY; D'ORBIGNY, p. 133, Nr. 3, fide Catalogue Ellis et Messina.

1846. *Triloculina gibba* D'ORBIGNY; D'ORBIGNY, p. 274, Taf. 16, Fig. 22-24.

1846. *Triloculina austriaca* D'ORBIGNY; D'ORBIGNY, p. 275, Taf. 16. Fig. 25-27.

1846. *Triloculina inornata* D'ORBIGNY; D'ORBIGNY, p. 279, Taf. 17, Fig. 16-18.

1958. *Miliolina austriaca* (D'ORBIGNY); VENGLINSKI, p. 65, Tabl. 13, fig. 1.

1964. *Triloculina austriaca* D'ORBIGNY; KORECZ-LAKY, p. 478, Taf. 1, Fig. 13.

1968. *Triloculina gibba* D'ORBIGNY; KORECZ-LAKY, p. 67.

1968. *Triloculina austriaca* D'ORBIGNY; KORECZ-LAKY, p. 67, Taf. I, Fig. 4.

1970. *Triloculina austriaca* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 54, Tabl. 32, Fig. 1.

1970. *Triloculina gibba gibba* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 56, Tabl. 33, Fig. 3.

1973. *Triloculina austriaca* D'ORBIGNY; KORECZ-LAKY, pl.1, fig. 8.

1974. *Triloculina gibba* D'ORBIGNY; LUCZKOWSKA, p. 134, pl. XXIII, Fig. 2a-c; Text-fig. 46/2.

1975. *Triloculina gibba* D'ORBIGNY; VENGLINSKI, p. 167, Tabl. 19, Fig. 3.

1985. *Trilocullina gibba* D'ORBIGNY; PAPP et SCHMID, p. 93, Pl. 86, Fig. 1-4, text-plate 14, fig. 1; p. 94, Pl. 86, Fig. 5-7; p. 95, Pl. 89, fig. 4-6.

Material. 18 specimens.

Description. Test broad-oval, tapering at both ends; subtriangular in section; periphery rounded; two or three chambers visible from the exterior; chambers broad, inflated, middle chamber inflated; sutures depressed; wall calcareous, thick; surface smooth; aperture circular, bearing a large bifid tooth.

Dimensions. Length: 0.4-0.8 mm; breadth: 0.34-76 mm; thickness: 0.3-0.5 mm.

Variability. The size of the middle chamber is variable, sometimes only two chambers are visible, as in T. bipartia. The chambers may be more or less inflated. Occasionally chambers have more or less rounded edges.

Remarks. Triloculina austriaca D'ORBIGNY, *T. inornata* D'ORBIGNY, and *T. bipartia* D'ORBIGNY differ from *T. gibba* D'ORBIGNY only in the features mentioned above. In our material the specimens with different morfology occured together, for which reasons we accept the opinion of PAPP et SCHMID (1985), that these species belong to *T. gibba* D'ORBIGNY.

Distribution: Austira: Nussdorf, Vöslau, Vienna Basin – Badenian; Poland: Benczyn, Bogoria, Bogucice, Grabowiec, Karsy, Rybnica, Weglinek – Badenian and Lower Sarmatian; Ukraine: Volhyn-Podolian Platform, Precarpathian Foredeep – Badenian; Black Sea Depression – Upper Badenian; Hungary: Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

This species was frequent in Lower and Middle Sarmatian (BRESTENSKA, 1974), recently lives in Adriatic Sea (LUCZKOWSKA, 1974).

Triloculina intermedia KARRER, 1868
(Pl. VII, figs. 3-4)

1868. *Triloculina intermedia* KARRER; KARRER, p. 138, Taf. 1, Fig. 1.
1958. *Miliolina intermedia* (KARRER); VENGLINSKI, Tabl. 77, Tabl. XIV, fig. 1.
1970. *Triloculina intermedia* KARRER; DIDKOWSKI et SATANOVSKAJA, p. 58, Tabl. 35, fig. 3.
1974. *Triloculina intermedia* KARRER; LUCZKOWSKA, p. 136, Pl. 23, fig. 1, text-fig. 46/4.

Material. 7 specimens.

Description. Test irregularly circular, triangular in cross-section; periphery angular, keeled; three chambers visible from the outside; two last chambers large, inflated, tapering at both ends, trapezoid in cross-section, bear two strong ridges placed wide apart on the periphery; third chamber small, convex, with one ridge; sutures depressed, distinct; wall thick; surface smooth; aperture circular or subtriangular, bordered by everted, rim, with a sort, bifid tooth.

Dimensions. Length: 0.5-0.9 mm; breadth: 0.4-0.7 mm; thickness: 0.5-0.8 mm.

Variability. The edges of the chambers may be more or less sharp and occasionally waved.

Remarks. Our specimens are very similar to the illustration of KARRER, having distinct ridges.

Distribution. Romania: Kostej in Banat, Buitur – Badenian; Ukraine: Volhyn-Podolian Platform, Precarpathian Foredeep – Middle Miocene, Transcarpathians – Upper Badenian and Lower Sarmatian; Poland: Karsy, Korytnica, Niskowa – Lower Badenian; Hungary. Zsámbék Basin – Sarmatian.

Recently lives in Mediterranean Sea (LUCZKOWSKA, 1974).

Genus Varidentella LUCZKOWSKA, 1972

Varidentella latelacunata (VENGLINSKI, 1953)
(Pl. VII. figs. 5-6)

1958. *Miliollina latelacunata* VENGLINSKI; VENGLINSKI, p. 79, Tabl. 14, fig. 3.
1960. *Miliolina latelacunata* VENGLINSKI; STANCHEVA, p. 12, Tabl. I, fig. 2.
1970. *Miliolina latelacunata* VENGLINSKI; DIDKOWSKI et SATANOVSKAJA, p. 26, Tabl. 14, fig. 1.
1974. *Varidentella latelaculata* VENGLINSKI; LUCZKOWSKA, p. 140, Pl. 27, figs. 7, 8.

Material. About 400 specimens.

Description. Test oval, slender; periphery rounded; four or five chambers visible from the outside; chambers one-half coil in length, tubular, narrow, in the lower part somewhat inflected; elevated middle chambers long, convex; sutures strongly depressed, distinct; wall calcareous, imperforate; surface dull; aperture rounded to oval, bordered by erverted rim, bearing low, broad tooth slightly bifid at the end.

Dimensions. Length: 0.4-0.65 mm; breadth: 0.24-0.37 mm; thickness: 0.14-0.2 mm.

Variability. The shape of the test may be oval or narrowly oval. The shape of the aperture ranges from rounded to oval. The tooth is variable, usually broad, but may be narrow.

Remarks. The most distinctive features of this species are the long and tubular chambers, the strongly depressed sutures and the variable shape of the aperture.

Distribution. Ukraine: Transcarpathians – Lower Sarmatian; Poland: Budy, Grzybów, Mielec, Rytwiany, Zrecze – Lower Sarmatian; Bulgaria: Vladimirovo, Staroselci, Staverni, Orjahovina, Dimovo (Nortwestern Bulgaria) – Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium hauerinum* and *Spirolina austriaca* zone.

Varidentella pseudocostata (VENGLINSKI, 1958)
(Pl. VII, figs. 7-9)

1958. *Miliolina pseudocostata* VENGLINSKI; VENGLINSKI, p. 70, Tabl. 10, fig. 1-3, Tabl. 11, fig. 1-3.
1962. *Quinqueloculina pseudocostata* (VENGLINSKI); VENGLINSKI, p. 74, Tabl. 4, fig. 3, 4.
1970. *Quinqueloculina pseudocostata* (VENGLINSKI); DIDKOWSKI et SATANOVSKAJA, p. 31, Tabl. 17, fig. 5.
1973. *Quinqueloculina pseudocostata* (VENGLINSKI); KORECZ-LAKY, Pl. II, fig. 5.
1974. *Varidentella pseudocostata* (VENGLINSKI); LUCZKOWSKA, p. 140, Pl. 26. Fig. 7.
1975 *Quinqueloculilna pseudocostata* (VENGLINSKI); VENGLINSKI, p. 159, Tabl. 13, fig. 3.

Material. 36 specimens.

Description. Test broad-oval to circular in outline; oval or triangular in section; periphery broadly-rounded; three to five chambers visible from the exterior, fifth chamber usually poorly visible; chamber broad, in the lower part inflected, slightly narrower towards the aperture, middle chamber large, convex; sutures distinct, depressed; wall porcelaneous, massive; surface covered with fine, longitudinal grooves, which stronger on the outer part of the chamber, usually disappearing near the aperture; aperture large, oval, with low, broad, quadrate, bifurcated tooth.

Dimensions. Length: 0.3-0.68 mm; breadth: 0.3-0.56 mm; thickness: 0.2-0.34 mm.

Variability. The ornamentation may be more or less strong.

Remarks. Our specimens are very close to the original description of VENGLINSKI, 1958. They differ from specimens figured by LUCZKOWSKA in their more weak and thicker grooves. The different characters from *Cycloforina toreuma* (SEROVA) and from *C. vermicularis* (KARRER) are given at the desription of *C. toreuma.* The specimens described by VENGLINSKI, 1975 probably belong to *Varidentella georgiana* LUCZKOWSKA, 1974. *V. pseudocostata* differs from this species in its larger test, large oval aperture and bifid quadrangular tooth.

Distribution. Poland: Budy, Grzybów, Rytwiany, Zrecze – Lower Sarmatian; Ukraine: Transcarpathians – Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone.

Varidentella reussi (BOGDANOWICH, 1947)
(Pl. VII, figs. 10-11)

1958. *Miliolina reussi* BOGDANOWICH; VENGLINSKI, p. 83, Tabl. 14, fig. 1, 3.
1960. *Miliolina reussi* BOGDANOWICH; STANCHEVA, p. 10, Tabl. I, fig. 4.
1962. *Quinqueloculina reussi* (BOGDANOWICH); VENGLINSKI, p. 74, Tabl. IV, fig. 1.
1964. *Quinqueloculina reussi* (BOGDANOWICH); KORECZ-LAKY, p. 478, Taf. III, Fig. 2.
1970. *Quinqueloculina reussi reussi* (BOGDANOWICH); DIDKOWSKI et SATANOVSKAJA, p. 31, Tabl. 18, fig. 3.
1973. *Quinqueloculina reussi* (BOGDANOWICH); KORECZ-LAKY, Pl. II, fig. 4.

1974. *Varidentella reussi* (BOGDANOWICH); LUCZKOWSKA, p. 141, part I, Pl. 8, figs. 1-3, part 2, text-fig. 48-49.
1974. *Quinqueloculina reussi* (BOGDANOWICH); BRESTENSKÁ, p. 250, Taf, 1, Fig. 5.
1975. *Quinqueloculina reussi* (BOGDANOWICH); VENGLINSKI, p. 161, Tabl. 8. fig. 10.

Material. About 80 specimens.

Description. Test nearly circular to broad-oval, subtriangular in cross-section; periphery rounded; four to five chamber visible from the outside; chambers broad, compressing towards the aperture; the last chamber usually extended and inclined towards the penultimate one; elevated middle chambers slightly oblique; sutures distinct; wall porcelanous and thin; surface dull, smooth or often covered with irregular, longitudinal wrinkles; aperture low semicircular to slit-like, bordered with an everted rim, equipped with low, broad quadrangular or tape-shape tooth.

Dimensions. Length: 0.28-0.41 mm; breadth: 0.24-36 mm; thickness: 0.18-0.25 mm.

Variability. The shape of the test, the aperture and the tooth is variable. A clear review of the variability and ontogeny is presented by LUCZKOWSKA, 1974.

Remarks. The specimens from Zsámbék Basin are identical in detail with the desription and illsutration of LUCZKOWSKA, 1974.

Distribution. Ukraine: Precaucasus, Moldavia – Lower Sarmatian, Transcarpathians – Lower and Middle Sarmatian; North-Western Bulgaria: Vladimirovo, Pakevo, Pelovo, Krivodol – Sarmatian; Westslowakia – Sarmatian; Poland: Machów, Miechocin, Mokrzyszów, Piaseczno, Rytwiany – Lower Sarmatian; Hungary: Tokaj Mts. – Lower Sarmatian, Zsámbék Basin – Sarmatian, *Elphidium hauerinum* zone and the lower part of the *Spirolina austriaca* zone.

Varidentella rotunda (GERKE, 1938)
(Pl. VIII, figs. 1-2)

1958. *Miliolina akneriana var. rotunda* GERKE; VENGLINSKI, p. 79, Tabl. 14, fig. 4.
1970. *Quinqueloculina akneriana rotunda* GERKE; DIDKOWSKI et SATANOVSKAJA, p. 17, Tabl. 7, fig. 4.
1974. *Quinqueloculina akneriana rotunda* GERKE; BRESTENSKÁ, p. 248, Taf. 1, Fig. 6.
1974. *Varidentella rotunda* (GERKE); LUCZKOWSKA, p. 145, Pl. 27, figs. 5, 6, text-fig. 51.

Material. About 100 specimens.

Description. Test rounded, subtriangular in cross-section; periphery rounded; four to five chambers visible from the outside; the fifth chamber poorly or not visible; chambers broad, somewhat tapering toward the aperture; the last chamber usually extended and inclined towards the penultimate one; prominent middle chambers slightly oblique; sutures slightly depressed; wall thin; surface smooth and shiny; aperture large semicircular, usually bordared with a thickened rim, bearing a short bifid tooth.

Dimensions. Length: 0.4-0.7 mm; breadth: 0.2-0.6 mm; thickness: 0.25-0.4 mm.

Variability. The last chamber more or less extends and inclines toward the penultimate one. The aperture is surrounded with a strongly or weakly thickened rim. Ontogeny is discussed in detail by LUCZKOWSKA, 1974.

Remarks. This species somewhat close to *Varidentella pseudocostata* (VENGLINSKI, 1958), from wich it differs in ist smooth surface.

Distribution. Ukraine: Transcarpathinas – Upper Badenian – Lower Sarmatian; Russain Platform – Lower Sarmatian; Poland: Budy, Miechocin, Mokrzyszów, Grzybów, Rytwiany, Mielic, Zrecze – Upper Badenian and Lower Sarmatian; Westslovakia – Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Subfamily Tubinellinae RHUMBLER, 1906
Genus Articularia LUCZKOWSKA, 1972

Articularia articulinoides (GERKE et ISSAEVA, 1952)
(Pl. VIII, fig. 3)

? 1958. *Articulina cf. articulinoides* (GERKE et ISSAEVA); VENGLINSKI, p. 96, Tabl. XIX, fig. 2.
1960. *Articulina ? articulinoides* (GERKE et ISSAEVA); STANCHEVA, p. 13, Tabl. 2, fig. 5.
1970. *Articulina ? articulinoides* (GERKE et ISSAEVA); DIDKOWSKI et SATANOVSKAJA, p. 38, Tabl, 22, fig. 4.
? 1974. *Articulina articulinoides* (GERKE et ISSAEVA); BRESTENSKÁ, p. 253, Taf. 2, Fig. 46.
1974. *Articularia articulinoides* (GERKE et ISSAEVA); LUCZKOWSKA, p. 68, Pl. XVII. fig. 1, 2.

Material. 9 incomplete specimens (1 initial part).

Description. Initial part oval, flattened; periphery rounded; five chambers visible from the outside, one-half coil in length and in quinqueloculine or cryptoquinqueloculine arrangement; chambers tubular, strongly inflected in the lower part; middle chambers elongated; sutures tape-shaped, distinct, slightly depressed; wall relatively thick; surface smooth and dull; aperture semicircular, with low, broad tooth.

Later part uniserial; of one to three elongate, pipe-like chambers, broadering at the base and tapering towards the end; sutures depressed; surface smooth and dull; aperture rounded, bordered with a thickened lip, without a tooth.

Dimensions. Inital part: length: 0.34 mm; breadth: 0.22 mm; thickness: 0.09 mm. Uniserial part: length: 0.4-0,75 mm; maximum diameter: 0.08-1,3 mm.

Variability. The shape of the initial part is unvaried. Often the uncoiled part grows obliquely to the coiling axis. The uniserial chambers have usually a more or less irregular shape, bearing constrictions.

Remarks. The initial part of this species is very resembles *Varidentella reussi* (BOGDANOWICH), according LUCZKOWSKA (1974) *Articularia articulinoides* may have arisen from *Varientella reussi.*

VENGLINSKI (1958) and BRESTENSKÁ (1974) desribed only the uniserial part and the illustrated chambers have a regular shape.

Distribution. Russia: North Caucasus, Azerbaidjan, Moldavia and Ukraine: Volhyn- Podolian Platform – Lower Sarmatian; Poland: Gryzybów, Miechocin, Mokrzyszów, Rytwiany – Lower Sarmatian; Bulgaria: Vladimirovo in Moldavian Platform (Northwestern Bulgaria) – Lower Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

Genus Articulina D'ORBIGNY, 1826

Articulina af. nitida D'ORBIGNY, 1826

(Pl. VIII, fig. 5)

1826. *Articulina nitida* D'ORBIGNY; D'ORBIGNY, p. 300. fide Catalogue Ellis et Messina.
1970. *Articulina nitida nitida* D'ORBIGNY; DIDKOWSKI at SATANOVSKAJA, p. 40, Tabl. 23, fig. 2.
1973. *Articulina nitida* D'ORBIGNY; KORECZ-LAKY, Pl. II, fig. 3.

Material. 4 chambers of the uniserial part.

Description. Test elogate, consists of a few onion-like chambers; chambers inflated at the base and narrowing toward the aperture; length: diameter rate is 1:1.5; wall relatively thick; surface covered with distinct, longitudinal costae; aperture circular, bordered with a thickened rim, without a tooth.

Dimensions. Length: 0.2-0.25 mm; maximum diameter:0.15-0.19 mm.

Remarks. The ornamentation of this species is very similar to *Articulina gibbosula* D'ORBIGNY, 1846, the latter species differs in its oval aperture, and more thickened rim. The shape of the chambers is close to *Articulina sarmatica* (KARRER, 1877), but differs in its distinct and thicker ornamentation.

Distribution. Ukraine – Upper Badenian; Hungary: Tokaj Mts. – Lower Sarmatian, Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Articulina problema BOGDANOWICH, 1952

(Pl. VIII, fig. 4)

1958. *Articulina problema* BOGDANOWICH; WENGLINSKI, p. 93, Tabl, XIX, fig. 1-10.

1960. *Articulina problema* BOGDANOWICH; STANCHEVA, p.13, Tabl. II, fig. 6.
1964. *Articulina problema* BOGDANOWICH; KORECZ-LAKY, Taf, II. fig. 5.
1970. *Articulina problema* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 41, Tabl. 23, fig. 5-7.
1973. *Articulina problema* BOGDANOWICH; KORECZ-LAKY, Pl. V, fig. 1.
1974. *Articulina problema* BOGDANOWICH; BRESTENSKÁ, p.253. Taf. 3. Fig. 1-2.
1974. *Articulina problema* BOGDANOWICH; LUCZKOWSKA, p. 71. Pl. XVII. figs. 7-10.
1975. *Articulina problema* BOGDANOWICH; VENGLINSKI, p. 164, Tabl. XV, fig. 10.

Material. About 100 specimens.

Description . Initial part relatively small, broad to elongated oval, usually quadrangular at the base and slightly tapering towards the end, flattened; periphery rounded or subrounded; three to five chambers visible from the outside; chambers one-half coil in length, in the early part planispiral, than in triloculine or quinqueloculine arrangement; chambers tubular, basically somewhat widened and strongly inflected; middle chambers nearly circular to elongated oval, sometimes slightly depressed; sutures slightly depressed; aperture more or less rounded, with a low, simple tooth.

Uniserial part long, number of the chambers up to six; chambers elongated, cone shaped, slightly inflated at the base and narrowed towards the end, and slightly increasing in size; length: diameter rate is 1:2-3; sutures strongly depressed; aperture circular, bordered with a more or less thickened lip, without a tooth.

Wall of test relatively thick; surface smooth and dull, in adult specimens covered with fine, longitudinal grooves.

Dimensions. Initial part: length: 0.15-0.31 mm; breadth: 0.11-0.16 mm; thickness: 0.08-0.1. Chamber of uniserial part: length: 0.3-0.4 mm; maximum diameter: 0.1-0.15 mm.

Variability. The shape of the initial part is variable.

Remarks. This species differs from *Articulina sarmatica* (KARRER) in its slender shape of the uncoiled chambers.

Distribution. Ukraine: Crime, Volhyn-Podolian Platform, Transcarpathians – Sarmatian; North Caucasus, Georgia, Moldavia – Lower and

Middle Sarmatian; Poland: Dwikozy,Cryzybów, Miechocin, Mokrzyszów, Rytwiany, Zrecze – Lower Sarmatian; Bulgaria: Pelovo, Dimovo, Kosava and Dlgodelci in Northwestern Bulgaria – Lower and Middle Sarmatian; Czecho-Slovakia – Sarmatian; Hungary: Tokaj Mts. – Upper part of Lower Sarmatian, Zsámbék Basin – Sarmatian, from the *Elphidium reginum* zone to the lower part of the *Spirolina austriaca* zone.

Most common in the upper part of the Lower Sarmatian.

Superfamily Alveolinacea EHRENBERG, 1839
Family Soritidae EHRENBERG, 1839
Subfamily Peneroplinae SCHULTZ, 1854
Genus Spirolina LAMARCK, 1804

Spirolina austriaca D'ORBIGNY, 1846
(Pl. VIII, fig. 6-9)

1846. *Dendritina elegans* D'ORBIGNY; D'ORBIGNY, p. 135, Taf. 7, Fig. 5, 6.
1846. *Spirolina austriaca* D'ORBIGNY; D'ORBIGNY, p. 137, Taf. 7, Fig. 7-9.
1968. *Spirolina austriaca* D'ORBIGNY; KORECZ-LAKY, p. 95, Taf. VI, Fig. 5.
1970. *Spirolina austriaca* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 65, Tabl. 40, fig. 4.
1970. *Spirolina austriaca konkia* DIDKOWSKI; DIDKOWSKI, et SATANOVSKAJA, p. 65, Tabl. 40. fig. 2.
1970. *Spirolina elegans* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 66, Tabl. 41, fig. 5.
1975. *Spirolina austriaca* D'ORBIGNY; VENGLINSKI, p. 169, Tabl. 20. fig. 1.
1985. *Spirolina austriaca* D'ORBIGNY; PAPP et SCHMID, p. 54, Pl. 44, figs. 7-9, Pl. 45, figs. 1-5.

Material. Over 500 specimens.

Description. Test large, robust; juvenile part planispirally coiled, seven to eighteen chambers, flattened; adult part free, zero to seven barrel-like chambers, in uniserial arrengement; periphery rounded; sutures distinct, in the juvenile portion ribbon-like, in the uniseral part deeply depressed; umbilicus distinct, depressed; wall calcereous, porcelaneous; surface in the juvenile stage polished, in adult stage more or less dull; ornamented with longitudinal striation at right angle to sutures, stronger on the uniserial part; aperture of juvenile specimens is elongate, lobately notched; aperture of adults rounded, lobately notched.

Dimensions. Coilled part: diameter: 0.4-0.7 mm; thickness: 0.23-0.35. Uniserail part: length up to 1 mm; diamter: 0.15-0.3 mm.

Variability. The number of the chambers is variable. The section of the uniserial part may be more or less circular. The intensity of the ornamentation on the juvenile portion ranges from strong and distinct to weak and poorly visible.

Remarks. The morfologically and ornamentically different specimens occured together. We agree with PAPP et SCHMID that *Dendritina elegans* D'ORBIGNY, 1846 corresponds to *Spirolina austriaca* D'ORBIGNY, 1846. *Dentritina* genus differs from *Spriolina* genus in its striation aligned with the direction of the coiling.

Distribution. Austira: Nussdorf, Baden, Vienna Basin – Badenian; Russia: Moldavia – Upper Badenian; Ukraine: Transcarpatians – Middle Sarmatian; Ukraine: Volhyn-Podolian Platform, Balck Sea Depression – Upper Badenian; Hungary: Mecsek Mts. – Upper Badenian, Zsámbék Basin – Sarmatian, *Spirolina austriaca* zone.

Spirolina and *Peneroplis* genus are frequent in the Middle Sarmatian in Eastern Paratethys.

Superfamily Nodosariacea EHRENBERG, 1838
Family Polymorphinidae D'ORBIGNY, 1839
Subfamily Polymorphininae D'ORBIGNY, 1839
Genus Guttulina D'ORBIGNY, 1839

Guttulina communis D'ORBIGNY, 1846
(Pl. VIII, fig. 10)

1846. *Guttulina problema* D'ORBIGNY; D'ORBIGNY, p. 224, Taf. 12, Fig. 26-28.
1846. *Guttulina communis* D'ORBIGNY; D'ORBIGNY, p. 224, Taf. 13, Fig. 6-8.
1846. *Guttulina irregularis* D'ORBIGNY; D'ORBIGNY, p. 226, Taf. 13, Fig. 9-10.
1951. *Guttulina irregularis* D'ORBIGNY; Marks, p. 47.
1962. *Guttulina problema* D'ORBIGNY; VENGLINSKI, p. XI, fig. 3.
1962. *Guttulina communis* D'ORBIGNY; VENGLINSKI, p. XI, fig.4.
1968. *Guttulina communis* D'ORBIGNY; KORECZ-LAKY, p. 85.

1968. *Guttulina problema* D'ORBIGNY; KORECZ-LAKY, p. 85, Taf. IV, Fig. 17.
1973. *Guttulina problema* D'ORBIGNY; KORECZ-LAKY, Pl. VII. fig. 13.
1985. *Guttulina communis* D'ORBIGNY; PAPP et SCHMID, p. 78-79, Pl. 70, figs. 2-12, Pl. 71, figs. 1-4.

Material. 4 specimens.

Description. Test broad-oval, tapering at the aperture, subtriangular in cross-section; periphery broadly rounded; three chambers visible from the outside; chambers inflated, more or less elongeted; sutures distinct, depressed; wall fine perforated; surface smooth; aperture small, radial, placed at the narrowed end of the final chamber.

Dimensions. Length of chamber: 0.4-0.9 mm.

Variability. The shape of the chambers may be more or less inflated and elongated. Sutures vary from depressed to flat.

Remarks. We agree with the conclusion of MARKS (1951) and PAPP et SCHMID (1985), that *Guttulina irregularis* and *G. problema* are synonymus with *G. communis.* In spite of the fact that *G. communis* was described before, MARKS named these forms as *G. irregularis.*

Distribution. Oligocene to Recent. Especially abundant in the shallow-water and sand facies during the Badenian (PAPP et SCHMID, 1985). Austria: Baden, Nussdorf, Vienna Basin – Badenian, Ukraine: Transcarpathians – Badenian; Hungary: Mecsek Mts. – Badenian, Tokaj Mts. – Middle Badenian, Zsámbék Basin – Sarmatian, upper part of the *Elphidium hauerinum* zone. Very rarely.

Family Glandulinidae REUSS, 1860
Suibfamily Oolininae LOEBLICH et TAPPAN, 1961
Genus Oolina D'ORBIGNY, 1839

Oolina mironovi (BOGDANOWICH, 1947)
(Pl. VIII, figs. 11-12)

1947. *Entosolenia mironovi* BOGDANOWICH; BOGDANOWICH, p. 28, Tabl. 3, fig. 6, fide Catalogue Ellis et Messina.

1970. *Entosolenia mironovi* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 133, Tabl. 78, fig. 7.

Material. 4 specimens.

Description. Test consists of only one chamber, small, egg-shaped, slightly flattened; periphery rounded; wall calcareous, gently perforate, thin; surface smooth, shiny, with a longitudinal, broad rib, at the lower part somewhat bent, connected to a wide rim around the aperture narrow slit, placed at the to of the test.

Dimensions. Length: 0.24-0.3 mm.

Remarks. This species differs from the other *Entosolenia* species in its characteristic longitudinal ornamentation and broad apertural rim. VENGLINSKI (1958) described *E. isa* VENGLINSKI, 1958 and *E. marginata* (WALTER et BOYS, 1784) from Transcarpathians, from Lower Sarmatian.

Distribution. Ukraine: Crime – Middle Badenian; Russia: North Caucasus – Middle Badenian; Hungary: Zsámbék Basin – Sarmatian *Elphidium hauerinum* zone. Very rarely.

Subordo Rotaliina DELAGE and HÈROUARD, 1896

Superfamily Bolivinacea GLAESSNER, 1937

Family Bolivinidae GLAESSNER, 1937

Genus Bolivina D'ORBIGNY, 1839

Bolivina antiqua D'ORBIGNY, 1846
(Pl. IX, fig. 1)

1846. *Bolivina antiqua* D'ORBIGNY; D'ORBIGNY, p. 240, Taf. 14, Fig. 11-13.

1961. *Bolivina antiqua* D'ORBIGNY; CICHA et ZAPLETALOVÁ, p. 160, Abb. 33.

1968. *Bolivina antiqua* D'ORBIGNY; KORECZ-LAKY, p. 101.

1970. *Bolivina antiqua* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 142, Tabl. 82, fig. 2.

1975. *Bolivina antiqua* D'ORBIGNY; VENGLINSKI, p. 199, Tabl. XXXIV, fig. 6.

1985. *Bolivina antiqua* D'ORBIGNY; PAPP et SCHMID, p. 83, Pl. 77, Figs. 1-6.

Material. About 30 specimens.

Description. Test elongated flattened; periphery subacute; biserial throughout; the number of chambers up to twenty six; proloculus large; chambers low, broad, gradually increasing in size; length: breadth rate is 4:1; sutures slightly depressed and straight; there is an angle of 40° between the sutures and the logitudinal axe of the test; wall hyaline; surface finely perforate on the inner part of the chambers and imperforate at the sutures; pustules appeare on the inner part of the latest chambers; aperture a loop at the apertural face.

Dimensions. Length: 0.2-0.7 mm; breadth: 0.1-0.18 mm.

Remarks. Our specimens differ from the specimens of CICHA et ZAPLETALOVÁ (1961) and PAPP et SCHMID (1985) in the more distinct pustules.

Distribution. Neogene, widely distributed. Austria: Baden – Badenian; Ukraine: Volhyn-Podolian Platform, Transcarpathians – Upper Badenian and Lower Sarmatian; West-Carpathians – Aquitanian to Middle Badenian; Hungary: Mecsek Mts. – Badenien, Zsámbék Basin – Sarmatian, upper part of the *Elphidium hauerinum* zone.

Bolivina moldavica DIDKOWSKI, 1959
(Pl. IX, fig. 2)

1961. *Bolvina moldavica granensis* CICHA et ZAPLETALOVÁ; CICHA et ZAPLETALOVÁ, p. 156, Abb. 29.
1970. *Bolivina modavica* DIDKOWSKI; DIDKOWSKI et SATANOVSKAJA, p. 143, Tabl. 82, fig. 7.
1974. *Bolivina moldavica granensis* CICHA et ZAPLETALOVÁ; BRESTENSKÁ, p. 256, Taf. 3, Fig. 6.

Material. Over 1000 specimens.

Description. Test elongated, compressed; periphery subrounded; biserial throughout; the number of chambers fourteen to twenty; proloculus relative large; gradually enlarging chambers are low and broad; length: breadth rate is 1.5-2:1; sutures distinct, slightly depressed and somewhat curved towards the initial part of the test, sometimes bearing one or two lobes; there is an angle of 60-65° between the sutures and the logitudinal axe of the test; wall hyaline, finely perforate; surface ornamented with imperforate, irregularly anastomosing costae; aperture a slit, broadering at the suture on the apertural face.

Dimensions. Length: 0.2-0.5 mm; breadth: 0.1-0.25 mm.

Variability. The shape of the test may be more or less broad at the apertural end. The intensity of the ornamentation is variable. The appearence of one or two lobes is occassional. The longitudinal plane of the test is often turned.

Remarks. Bolivina moldavica granensis CICHA et ZAPLETALOVÁ differs from *Bolivina moldavica* DIDKOWSKI only in the variable characters.

Distribution. Ukraine: Volhyn-Podolian Platform – Middle Sarmatian; Russia: Moldavia – Middle Sarmatian; West-Carpathians – Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Bolivina moravica CICHA et ZAPLETALOVÁ, 1961
(Pl. IX, fig. 3)

1961. *Bolivina moravica* CICHA et ZAPLETALOVÁ; CICHA et ZAPLETALOVÁ, p. 155, Abb. 28.
1975. *Bolivina moravica* CICHA et ZAPLETALOVÁ; VENGLINSKI, p. 203, Tabl. XXXIV, fig. 9.

Material. About 50 specimens.

Description. Test slender, flattened; periphery subacute; biserial throughout; the number of chambers fourteen to eighteen; proloculus relative large; the first eight or twelve chambers are small, low and strongly increasing in size; length: breadth rate is 2,5-3:1; later chambers low, broad and nearly uniform in width; sutures distinct, strongly deepen and somewhat curved towards the initial part of the test; there is an angle of 45-50° between the sutures and the logitudinal axe of the test; wall hyaline, finely perforate; surface ornamented with imperforate, irregularly anastomosing costae; aperture a slit, broadering at the suture on the apertural face.

Dimensions. Length: 0.2-0.36 mm; breadth: 0.09-0.12 mm; thickness: 0.05-0.07 mm.

Variability. The longitudinal plane of the test is often turned. Sometimes the latest chambers are slightly inflated; irregular in shape and usually they are not in the plane of the test. The intensity of the ornamentation is variable.

Remarks. This species differs from *Bolivina moldavica granensis* CICHA et ZAPLETALOVÁ in its narrower test, strongly depressed sutures and lack of the lobes.

Distribution. West-Carpathians – Sarmatian; Austria: Jakubov in Vienna Basin – Sarmatian; Ukraine: Transcarpathians – Middle Badenian; Hungary: Zsámbék Basin – Sarmatian; *Elphidium reginum* and *Elhidium hauerinum* zone.

Bolivina sagittula DIDKOWSKI, 1959
(Pl. IX, fig. 4)

1961. *Bolivina sagittula* DIDKOWSKI; CICHA et ZAPLETALOVÁ, p. 153, Abb. 26.
1970. *Bolivina sagittula* DIDKOWSKI; DIDKOWSKI et SATANOVSKAJA, p. 144, Tabl. 82, fig. 12.

Material. 6 specimens.

Description. Test long, narrow elongated, compressed; periphery rounded; biserial throughout; the number of chambers up to thirty two; proloculus small; the first ten or twelve chambers are small, low and strongly increasing in size; later chambers low, broad and nearly uniform in width; sutures distinct, slightly depressed and straight; there is an angle of 60° between the sutures and the logitudinal axe of the test; wall hyaline, finely perforate; surface smooth; aperture a narrow loop at the apertural face bordered by a thickened and imperforate rim on one margin.

Dimensions. Length: 0.3-0.4 mm; breadth: 0.08-0.1 mm.

Remarks. The longitudinal plane of the test is often turned.

Distribution. West-Carpathians – Sarmatian; Russia: Moldavia – Middle Sarmatian; Ukraine: Volhyn-Podolian Platform, Transcarpathians – Middle Sarmatian; Hungary: Zsámbék Basin – Sarmatian, lower most part of the, *Spirolina austriaca* zone.

MAGYAR
TUDOMÁNYOS AKADÉMIA
KÖNYVTÁRA

Bolivina sarmatica DIDKOWSKI, 1959
(Pl. IX, fig. 5)

1961. *Bolivina aff. sarmatika* DIDKOWSKI; CICHA et ZAPLETALOVÁ, p. 152, Abb. 25.
1970. *Bolivina sarmatica* DIDKOWSKI; DIDKOWSKI et SATANOVSKAJA, p. 144, Tabl. 82, fig. 9.
1975. *Bolivina sarmatica* DIDKOWSKI; VENGLINSKI, p. 201, Tabl. XV, fig. 1-4.

Material. Over 100 specimens.

Description. Test small, elongated, flattened; periphery subrounded; biserial throughout; the number of chambers twenty-twenty two; proloculus small; in early stage the chambers are small, low and strongly increasing in size; later chambers low, broad and nearly uniform in width; the last two chambers large, about double size than the previous, nearly spherical in shape; sutures distinct, slightly depressed and somewhat curved towards the apertural end of the test; there is an angle of 60-80° between the sutures and the longitudinal axe of the test; wall hyaline, finely perforate; surface covared with small, imperforate costae expect the last two chambers, which ornamented with short and deep, wavy wrinkles; aperture a broad and low loop at the apertural face.

Dimensions. Length: 0.2-0.34 mm; breadth: 0.09-0.13 mm.

Variability. The angel between the suture and the axe of the test varies from acute angle (60°) to nearly perpendicular.

Distribution. West-Carpathians – Sarmatian; Russia: Moldavia – Middle Sarmatian; Ukraine: Transcarpathians, Precarpathians, Volhyn-Podolian Platform – Middle Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Superfamily Cassidulinacea D'ORBIGNY, 1839
Family Cassidulinidae D'ORBIGNY, 1839
Subfamily Cassidulininae D'ORBIGNY, 1839
Genus Cassidulina D'ORBIGNY, 1826

Cassidulina margareta KARRER, 1877
(Pl. IX, fig. 6-7)

1877. *Cassidulina Margareta* KARRER; KARRER, p. 386, Taf. XVI, Fig. 52.

1958. *Cassidulina margareta* KARRER; VENGLINSKI, p. 155, Tabl. XXXIV, fig. 3.
1962. *Cassidulina margareta* KARRER; VENGLINSKI, p. 155, Tabl. XVIII, fig. 1.
1970. *Cassidulina margareta* KARRER; DIDKOWSKI et SATANOVSKAJA, p. 1 41, Tabl. 81, fig. 4.

Material. About 50 specimens.

Description. Test nearly circular, flattened, small; periphery subrounded or subacute; chambers biserially arranged and plane of the biseriality planispirally enrolled, for this reason four large diagonally arranged chambers and at their contacts four small chambers are visible on both side of the test; chambers inflated; sutures depressed, distinct; wall thin, perforate; surface smooth, polished; aperture elongate, slit-like, deepen, placed near and parallel to the peripheral margin.

Dimensions. Length: 0.16-0.21 mm; breadth: 0.14-0.2 mm; thickness: 0.04-0.08 mm.

Variability. The chambers may be more or less inflated.

Remarks. This species is easily distinguished from the other *Cassidulina* species by the less number of chambers and lacking of umbonal boss.

Distribution. Austria: Baden, Vöslau – Miocene; Ukraine: Transcarpathians – Badenian, Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Superfamily Buliminacea JONES, 1875
Family Buliminiadae JONES, 1875
Genus Bulimina D'ORBIGNY, 1826

Bulimina elongata (D'ORBIGNY, 1826)
(Pl. IX, fig. 8)

1846. *Bulimina elongata* D'ORBIGNY; D'ORBIGNY, p. 187, Taf. 11, Fig. 19, 20.
1951. *Bulimina elongata* D'ORBIGNY; MARKS, p. 57, pl. 7, fig.12.
1958. *Bulimina elongata* D'ORBIGNY; VENGLINSKI, p. 132, Tabl. XXIX, fig. 1, 2. Tabl. XXVIII, fig. 3-6.

1968. *Bulimina elongata* D'ORBIGNY; KORECZ-LAKY, p. 89, Taf. V, Fig. 3.
1970. *Bulimina elongata elongata* D'ORBIGNY; DIDKOWSKI et SATANOVSKAJA, p. 129, Tabl, 77, fig. 2.
1973. *Bulimina elongata* D'ORBIGNY; KORECZ-LAKY, Pl. VII, fig. 6.
1985. *Bulimina elongata* D'ORBIGNY; PAPP et SCHMID, p. 73, Pl. 63, figs. 5-9.
1991. *Bulimina elongata* D'ORBIGNY; CIMERMAN and LANGER, p. 62, pl. 64, figs. 3-8.

Material. 18 specimens.

Description. Test elongated, triserial; chambers, inflated, size increase gradually; sutures depressed, distinct, curved and oblique; there is an angle of 30-45^{o} between the sutures and the logitudinal axe of the test; wall calcareous, semi-transparent and finely perforate; surface smooth; aperture a long loop at the apertural face of the last chamber, boardering with a narrow and raised rim and provided with a toothplate.

Dimensions. Length: 0.3-0.55 mm; breadth: 0.15-0.2 mm.

Variability. Often the later chambers are in uniserail arrengement.

Remarks. The longitudinal axe of the test is often curved. Sometimes spines and nodes appeare on the oldest chambers of the test.

Distribution. Oligocene – Recent. Recently lives between 70 - 2500 m (DIDKOWSKI et SATANOVSKAJA, 1970). Austria: Vienna Basin – Carpathian, Badenian; Ukraine: Transcarpathians – Upper Badenian, Lower and Middle Sarmatian; Hungary: Mecsek Mts., Tokaj Mts. – Badenian, Zsámbék Basin – Sarmatian.

Family Buliminaellidae HOFKER, 1951
Genus Buliminella CUSHMAN, 1911

Buliminella elegantissima (D'ORBIGNY, 1839)
(Pl. XI, figs. 9-10)

1839. *Bulimina elegantissima* D'ORBIGNY; D'ORBIGNY, p. 51, Taf. 5.
1970. *Buliminella elegantissima* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 127, Tabl. 76, fig. 2.

Material. 36 specimens.

Description. Test elongated, small; only two whorls in a high trochospiral coil; numerous chambers low and very broad; intercameral sutures slightly depressed, distinct, slightly curved; spiral suture despressed, distinct; wall perforate, thin; surface smooth; aperture elongate, drop-shape, the boardest at the upper end, strongly deepen in the final chamber.

Dimensions. Length: 0.25-0.32 mm; diameter: 0.09-0.11 mm.

Remarks. In our material no specimens were found with three whorls as figured D'ORBIGNY, 1839.

Distribution. d'Orbigny desribed from Cuba, recent. Frequent in Oligocene and Miocene. some desriptions from Sarmatian: Ukraine: Black Sea Depression – Middle Sarmatian; Russia: Moldavia – Middle Sarmatian; Hungary: Zsámbék Basin – Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone. Occuranced together with *Bulimina, Bolivina* and *Caucasina* species.

Superfamily Fursenkoinacea LOEBLICH and TAPPAN, 1961
Family Fursenkoinidae LOEBLICH and TAPPAN, 1961
Genus Fursenkoina LOEBLICH and TAPPAN, 1961

Fursenkoina acuta (D'ORBIGNY, 1846)
(Pl. IX, figs. 11-12)

1846. *Polymorphina acuta* D'ORBIGNY; D'ORBIGNY, p. 234, Taf. 13, Fig. 4, 5; Taf. 14, Fig. 5-7.
1848. *Virgulina Schreibersii* CZJZEK; CZJZEK, p. 147, Taf. XIII. Fig. 18-21.
1951. *Virgulina schreibersiana* CZJZEK; MARKS, p. 59.
1958. *Virgulina schreibersiana* CZJZEK; VENGLINSKI, p. 136, Tabl. XXIX, fig. 10.
1968. *Virgulina schreibersiana* CZJZEK; KORECZ-LAKY, p. 101, Taf. V, fig. 4.
1970. *Virgulina schreibersiana* CZJZEK; DIDKOWSKI et SATANOVSKAJA, p. 128, Tabl. 76, fig. 9.
1973. *Virgulina schreibersiana* CZJZEK; KORECZ-LAKY, Pl. VII, fig. 7.
1985. *Virgulina acuta* (D'ORBIGNY); PAPP et SCHMID, p. 82, Pl. 75, figs. 1-6.
1991. *Virgulina acuta* (D'ORBIGNY); CIMERMAN and LANGER, p. 64, pl. 67, figs. 1-2.

Material. 25 specimens.

Description. Test elongeted, slightly flattened, periphery subrounded; biserial; chambers elongated, slightly inflated; sutures oblique, depressed; wall hyaline, very thin, finely perforate; surface smooth; aperture narrow, elongated, with a denticulate toothplate.

Dimensions. Length: 0.3-0,55 mm; breadth: 0.1-0.16 mm.

Variability. The test may be somewhat curved.

Remarks. The difference between the descriptions of *Polymorphina acuta* D'ORBIGNY, 1846, and of *Virgulina Schreibersii* CZJZEK, 1848, lies in the radiate aperture in the first and comma-shaped aperture in the latter species. According to the revision of D'ORBIGNY, 1846, in PAPP et SCHMID, 1985, the illustrations of D'ORBIGNY fit only a few juvenile specimens, and the typical aperture shape is the same as *Virgulina Schreibersii* CZJZEK. This species differs from *V. sarmatica* VENGLINSKI, 1958 in its slenderer test shape and larger dimensions.

Distribution. Paleogene - Recent, cosmopolitan in warm shallow seas. Austria: Baden, Möllersdorf - Miocene; Ukraine: Transcarpathians - Badenian; Hungary: Mecsek Mts. and Tokaj Mts. - Badenian, Zsámbék Basin - Sarmatian, *Elphidium reginum* zone.

Superfamily Delosinacea PARR, 1950,
Family Caucasinidae N. K. BYKOVA, 1950
Subfamily Caucasininae N. K. BYKOVA, 1959
Genus Caucasina KHALILOV, 1951

Caucasina schichkinskye (SAMOYLOVA, 1947)
(Pl. IX, fig. 13, Pl. X, fig. 1)

1951. *Bulimina elongata* D'ORBIGNY var subulata CUSHMAN et PARKER; MARKS, p. 57, Pl. 7, fig. 13.
1951. *Bulimina elongata* D'ORBIGNY var. lappa CUSHMAN et PARKER; MARKS, p. 57, Pl. 7, fig. 14.
1958. *Caucasina schischkinskye* SAMOYLOVA; VENGLINSKI, p. 135, Tabl. XXIX, fig. 4-9.
1962. *Caucasina lalova* VENGLINSKI; VENGLINSKI, p. 109, Tabl. 17, fig 4

1970. *Caucasina lalovi* VENGLINSKI; DIDKOWSKI et SATANOVSKAJA, p. 134, Tabl. 79, fig. 1.
1975. *Caucasina khalilovi* LOEBLICH et TAPPAN sarmatica VENGLINSKI; VENGLINSKI, p. 193, Tabl. XXXI, fig. 6-38.
1975. *Caucasina subaculeata* VENGLINSKI; VENGLINSKI, p. 194, Tabl. XXXI, fig. 1-5.

Material. 54 specimens.

Description. Test elongate, nearly circular in cross-section; base bluntly rounded; oblique cutted at the aperture; initial portion low trochospiral, only one or two whorls, five or six chambers per whorl; later chamberrs triserial, inflated, nearly spherical, size increase continously; sutures depressed, distinct and curved; the sutures between the whorls nearly at right angle to the longitudinal axe of the test; wall thin, semitransparent and finely perforated; surface smooth or may be covered by short spines and, or nodes on the basal part of the early chambers; aperture narrow and elongated loop, surrounding by a narrow and raised rim, with a broad toothplate.

Dimensions. Length: 0.24-0.43 mm; diameter: 0.12-0.2 mm.

Variability. The shape of the test may be subcylindrical, gradually increase in cross-section or nearly spherical. The specimens occasionally bear spines and nodes on the basal of the test.

Remarks. In our material the spines and the nodes appeared frequently on the small, squat specimens. Presence or lack of the spines is not a characteristic feature.

The text of the descriptions of *Caucasina schischkinskye* SAMOYLOVA in VENGLINSKI, 1958 is the same as *Caucasina subaculeata* VENGLINSKI in VENGLINSKI, 1975, the only difference is that the spines are always present on the latter species. *Caucasina khalilovi* LOEBLICH et TAPPAN sarmatica VENGLINSKI, 1975, differs from the *Caucasina subaculeata* VENGLINSKI, 1975, in the lack of spines and the somewhat larger test. The size of the test is in the range given for *Caucasina schischkinskye* SAMOYLOVA.

In Mány-17. borehole, between 141.1-143,3 meters in *E. hauerinum* zone there are many degenerate, specimens, with bifurcated test bearing two aperture similarly as figured by VENGLINSKI, 1975, on plate XXXI, figure 31a. According to BOLTOSKOY (1976) it is in connection with the regenerating of mechanical damages.

Distribution. Oligocen – Miocene. Ukraine: Transcarpathians – Upper Badenian Sarmatian; Hungary: Zsámbék Basin – Sarmatian. Common in *E.*

hauerinum zone and in Ukraine, Eastern Paratethys in *Bolivina sarmatica* zone (VENGLINSKI, 1975).

Superfamily Discorbacea EHRENBERG, 1838
Family Rosalinidae REISS, 1963
Genus Rosalina D'ORBIGNY, 1826

Rosalina obtusa D'ORBIGNY, 1846
(Pl. X, figs. 2-4)

1846. *Rosalina obtusa* D'ORBIGNY; D'ORBIGNY, p. 179, Taf. 11, Fig. 4-6.
1951. *Discorbis obtusus* (D'ORBIGNY); MARKS, p. 63.
pars 1958. *Discorbis obtusum* (D'ORBIGNY); VENGLINSKI, p. 148. Tabl. 32, fig. 1, 2, 3.
1968. *Discorbis obtusa* (D'ORBIGNY); KORECZ-LAKY, p. 107, Taf. 6, Fig. 13-14.
non 1970. *Discorbis obtusum* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 80, Tabl. 51, fig. 7.
1975. *Discorbis obtusum* (D'ORBIGNY); VENGLINSKI, p. 177, Tabl. 24, fig. 1, 2.
1985. *Rosalina obtusa* D'ORBIGNY; PAPP et SCHMID, p. 67, Pl. 61, figs. 7-12.

Material. 48 specimens.

Description. Test trochospiral, nearly circular to broadly oval, flattened with slightly convex dorsal face and more or less concave ventral face; periphery subacute; on the spiral side are two whorls; inner whorl consists of four to six small chambers, wich indistict in the adult specimens; on the outer whorl and on the umbilical side are four to six chambers; size of chambers increases rapidly, the last chamber occupying one-third of the whorl; sutures slightly depressed and curved back at the periphery – on the dorsal side, strongly depressed and nearly straight on the ventral side; wall thin, distinctly perforate on the spiral side, gently or not perforate on the umbilical side; surface smooth, often granulated in the umbilicus; aperture long arch on the umbilical side, broader at the umbilicus and narrower at the periphery of the test.

Dimensions. Maximum diamter: 0.2-0.5 mm; thickness: 0.18-0.3 mm.

Variability. The shape of the test is variable, depends on the size and shape of the last chamber. The ventral side may be perforate or unperforate, with or without granules in the umbilicus.

Remarks. The plate XXXII, fig.1. in VENGLINSKI (1958) is the same as the plate 51, fig. 7. in DIDKOWSKI et SATANOVSKAJA (1970). These specimens differs from *Rosalina obtusa* D'ORBIGNY in their smallest test size, more chambers (nine) on the ventral side and broad, irregular and keeled edge on the periphery of the test.

Distribution. Austria: Nussdorf, Ukraine: Transcarpathians – Upper Badenian – Lower Sarmatian; Hungary: Mecsek Mts. – Upper Badenian, Zsámbék Basin – Sarmatian.

Superfamily Glabratellacea LOEBLICH and TAPPAN, 1964
Family Glabratellidae LOEBLICH and TAPPAN, 1964
Genus Schackoinella WEINHANDL, 1958

Schackoinella imperatoria (D'ORBIGNY, 1846)
(Pl. X, figs. 5-6)

1846. *Rosalia imperatora* D'ORBIGNY; D'ORBIGNY, p. 176, Taf. 10, Fig. 16-18.
1877. *Calcarina Carpenteri* KARRER; KARRER, p. 387. Taf. XVI, Fig. 58.
1958. *Discorbis imperatorius* (D'ORBIGNY); VENGLINSKI, p. 146, Tabl. 31. fig. 5.
1964. *Discorbis imperatorius* (D'ORBIGNY); KORECZ-LAKY, Taf. I, Fig. 11.
1967. *Glabratella plana* LUCZKOWSKA; LUCZKOWSKA, p. 237, Pl. VIII, fig. 13-15.
1970. *Discorbis imperatorius* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 79, Tabl. 51, fig. 3.
1973. *Discorbis imperatorius* (D'ORBIGNY); KORECZ-LAKY, Pl.I, fig. 2.
1974. *Glabratella imperatoria* (D'ORBIGNY); BRESTENSKÁ, p. 258, Taf. 4, Fig. 1-3.
1985. *Schackoinella imperatoria* (D'ORBIGNY); PAPP et SCHMID, p. 66, Pl. 60, figs. 1-5.
1991. *Conorbella imperatoria* (D'ORBIGNY); CIMERMAN and LANGER, p. 68, pl. 72, figs. 9-11.

Material. 5 specimens.

Description. Test small, trochospiral; nearly circular in outline; dorsal and ventral side are convex; on the spiral side are two or two and half whorls; the inner whorl consists of four to six chambers, on the last whorl and on the umbilical side are four to seven chambers; on the dorsal side each rapidly enlarging chamber bears a long pointed spine forming a stellate outline of the test; imbilicus strongly deepen on the ventral side; sutures somewhat depressed, indistinct and slightly inflected on the dorsal side, depressed and radiate on the ventral side; wall smooth and finely perforate ont he dorsal side; surface on the ventral is ornamented with striae radiating from the imbilicius and with separating rows of fine granules; aperture an interiomaginal umbilical slit.

Dimensions. Diameter: 0.23-0.32 mm.

Variability and ontogeny. The dimorfism appear in the shape of the test. The schizont form differs from the gamont form in its more flattened stellate outline, the radially elongated chambers and the horizontal spines as *Calcarian Carpenteri* KARRER, 1877 and *Glabratella plana* LUCZKOWSKA, 1967.

Distribution. Miocene to Recent, recently lives Mediterranean Sea (CIMERMAN and LANGER, 1991). Poland: Tarnopol and Holubica in Galicia – Lower Sarmatian, Holy Cross Mts. – Lower Sarmatian; Ukraine. Transcarpathians – Upper Badenian to Lower Sarmatian; Hungary: Tokaj Mts., Zsámbék Basin – Sarmatian, *Elphidium reginum* zone.

Superfamily Planorbulinacea SCHWAGER, 1877
Family Cibicididae CUSHMAN, 1927
Subfamily Cibicidinae CUSHMAN, 1927
Genus Cibicides de MONFORT, 1808

Cibicides lobatulus (WALKER et JACOB, 1798)
(Pl. X, figs. 7-8)

1846. *Truncatulina lobatula* D'ORBIGNY; D'ORBIGNY, p. 168, Taf. 9, Fig. 18-23.
1846. *Anomalina variolata* D'ORBIGNY; D'ORBIGNY, p. 170, Taf. 9, Fig. 27-29.
1951. *Cibicides lobatulus* (WALKER et JACOB); MARKS, p. 73.
1961. *Cibicides lobatulus* (WALKER et JACOB); DUPEUBLE, p. 197, Pl. 1, fig. 1.
1962. *Cibicides lobatulus* (WALKER et JACOB); VENGLINSKI, Tabl. 13, fig. 3.

1964. *Cibicides lobatulus* (WALKER et JACOB); KORECZ-LAKY, Taf. III, Fig. 1.
1968. *Cibicides lobatulus* (WALKER et JACOB); KORECZ-LAKY, p. 122, Taf. IX, Fig. 16.
1970. *Cibicides lobatulus* (WALKER et JACOB); DIDKOWSKI et SATANOVSKAJA, p. 93, Tabl. 60, fig. 1.
1973. *Cibicides lobatulus* (WALKER et JACOB); KORECZ-LAKY, Pl. I, fig. 10.
1973. *Cibicides datensis* FUJITA-ITO; KORECZ-LAKY, Pl. I, fig. 11.
1974. *Cibicides lobatulus* (WALKER et JACOB); BRESTENSKÁ, p. 273, Taf. 4, Fig. 5.
1975. *Cibicides variolatus* (D'ORBIGNY); VENGLINSKI, p. 180. Tabl. 25, fig. 2, 5.
1985. *Cibicides lobatulus* (WALKER et JACOB); PAPP et SCHMID, p. 64, 65, Pl. 56, figs. 1-5, Pl. 57, figs. 1-3.
1991. *Lobatula lobatula* (WALKER et JACOB); CIMERMAN and LANGER, p. 71, pl. 75, figs. 1-4.

Material. Over 1000 speciemens.

Description. Test large, trochospiral, variable in shape; periphery carinate, often irregular; dorsal side evolute, convex, six to eight chambers visible; ventral side involute, plan or convex depending on the substrata, seven to twelve chambers visible; sutures strongly depressed and slightly cuved on the spiral side, depressed and strongly bent back at the periphery on the umbilical side; wall optically radial, dorsal side coarsely perforate, ventral side finely perforate, sutures and peripherical keel imperforate; surface smooth; aperture a low interiomarginal, equatorial arch, somewhat extending onto the spiral side, surrounded with an imperforate, narrow rim.

Dimensions. Maximum diameter of the test: 0.4-1.4 mm.

Variability. As this species lives attached to the substrate the shape of the test is variable.

Distribution. Neogene – Recent, cosmopoliten. Austria: Vienna Basin (Nussdorf) – Badenian and Sarmatian; Ukraine: Transcarpathians – Badenian and Lower Sarmatian; Czecho-Slovakia – Sarmatian; Hungary: Mecsek Mts., Tokaj Mts. – Badenian and Lower Sarmatian, Zsámbék Basin – Sarmatian.

Very common in the Lower Sarmatian, *Elphidium reginum* zone.

Superfamily Rotaliacea EHRENBERG, 1839
Family Nonionidae SCHULTZE, 1854
Subfamily Nonioninae SCHULTZE, 1854
Genus Nonion de MONFORT, 1808

Nonion bogdanowiczi VOLOSHINOVA, 1952
(Pl. XI, fig. 4)

1952. *Nonion bogdanowiczi* VOLOSHINOVA; VOLOSHINOVA, p. 19, Tabl. I, fig. 7-8.
non 1958. *Nonion bogdanowiczi* VOLOSHINOVA; VENGLINSKI, p. 108, Tabl. 21, fig. 4.
1960. *Nonion bogdanowiczi* VOLOSHINOVA; STANCHEVA, p. 16, Tabl. III, fig. 4.
non 1970. *Nonion bogdanowiczi* VOLOSHINOVA; DIDKOWSKI et SATANOVSKAJA, p. 96, Tabl. 62, fig. 4.
1973. *Nonion bogdanowiczi* VOLOSHINOVA; KORECZ-LAKY, p. V, fig. 8.
1974. *Florilus bogdanowiczi* (VOLOSHINOVA); BRESTENSKÁ, p. 267, Taf. 8, Fig. 3.

Material. Over 500 speciemens.

Description. Test small, nearly rounded or slightly oval, compressed and biumbilicate; planispirally coiled, involute; periphery rounded; six to nine chambers visible from the outside; chambers somewhat inflated, rapidly increasing in size; sutures distinct, slightly curved back; flat or slightly depressed at the periphery and deepen and broaden towards the umbilicus; umbilicus somewhat depressed or flat; wall thin, finely perforate; surface smooth except the umbilicus and central part of sutures, wich completely filled with fine granules; aperture a low interiomarginal arch at the base of the aperural face.

Dimensions. Diameter: 0.17-0.32 mm; thickness: 0.05-0.13 mm.

Variability. The characteristic featues of this species are rapidly enlarging chambers and the ornamented umbilicus and central part of the sutures.

Remarks. Our specimens can be well indentified with the type described and figured by VOLOSHINOVA, 1952. The specimens described and illustrated by VENGLINSKI (1958) and DIDKOWSKI et SATANOVSKAJA (1970) differ from it in having slightly evolute test, more chambers in the final whorl and the size of the chambers increases gradually.

Distribution. Russia (Crime, Caucasus) and Ukraine East-Precaucasus – Lower and Middle SArmatian; North-Western Bulgaira – Lower and Middle Sarmatian. Czecho-Slovakia – Lower Sarmatian; Hungary: Tokaj Mts. – Lower Sarmatian, Zsámbék Basin – Sarmatian.

Genus Porosononion PUTRYA, in VOLOSHINOVA, 1958

Porosononion granosum (D'ORBIGNY, 1826)
(Pl. XI, fig. 5)

1846. *Nonionina perforata* D'ORBIGNY; D'ORBIGNY, p. 110, Taf. 5, Fig. 17, 18.
1846. *Nonionina granosa* D'ORBIGNY; IBIDEM, p. 110, Taf. 5, Fig. 19, 20.
1846. *Nonionina punctata* D'ORBIGNY; IBIDEM, p. 111, Taf. 5, Fig. 21, 22.
1951. *Nonion granosum* (D'ORBIGNY); MARKS, p. 48.
1951. *Nonion perforatum* (D'ORBIGNY); MARKS, p. 48, Pl. 6, fig. 4.
1952. *Nonion granosus* (D'ORBIGNY); VOLOSHINOVA, p. 20, Tabl. 1, fig. 6.
1958. *Nonion granosus* (D'ORBIGNY); VENGLINSKI, p. 105, Tabl. XXI, fig. 3.
1964. *Nonion granosum* (D'ORBIGNY); KORECZ-LAKY, p. 479, Taf. I, Fig. 8.
1968 *Nonion granosum* (D'ORBIGNY); KORECZ-LAKY, p. 89, Taf. 1, Fig. 6.
1970. *Nonion granosus* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 97, Tabl. 62, fig. 5.
1973. *Nonion granosum* (D'ORBIGNY); KORECZ-LAKY, Pl. IV, fig. 13.
1974. *Protelphidium ex. gr. granosum* (D'ORBIGNY); BRESTENSKÁ, p. 263, Taf. 8, Fig. 4.
1982. *Nonion granosum* (D'ORBIGNY); KORECZ-LAKY, p. 166, fig. 1-3.
1985. *Elphidium (Porosononion) granosum* (D'ORGIBNY); PAPP et SCHMID, p. 46-47, Pl. 36, figs. 6-8, Pl. 37, figs. 1-9, text-plate 6.

Material. Over 5000 specimens.

Description. Test circular, compressed and biumbilicate, planispirally enrolled, involute; periphery rounded nine to twelve slightly inflated chambers visible in the final whorl, gradually increasing in size sutures depressed and slightly bent umbilicus wide and more or less flat, with umbilical spiral canal system no ponticuli, septal canals and sutural pores wall relatively thick, distinctly perforate surface smooth except the umbilical area, which covered with numerous warts aperture multiple, interiomarginal, placed at the base of the apertural face.

Dimensions. Diameter: 0.2-0.5 mm thickness: 0.11-0.26 mm.

Variability. The umbilicus may be more less wide and its ornamentation may be stronger or weaker. The size of the pores of wall is variable.

Remarks. We accept the conclusion os PAPP et SCHMID (1985),that *Nonionina perforata* D'ORBIGNY, 1846 and *Nonionina punctata* D'ORBIGNY, 1846 are synonymous with *Nonionina granosa* D'ORBIGNY, 1846.

Distribution. Miocene to Recent. In Paratethys widely distributed, especially typical int he early Sarmatian, in *"Nonion" granosum* zone. Zsámbék Basin - abundant in Sarmatian.

Family Trichohyalidae SAIDOVA, 1981
Genus Aubignyna MARGEREL, 1970

Aubinyna simplex (D'ORBIGNY, 1846)
(Pl. X, figs. 9-12)

? 1846. *Rosalina simplex* D'ORBIGNY; D'ORBIGNY, p. 178, pl. 10, Fig. 25-27.
1958. *Rotalia simplex* (D'ORBIGNY); VENGLINSKI, p. 152, Tabl. XXXIII, fig. 3.
1970. *Rotalia simplex* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 113, Tabl. 69, fig. 3.
? 1985. *Anomalina badenensis* (D'ORBIGNY); PAPP et SCHMID, p. 67, Pl. 61, fig. 6.
1991. *Aubignyna planidorso* (ATKINSON); CIMERMAN and LANGER, p. 75, pl. 86, figs. 5-6.

Material. About 60 specimens.

Description. Test small, broad-oval, low trochospiral coil of two or two and half whorls; periphery broadly rounded; nine to eleven chambers are on the slightly convex to plan spiral side; five to seven chambers visible on the ventral side; size of slightly inflated chambers increases gradually; sutures more or less depressed, slightly curved back on the dorsal side; on the ventral side umbilicus deepen, surrounded by radial, sutural fissures, which continue as slightly depressed sutures towards the periphery of the test; wall thin, finely perforate; surface smooth, except for the finely granulated umbilicus and the sutural fissures; aperture an interiomarginal narrow arch, extending from the periphery to the umbilicus.

Dimensions. Maximum diameter of the test: 0.24-0.34 mm.

Variability. The inner whorl may be more or less elevated.

Remarks. The specimens from Zsámbék Basin can be well identified with the description and figuration of VENGLINSKI, 1958 and with *Aubignyna planidorso* (ATKINSON) in CIMERMAN and LANGER, 1991.

According to the revision of the original material of D'ORBIGNY published by PAPP et SCHMID (1985) *Rosalina simplex* D'ORBIGNY, 1846 should be synonymous with *Anomalina badenensis* (D'ORBIGNY, 1846). *Anomalina badenensis* (D'ORBIGNY) differs from *Rosalina simplex* D'ORBIGNY, in its larger size of the test, inner whorl usually invisible, or depressed, the surface coarsely perforate and the sutures slightly curved on the umbilical side.

Distribution. Badenian to Recent. Ukraina Transcarpathians – Upper Badenian, Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Family Rotaliidae EHRENBERG, 1839
Subfamily Ammoniinae SAIDOVA, 1981
Genus Ammonia BRÜNNICH, 1772

Ammonia beccarii (LINNÉ, 1758)
(Pl. XI, figs. 1-3)

1846. *Rosalina viennensis* D'ORBIGNY; D'ORBGINY, p. 177, Taf. 10, Fig. 22-24.
1958. *Rotalia beccarii* (LINNÉ); VENGLINSKI, p. 151, Tabl. 33, fig. 1, 2.
1963. *Ammonia beccarii* (LINNÉ); PAPP, p. 281, Taf. 14.
1964. *Rotalia beccarii* (LINNÉ); KORECZ-LAKY, Taf. 1, Fig. 9.
1968. *Rotalia beccarii* (LINNÉ); KORECZ-LAKY, p. 109, Taf. V, fig. 18.
1970. *Streblus beccarii* (LINNÉ); DIDKOWSKI et SATANOVSKAJA, p. 113, Tabl. 69, fig. 5.
1973. *Rotalia beccarii* (LINNÉ); KORECZ-LAKY, Pl. V, fig. 10.
1974. *Ammonia ex. gr. beccarii* (LINNAEUS); BRESTENSKÁ, p. 259, Taf. 3, Fig. 3, 4.
1975. *Ammonia beccarii* (LINNÉ); VENGLINSKI, p. 190. Tabl. 29, fig. 5, Tabl. 30, fig. 1, 3, 4.
1984. *Ammonia beccarii* (LINNÉ); LÉVY et al., p. 382, Pl. 1, fig. 4, 7-8, 12.
1985. *Ammonia beccarii* (LINNÉ); PAPP et SCHMID, p. 67, Pl. 61, figs. 1-5.
1991. *Ammonia beccarii* (LINNAEUS); CIMERMAN and LANGER, p. 76, pl. 87, figs. 3-4.

Material. Over 5000 specimens.

Description. Test round, trochospiral coil of two and half to four whorls; periphery rounded to subrounded; ten to twenty chambers are on the more or less convex spiral side; on the ventral side only the chambers of the last whorl are visible; size of slightly inflated chambers increases continously; sutures distinct, sometimes somewhat elevated and curved back on the dorsal side; on the ventral side umbilicus deepen, open and may have an umbilicus plug surrounded by radial, deeply incised, nearly straight sutural fissures; often bordered by folium from each chambers of the final whorl; wall thin, finely perforate; surface smooth, except for the more or less granulated umbilicus and sutural fissures; aperture an interiomarginal slit extending under the folium of chambers.

Dimensions. Diameter: 0.2-0.45 mm.

Variability. The size of the test and the intensity of the ornamentation in the umbilicus are variable, dependent on ecological factors. Variability is discussed in detail in PAPP (1963) and VÉNEC-PEYRÉ (1983).

Remarks. There are lot of degenerate specimens, with large irregularly coiled last chambers, or nearly flat or slightly depressed, spiral side (Pl. XI, fig.3), in the *Elphidium hauerinum* zone.

Distribution. Miocene - Recent. Widely distributed in Badenian and Sarmatian in Paratethys. Hungary: Zsámbék Basin – abundant in Sarmatian.

Family Elphidiidae GALLOWAY, 1933
Subfamily Elphidiinae GALLOWAY, 1933
Genus Elphidium MONFORT, 1808

Elphidium aculeatum (D'ORBGINY, 1846)
(Pl. XI, figs. 6-7)

1846. *Polystomella Josephina* D'ORBIGNY; D'ORBIGNY, p. 130, Taf. 6. Fig. 25-26.
1846. *Polystomella aculeata* D'ORBGINY; D'ORBIGNY, p. 131, Taf. 6, Fig. 27-28.
1951. *Elphidium aculeatum* (D'ORBGINY); MARKS, p. 50, Pl. 6, fig. 11.
1951. *Elphidium josephinum* (D'ORBIGNY); MARKS, p. 52.
1952. *Elphidium josephina* (D'ORBGINY); VOLOSHINOVA, p. 40, Tabl. IV, fig. 3.

1952. *Elphidium aculeatum* (D'ORBIGNY); VOLOSHINOVA, p. 41, Tabl. IV, fig. 2, 4, 6.
1958. *Elphidium josephinum* (D'ORBIGNY); VENGLINSKI, p. 112, Tabl. XXIII, fig. 3.
1958. *Elphidium aculeatum* (D'ORBIGNY); VENGLINSKI, p. 120, Tabl. XXII, fig. 3.
1960. *Elphidium aculeatum* (D'ORBIGNY); STANCHEVA, p. 18, Tabl. III, fig. 2.
1960. *Elphidium josephinum* (D'ORBIGNY); STANCHEVA, p. 19, Tabl. III, fig. 8.
1963. *Elphidium aculeatum aculeatum* (D'ORBIGNY); PAPP, p. 274, Taf. 11, Fig. 7.
1963. *Elphidium josephinum* (D'ORBIGNY); PAPP, p. 274, Taf. 11, Fig. 6.
1964. *Elphidium aculeatum* (D'ORBIGNY); KORECZ-LAKY, p. 479, Taf. I, Fig. 3.
1964. *Elphidium josephinum* (D'ORBIGNY); KORECZ-LAKY, p. 355, Taf. I, Fig. 6.
1968. *Elphidium aculeatum* (D'ORBIGNY); KORECZ-LAKY, p. 90, Taf. I, Fig. 11.
1970. *Elphidium aculeatum* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 144, Tabl. 70, fig. 1.
1970. *Elphidium josephina* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 120, Tabl. 71, fig. 7.
1973. *Elphidium josephinum* (D'ORBIGNY); KORECZ-LAKY, Taf. IV, fig. 1.
1973. *Elphidium aculeatum* (D'ORBIGNY); KORECZ-LAKY, pl. IV, fig. 14.
1974. *Elphidium aculeatum* (D'ORBIGNY); BRESTENSKÁ, p. 259, Taf. 5, Fig. 1.
1974. *Elphidium josephinum* (D'ORBIGNY); BRESTENSKÁ, p. 259, Taf. 5, Fig. 3.
1982. *Elphidium aculeatum* (D'ORBIGNY); KORECZ-LAKY, pl. I, fig. 1, 2.
1985. *Elphidium aculeatum* (D'ORBIGNY); PAPP et SCHMID, p. 52, Pl. 43, figs. 1-7.
1991. *Elphidium aculeatum* (D'ORBIGNY); CIMERMAN and LANGER, p. 77, pl. 89, figs. 1-4.

Material. Over 500 specimens.

Description. Test planispirally enrolled, involute, nearly circular in outline, flattened; periphery angled; eleven or twelve chambes are in the final whorl, slowly increasing in size in the adult stage; sutures distinct, depressed; septa gently curved and terminating in spines; ponticuli long and narrow, eight to twelve on each chambers; fossettes granulated; umbilicus slightly depressed; wall optically radial; aperture, row of foramina at the base of low septal face.

Dimensions. Diameter: 0.4-1.0 mm; thickness: 0.16-0.32 mm.

Variability. The size of the spines is variable.

Remarks. We accept the discussion of PAPP et SCHMID (1985), that *E. josephinum* is the juvenile stage of *E. aculeatum.*

Distribution. Characteristic species of Paratethys during the Sarmatian, particularly common in the Lower Sarmatian, in the *Elphidium reginum* zone (PAPP et SCHMID, 1985).

Elphidium crispum (LINNÉ, 1758)
(Pl. XI, figs. 8-9)

1846. *Polystomella crispa* D'ORBIGNY; D'ORBIGNY, p. 125, Taf, 6, Fig. 9-14.
1951. *Elphidium crispum* (LINNÉ); MARKS, p. 51.
1958. *Elphidium crispum* (LINNÉ); VENGLINSKI, p. 115, Tabl. XXV, fig. 2, 6.
1963. *Elphidium crispum* (LINNÉ); PAPP, p. 264, Taf. 7, Fig. 2, Taf. 8, Fig. 1-5.
1964. *Elphidium crispum* (LINNÉ); KORECZ-LAKY, p. 478. Taf, 5, Fig. 1.
1968. *Elphidium crispum* (LINNÉ); KORECZ-LAKY, p. 90, Taf. V, Fig. 15.
1970. *Elphidium crispum* (LINNÉ); DIDKOWSKI et SATANOVSKAJA, p. 116, Tabl. 71, fig. 1.
1985. *Elphidium crispum* (LINNÉ); PAPP et SCHMID, p. 50, Pl. 40, figs. 5-8.
1991. *Elphidium crispum* (LINNAEUS); CIMERMAN and LANGER, p. 77, pl. 90, figs. 1-6.

Material. Over 100 specimens.

Description. Test planispiral, large, lenticular, rhombic in cross-section; periphery carinate; fourteen to thirty slender chambers visible from the exterior; sutures distinct, depressed and curved; ponticuli narrow and long, eight to twelve on each chamber; fossettes granulated; umbilicus elevated, forming an umbilical plug, ornamented with nine to twelve small pits; wall optically radial; aperture row, of foramina at the base of septal face.

Dimensions. Diameter: 0.6-1.2 mm; thickness: 0.16-0.32 mm.

Variability. The umbilicus may be more or less ornamented.

Remarks. The characteristic feature of this species is the rhombic cross-section of the test and the ornamented umbilical plug.

Distribution. Paleogene to Recent. Widely distributed in the Paratethys during the Sarmatian. Zsámbék Basin – Sarmatian.

Elphidium fichtelianum (D'ORBIGNY, 1846)
(Pl. XI, fig. 10)

1846. *Polistomella Fichtelliana* D'ORBIGNY; D'ORBIGNY, p. 125, Taf. 6, Fig. 7, 8.
1951. *Elphidium fichtelianum* (D'ORBIGNY); MARKS, p. 52, Pl. 6, fig. 12.
1958. *Elphidium fichtellianum* (D'ORBIGNY); VENGLINSKI, p. 116, Tabl. XXIV, fig. 4.
1963. *Elphidium fichtelianum* (D'ORBIGNY); PAPP, p. 268, Taf. 11, Fig. 1, 2.
1964. *Elphidium fichtellianum* (D'ORBIGNY); KORECZ-LAKY, p. 354. Taf, I, Fig. 4.
1970. *Elphidium fichtellianum* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 118, pl. 71, fig. 3.
1973. *Elphidium fichtellianum* (D'ORBIGNY); KORECZ-LAKY, Pl. IV, fig. 3.
1974. *Elphidium fichtelianum* (D'ORBIGNY); BRESTENSKÁ, p. 260, Taf, 6, Fig. 2.
1982. *Elphidium fichtellianum* (D'ORBIGNY); KORECZ-LAKY, Pl. V, Fig. 1, 2.
1985. *Elphidium fichtelianum* (D'ORBIGNY); PAPP et SCHMID, p. 50, Pl. 40,. figs. 1-5.

Material. Over 300 specimens.

Description. Test nearly oval to circular, strongly compressed, biumbilicate, planispirally coiled; periphery sharply angled and carinate; the last whorl consists of sixteen to eighteen narrow chambers; sutures distinct, depressed and curved; ponticuli long and up to twelve on the last chambers; umbilicus slilghtly depressed, without central pillar; wall finely perforate; surface finely granulated; aperture a low slit or a row of small pores at the base of the apertural face.

Dimensions. Diameter: 0.4-0.8 mm; thickness: 0.12-0.18 mm.

Variability. Remarkable and constant character of this specimens is the very flattened test shape. The outline of the test ranges from oval to circular.

Remarks. The specimens from Zsámbék Basin can be well identified with the type described by D'ORBIGNY, 1846.

Distribution. Eocene to Recent. Type locality: Austria: Nussdorf in Vienna Basin - Badenian - Sarmatian. Widely distributed in Paratethys, especially common in the Lower Sarmatian. Zsámbék Basin - Sarmatian, *Elphidium reginum* and *Elphidium hauerinum* zone.

Elphidium flexuosum reussi MARKS, 1951
(Pl. XI, figs. 11-12)

1951. *Elphidium flexuosum reussi* MARKS; MARKS, p. 53, Taf, 6. Fig. 7.
1963. *Elphidium flexuosum reussi* MARKS; PAPP, p. 271, Taf. 13, Fig. 3.
? 1974. *Elphidium microelegans* SEROVA; BRENSTENSKÁ, p. 262, Taf. 5, Fig. 6.

Material. Over 100 specimens.

Description. Test relatively small, lenticular, planispirally enrolled, involute; periphery keeled; twelve to fourteen chambers visible on the last whorl, somewhat inflated; sutures distinct, depressed and slightly curved; ponticuli narrow, six to nine on each chamber; umbilicus prominent, smooth and polished; wall relatively thin and finely perforate; surface smooth; aperture a row of small pores at the low and broad apertural face.

Dimensions. Diameter: 0.22-0.31 mm; thickness: 0.09-0.11 mm.

Variability. The characteristic and constant feature of this species is the polished and prominent umbilical boss. The edge may be more or less keeled.

Remarks. The specimens of Zsámbék Basin are identical in detail with the type described and illustrated by MARKS, 1951. This subspecies differs from the other one in its fewer chambers, and large, smooth, polished and convex umbilical boss.

Distribution. Type locality: Austria: Beethovenansicht, Nussdorf in Vienna Basin – Badenian; Czecho-Slovakia – Sarmatian; Hungary: Zsámbék Basin – Sarmatian.

Elphidium hauerinum (D'ORBIGNY, 1846)
(Pl. XII, figs. 1-5)

1846. *Polystomella Hauerina* D'ORBIGNY; D'ORBIGNY, p. 122, Taf. 6, Fig. 1, 2.
1846. *Polystomella Antonina* D'ORBIGNY; D'ORBIGNY, p. 128, Taf. 6, Fig. 17, 18.
1846. *Polystomella Listeri* D'ORBGINY; D'ORBIGNY, p. 128, Taf. 6, Fig. 19-22.
1951. *Elphidium antoninum* (D'ORBIGNY); MARKS, p. 51.
1951. *Elphidium hauerinum* (D'ORBIGNY); MARKS, p. 52.
1958. *Elphidium antoninum* (D'ORBIGNY); VENGLINSKI, p. 114, Tabl. 25, fig. 3.
1958. *Elphidium hauerinum* (D'ORBIGNY); VENGLINSKI, p. 118, Tabl. 26, fig. 3.
1960. *Elphidium hauerinum* (D'ORBIGNY); STANCHEVA, p. 20, Tabl. II, fig. 9.
1960. *Elphidium antoninum* (D'ORBIGNY); STANCHEVA, p. 21, Tabl. III, fig. 12.
1963. *Elphidium antoninum* (D'ORBIGNY); PAPP, p. 262, Taf. 10, Fig. 3-5.
1963. *Elphidium hauerinum* (D'ORBIGNY); PAPP, p. 263, Taf. 10, Fig. 6.
1963. *Elphidium listeri* (D'ORBIGNY); PAPP, p. 273, Taf. 12, Fig. 9.
1964. *Elphidium hauerinum* (D'ORBIGNY); KORECZ-LAKY, p. 479, Taf. 1, Fig. 7.
1968. *Elphidium hauerinum* (D'ORBIGNY); KORECZ-LAKY, p. 91, Taf. 1, Fig. 8.
1970. *Elphidium antonina* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 116, Tabl. 70, fig. 2.
1970. *Elphidium hauerinum* (D'ORBIGNY); IBIDEM, p. 119, Tabl. 72, fig. 2.
1974. *Elphidium antoninum* (D'ORBIGNY); BRESTENSKÁ, p. 262, Taf. 7, Fig. 1.
1974. *Elphidium hauerinum* (D'ORBIGNY); IBIDEM, p. 262, Taf. 7, Fig. 2.
1982. *Elphidium hauerinum* (D'ORBIGNY); KORECZ-LAKY, pl. IV, fig. 1, 2.
1985. *Elphidium hauerinum* (D'ORBIGNY); PAPP et SCHMID, p. 49, Pl. 38, figs. 5-10, p. 51, Pl. 41, figs. 5-10, Pl. 42, figs. 1-4.

Material. Over 2000 specimens.

Description. Test medium-size, nearly circular in outline, biumbilicate, planispirally enrolled, involute; periphery rounded; eight to fourteen inflated chambers in the final whorl; sutures distinct, depressed and nearly straight or slightly curved; ponticuli broad and short, six to nine on each chamber; no central pillar; umbilicus flat or slightly depressed; wall finely perforate and shiny; surface smooth, except sometimes the umbilicus ornamented with fine pearls; multiple aperture at the base of the septal face.

Dimensions. Diameter: 0.2-0.45 mm; thickness: 0.09-0.19 mm.

Variability. The chambers may be more or less inflated. Periphery varies from broadly rounded to subrounded. Sometimes the umbilicus granulated.

Remarks. We accept the revision of PAPP at SCHMID (1985), that *Elphidium antoninum* (D'ORBIGNY) and *Elphidium listeri* (D'ORBIGNY) are synonymous with *Elphidium hauerinum* (D'ORBIGNY).

Distribution. During Sarmatian widely distributed in Paratethys, especially abundant in the upper part of the Lower Sarmatian, therefore it is named after this species, *Elphidium hauerinum* zone.

Elphidium macellum (FICHTEL et MOLL, 1798)
(Pl. XII, figs. 6-8)

non 1798. *Nautilus macellus var.* α FICHTEL et MOLL; FICHTEL et MOLL, p. 68, Taf. 10, Fig. e-g.
1798. *Nautilus macellus var.* β FICHTEL et MOLL; IBIDEM, p. 68, Taf. 10, Fig. h, i, k.
1951. *Elphidium macellum* (FICHTEL et MOLL); MARKS, p. 53.
1958. *Elphidium macellum* (FICHTEL et MOLL); VENGLINSKI, p. 123, Tabl. XXIV, fig. 3, Tabl. XXVI, fig. 4.
1962. *Elphidium macellum convexia* VENGLINSKI; VENGLINSKI, p. 104, Tabl. XVI, fig. 1.
1964. *Elphidium macellum* (FICHTEL et MOLL); KORECZ-LAKY, p. 479, Taf. I, Fig. 5.
? 1964. *Elphidium macellum var. aculeatum* SILVESTRI; KORECZ-LAKY, p. 479, Taf. I, Fig. 4.
1968. *Elphidium macellum* (FICHTEL et MOLL); KORECZ-LAKY, p. 91, Taf. I, Fig. 15.
1970. *Elphidium macellum* (FICHTEL et MOLL); DIDKOWSKI et SATANOVSKAJA, p. 121, Tabl. 72. fig. 7.

1970. *Elphidium macellum converia* VENGLINSKI; VENGLINSKI, p. 12, Tabl. 72, fig. 6.
? 1973. *Elphidium macellum var. aculeatum* SILVESTRI; KORECZ-LAKY, Pl. IV, fig. 13.
1974. *Elphidium macellum* (FICHTEL et MOLL); BRESTENSKÁ, p. 263, Taf. 6, Fig. 4.
1982. *Elphidium macellum* (FICHTEL et MOLL); KORECZ-LAKY, Pl. I, fig. 3, 4.
1985. *Elphidium macellum* (FICHTEL et MOLL); RÖGL et HANSEN, p. 50, Pl. 14, Fig. 2, 5, 6, Pl. 15, Fig. 1, 2, Textfig. 18 B.
1991. *Elphidium macellum* (FICHTEL and MOLL); CIMERMAN and LANGER, p. 78, pl. 89, fig. 9.

Material. Over 3000 specimens.

Description. Test planispiral, involute, nearly circular in outline, slightly flattened, lenticular; periphery sharply angled and keeled; eleven to twelve chambers are in the final whorl; sutures distinct, depressed and gently curved; ponticuli long, distinct, seven to fifteen on each chamber; fossettes granulated; umbilicus flat or slightly depressed, without umbilical plug and ornamentation; wall optically radial; multiple aperture, with small protruding lips at the base of the low septal face.

Dimensions. Diameter: 0.35-0.8 mm; thickness: 0.2-0.35 mm.

Variability. The periphery may more or less harp.

Remarks. According to RÖGL et HANSEN (1984) *Nautilus macellus* var. α FICHTEL et MOLL corresponds to *E. planulatum* (LAMARCK, 1822). The distinctive features of the latter species are the more flattened test, more chambers per whorl and having multiple additional areal apertures.

This species differs from *Ephidium crispum* (LINNÉ) in its more flattened test shape and depressed umbilicus, without ornamentation.

Rarely small spines appear on the keel at the older part of the last whorl, as in MARKS (1951), VENGLINSKI (1958) and KORECZ-LAKY (1964 and 1973). Possibly these are transitional forms between. *E. aculeatum* and *E. macellum*.

Distribution. Eocene - Recent: Mediterranean Sea (CIMERMAN and LARGER, 1991). Very common in the Middle Sarmatian. Hungary: Tokaj Mts., Mecsek Mts. - Lower Sarmatian, Zsámbék Basin - Sarmatian.

Elphidium obtusum (D'ORBIGNY, 1846)
(Pl. XII,f igs. 9-10)

1846. *Polystomella obtusa* D'ORBIGNY; D'ORBIGNY, p. 124, Taf. 6, Fig. 5, 6.
? 1960. *Elphidium obtusum* (D'ORBIGNY); STANCHEVA, p. 261, Tabl. 9, fig. 4.
1963. *Elphidium obtusum* (D'ORBIGNY); PAPP, p. 261,Taf.9, Fig. 4.
1985. *Elphidium obtusum* (D'ORBIGNY); PAPP et SCHMID, p. 50, Pl. 39, figs. 5, 6.

Material. Over 150 specimens.

Description. Test lenticular in shape, planispirally coiled, involute; periphery subacute; thirteen to twenty chambers on the last whorl; sutures distinct and curved; ponticuli short, eight to ten on each chamber; umbilicus flat or sometimes slightly depressed; no central pillar; wall finely perforate; surface smooth; multiple aperture at the base of the septal face.

Dimensions. Diameter: 0.4-0.7 mm; thickness: 0.22-0.34 mm.

Variability. The distinctive and constant features of this species are the large number of the chambers and the subacute periphery without carinae.

Remarks. This species resembles *Elphidium hauerinum* (D'ORBIGNY), from which it differs in its larger test, more chambers on the last whorl and subacute periphery. STANCHEVA (1960) mentioned only ten to fourteen chambers on the final whorl, the other characters are the same.

Distribution. Austria: Vienna Basin - Eggenburgian to Sarmatian; North-Western Bulgaria - Lower Sarmatian. Hungary: Zsámbék Basin - Sarmatian, from the *Elphidium reginum* zone, to lower part of the *Spirolina austriaca* zone. Common in the Lower Sarmatian, together with *E. hauerinum.*

Elphidium reginum (D'ORBIGNY, 1846)
(Pl. XII, fig. 11)

1846. *Polystomella regina* D'ORBIGNY; p. 129, Taf. 6, Fig. 23, 24.
1951. *Elphidium reginum* (D'ORBIGNY); MARKS, p. 53.
1952. *Elphidium regina* (D'ORBIGNY); VOLOSHINOVA, p. 39, Tabl. IV, fig. 7-9.

1952. *Elphidium regina var. caucasina* BOGDANOWICH; VOLOSHINOVA, p. 40, Tabl. IV, fig. 8-9.
1958. *Elphidium reginum* (D'ORBIGNY); VENGLINSKI, p. 123, Tabl. XXIII. fig. 2, Tabl. XXIV, fig. 1, 2.
1958. *Elphidium georgium* VENGLINSKI; VENGLINSKI, p. 119, Tabl. XXIII.fig. 1.
1960. *Elphidium reginum* (D'ORBIGNY); STANCHEVA, p. 20, Tabl. III, fig. 7.
1963. *Elphidium reginum* (D'ORBIGNY); PAPP, p. 275, pl. 11, Fig.8.
1964. *Elphidium reginum* (D'ORBIGNY); KORECZ-LAKY, p. 479, Taf. I, Fig. 2.
1965. *Elphidium georgium* VENGLINSKI; KORECZ-LAKY, p. 354. Taf. I, Fig. 55.
1968. *Elphidium imperatrix* (BRADY); KORECZ-LAKY, p. 91, Taf. I, Fig. 16.
1968. *Elphidium reginum* (D'ORBIGNY); KORECZ-LAKY, p. 92.
1970. *Elphidium regina* (D'ORBIGNY); DIDKOWSKI et SATANOVSKAJA, p. 124, Tabl. 74, fig. 6.
1970. *Elphidium regina georgium* (VENGLINSKI); DIDKOWSKI et SATANOVSKAJA, p. 124, Tabl. 74, fig. 8.
1970. *Elphidium regina caucasicum* BOGDANOWICH; DIDKOWSKI et SATANOVSKAJA, p. 124, Tabl. 74, fig.7.
1974. *Elphidium georgium* VENGLINSKI; KORECZ-LAKY, pl. IV, fig. 4.
1973. *Elphidium reginum* (D'ORBIGNY); KORECZ-LAKY, p. IV, fig. 8.
1974. *Elphidium reginum* (D'ORBIGNY); BRESTENSKÁ, p. 260, Taf. 6, Fig. 3, 5, 6.
1982. *Elphidium imperatrix* (BRADY); KORECZ-LAKY, pl. II, fig. 3, 4. Pl. III, fig. 1-4.
1985. *Elphidium reginum* (D'ORBIGNY); PAPP et SCHMID, p. 52, Pl. 42, figs. 5-9, Pl. 43, fig. 8.

Material. Over 400 specimens.

Description. Test large, nearly circular to irregular in outline, flattened, planispirally coiled, involute; periphery acute; thirteen to twenty slightly inflated chambers on the final whorl; sutures distinct and strongly curved at the periphery; ponticuli long, seven to fifteen on each chamber; umbilicus flat or slightly depressed; a few long spines appear on the edge; wall finely perforate; surface finely granulated except the spines, which smooth and polished; multiple aperture at the base of the septal face.

Dimensions: Diameter: 0.4-1.2 mm; thickness: 0.15-0.25 mm.

Variability. The test shape is variable, often irregular. The number of the spines varies from three to five and may be longer or shorter.

Remarks. The remarkable character of this species is the long spines at the periphery.

Distribution. The type locatlity of this species is Baden in Vienna Basin, according to PAPP (1963) and PAPP et SCHMID (1985) it is probably came to daylight from the Sarmatian layers. From the other part of Paratethys *E. reginum* occured only in the Sarmatian formations. Especially typical in the Lower Sarmatian, but it was mentioned from the Middle Sarmatian of Eastern Paratethys (VENGLINSKI, 1975; DIDKOWSKI et SATANOVSKAJA, 1970). This is a species endemic to the Paratethys and it is regard as index fossil for the Sarmatian.

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PLATE I

Fig. 1. *Spiroloculina okrojantzi* BOGDANOWICH. Sarmatian, *Elphidium reginum* zone. Mány–17. borehole, depth 147.1-147.5 mm; Front view of a specimen.

N: 40x

Fig. 2. *Nodophthalmidium aff. prima* (BOGDANOWICH). Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.6-150.4 m; Oblique view with aperture.

N: 150x

Fig. 3-4. *Nodophthalmidium rugosum n. sp.*, Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.1-147.5 m;

3 – side view, holotype;

N: 74x

4 – oblique view of initial part with aperture, paratype.

N: 130x

Fig. 5. *Nodophtalpmidium asperum n. sp.*, Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 142-144 m; Slightly oblique view with narrow slit-like aperture, holotype.

N: 70x

Fig. 6. *Nodobaculariella didkowskii* BOGDANOWICH. Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 177.2-178.2 m; Oblique side view with large aperture.

N: 80x

Fig. 7-9. *Nodobaculariella ovalis* VENGLINSKI. Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 177.2-178.2 m;

7, 8 – opposite sides;

7 - N: 150x
8 - N: 100x

9 – apertural view.

N: 160 x

Fig. 10-12. *Nodobaculariella sulcata* (REUSS). Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 177.2-178.2 m;

10, 11 – opposite sides;

10 - N: 70x
11 - N: 90x

12 – side view with aperture.

N: 110x

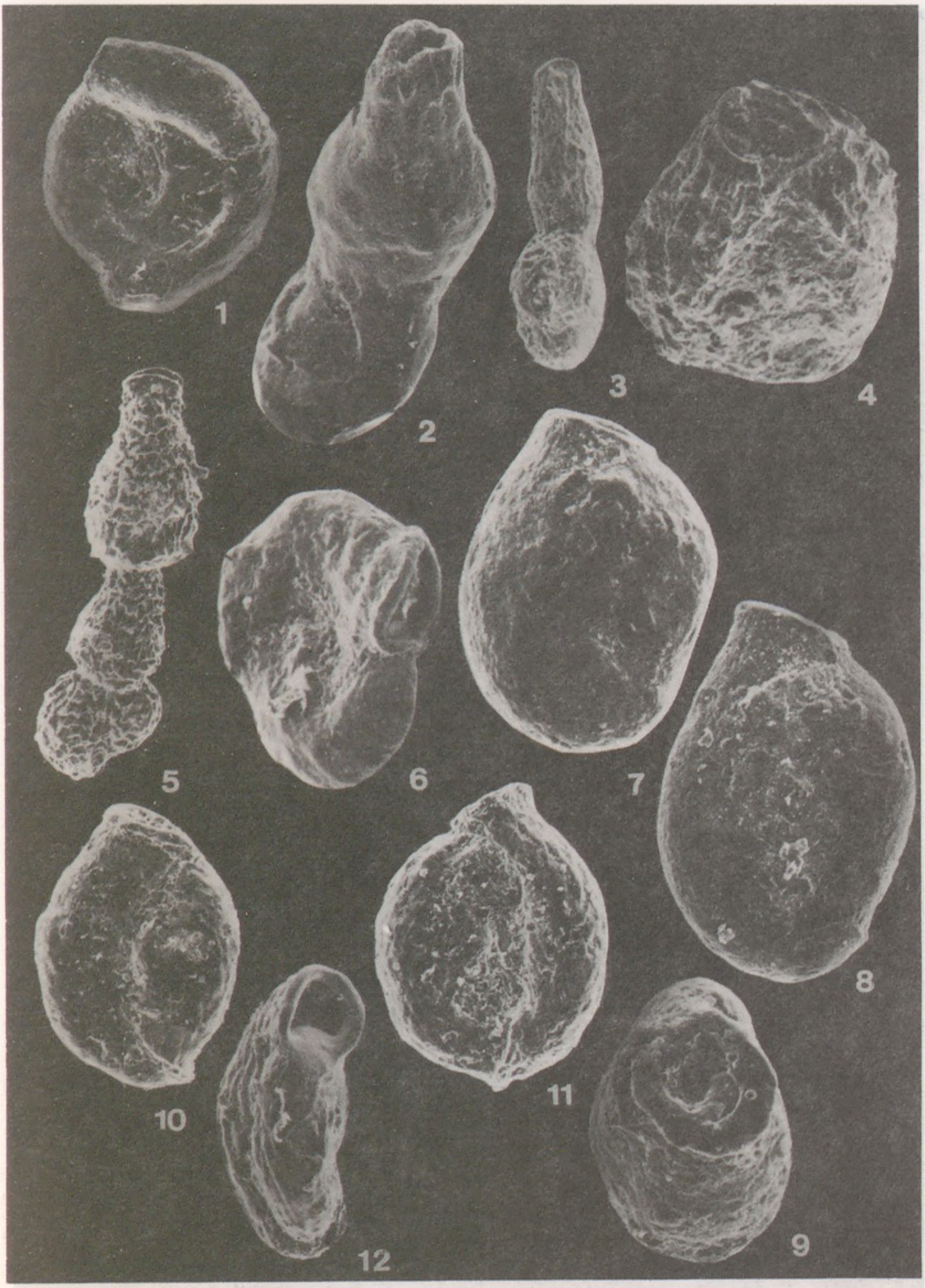
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PLATE II

Fig. 1-4. *Schlumbergerina fabularoides* (KARRER). Sarmatian, *Spirolina austriaca* zone. Mány-22. borehole, depth 41.7-42.6 m;

1 – front view;

N: 30x

2 – front view of an irregularly coiled specimen;

N: 60x

3 – apertural view with termatophore;

N: 100x

4 – aperture with termatophore damaged, showing crenellated border.

N: 140x

Fig. 5 - 8. *Siphonaperta longidentata n. sp.*, Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.1-147.5 m;

5 – front view, paratype;

N: 130x

6 – oblique view with aperture, paratype; 5 and 6 are opposite sides.

N: 80x

7 – apertural view, paratype;

N: 120x

8 – apertural view, elongated aperture with long, simple tooth.

N: 110x

Fig. 9-11. *Cycloforina badenensis* D'ORBIGNY. Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 45-52 m;

9, 10 – opposite sides;

9 - N: 90x
10 - N: 70x

11 – oblique view with aperture.

N: 150x

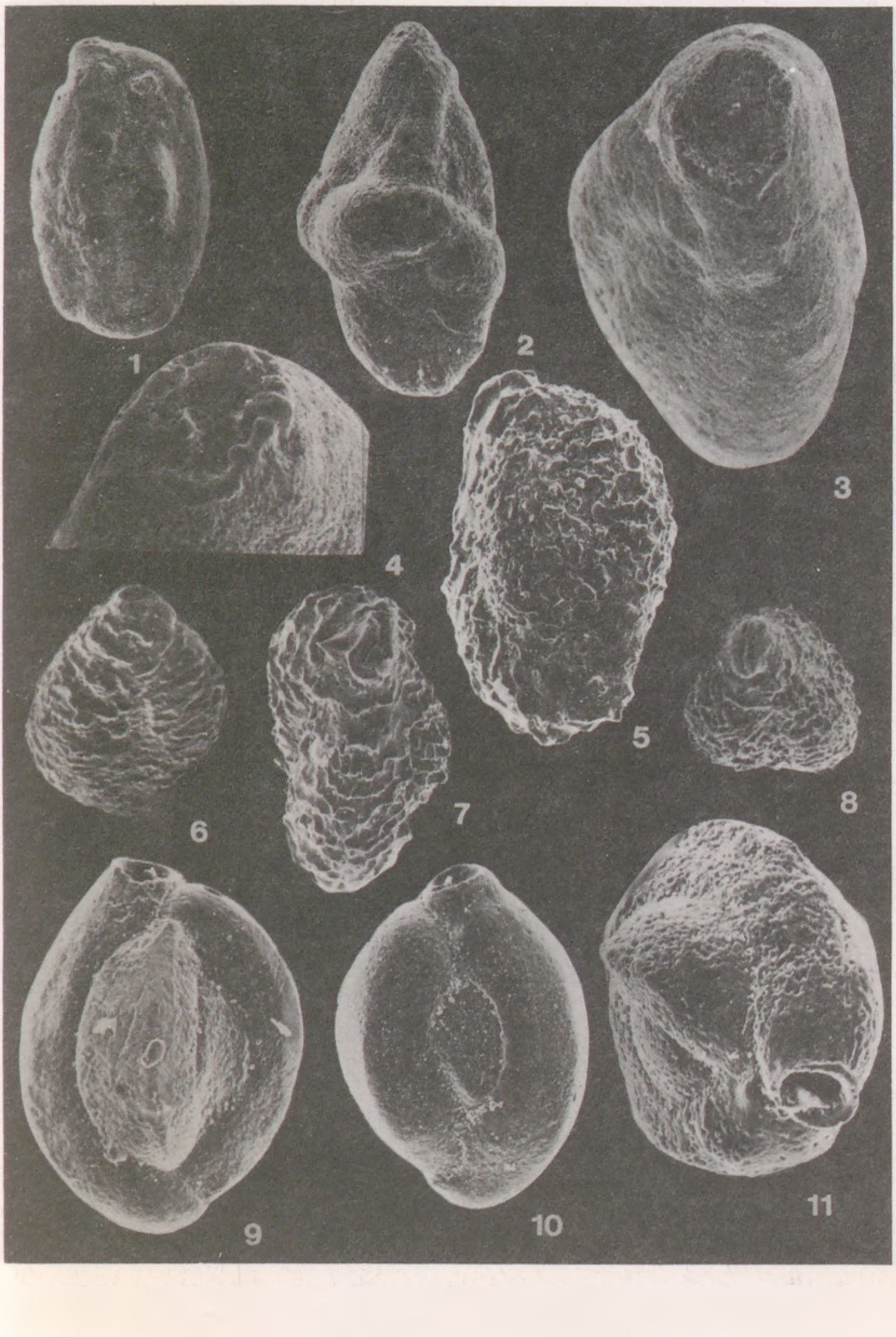
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PLATE III

Fig. 1-3. *Cycloforina contora* (D'ORBIGNY). Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 92.0-92.3 m;

1 – front view of a sharply carinated specimen;
N: 100x

2 – front view of a specimen with blunt carinae;
N: 80x

3 – oblique view with circular aperture and bifid tooth.
N: 75x

Fig. 4 - 6. *Cycloforina fluviata* (VENGLINSKI). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 39.8-41.1 m;

4, 5 – opposite sides;
4 - N: 120x
5 - N: 150x

6 – oblique view with aperture.
N: 140x

Fig. 7-9. *Cycloforina predkarpatica* (SEROVA). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 45-52 m;

7,8 – opposite sides;
7 - N: 65x
8 - N: 80x

9 – apertural view.
N: 100x

Fig. 10-11. *Cycloforina stomata* LUCZKOWSKA. Sarmatian. *Spirolina austriaca* zone, Mány-22. borehole, depth 45-52 m;

10 – front view;
N: 140x

11 – apertural view.
N: 100x

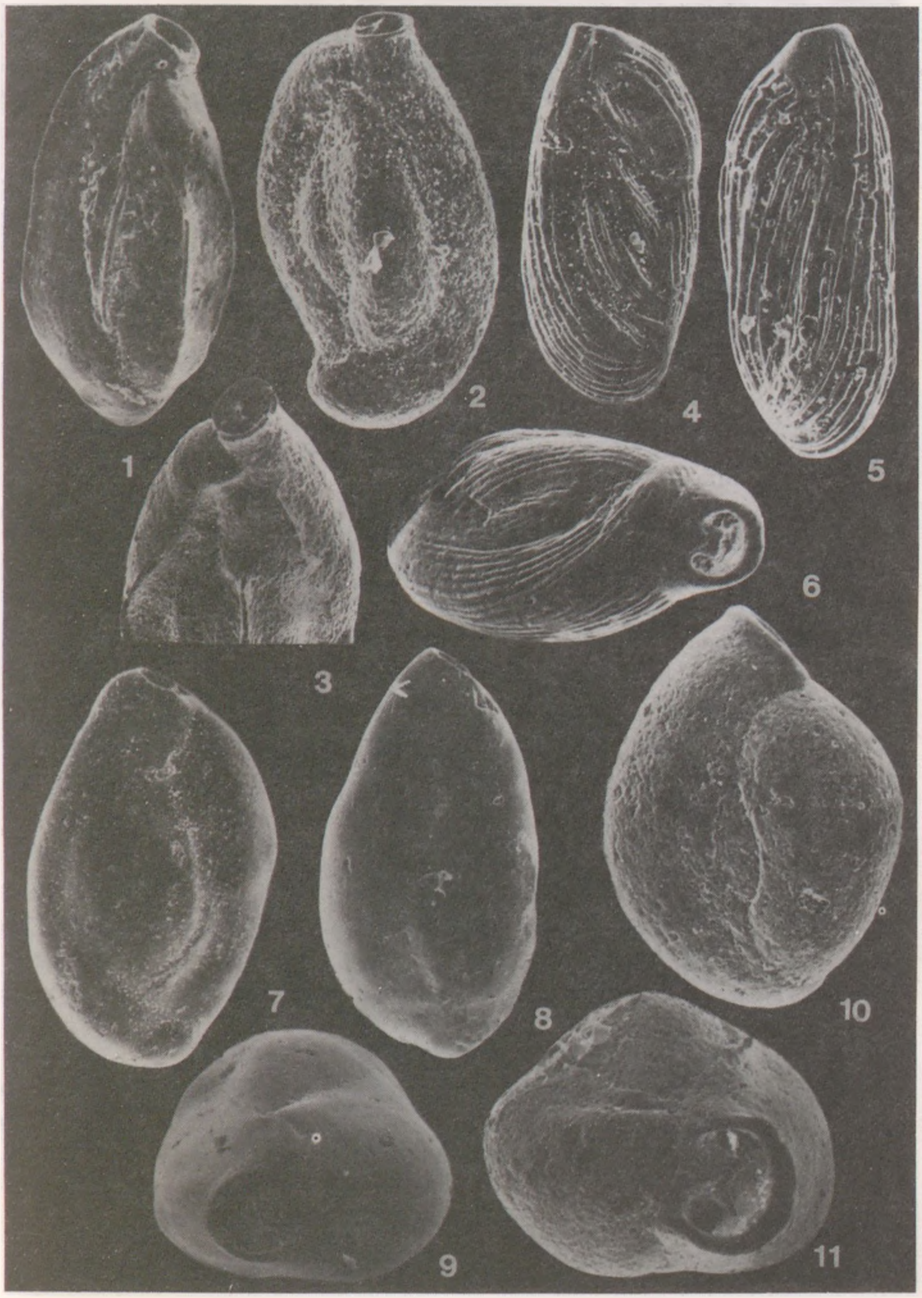
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PLATE IV

Fig. 1-2. *Cycloforina toreuma* (SEROVA). Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 170.6-173 m;

1,2 - opposite sides.

1 - N: 140x
2 - N: 120x

Fig. 3-5. *Cycloforina vermicularis* (KARRER). Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 95.8-96.8 m;

3,4 - opposite sides;

3 - N: 90x
4 - N: 160x

5 - front view of an adult specimen with irregular longitudinal striae.

N: 70x

Fig. 6-9. *Hauerina irschavensis* VENGLINSKI et BURINDINA. Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 39.8-41.4 m;

6,7 - front views of adult specimens with triangular, termathophore aperture;

6 - N: 110x
7 - N: 70x

8 - oblique view of a juvenile specimen with nearly circular, termathophore aperture;

N: 70x

9 - front view of a juvenile specimen with convex and clearly visible middle chamber;

N: 75x

Fig. 10-12. *Hauerina podolica* SEROVA. Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 39.8-41.4 m;

10, 11 - opposite sides;

10 - N: 140x
11 - N: 150x

12 – apertural view with termathophore aperture.

N: 130x

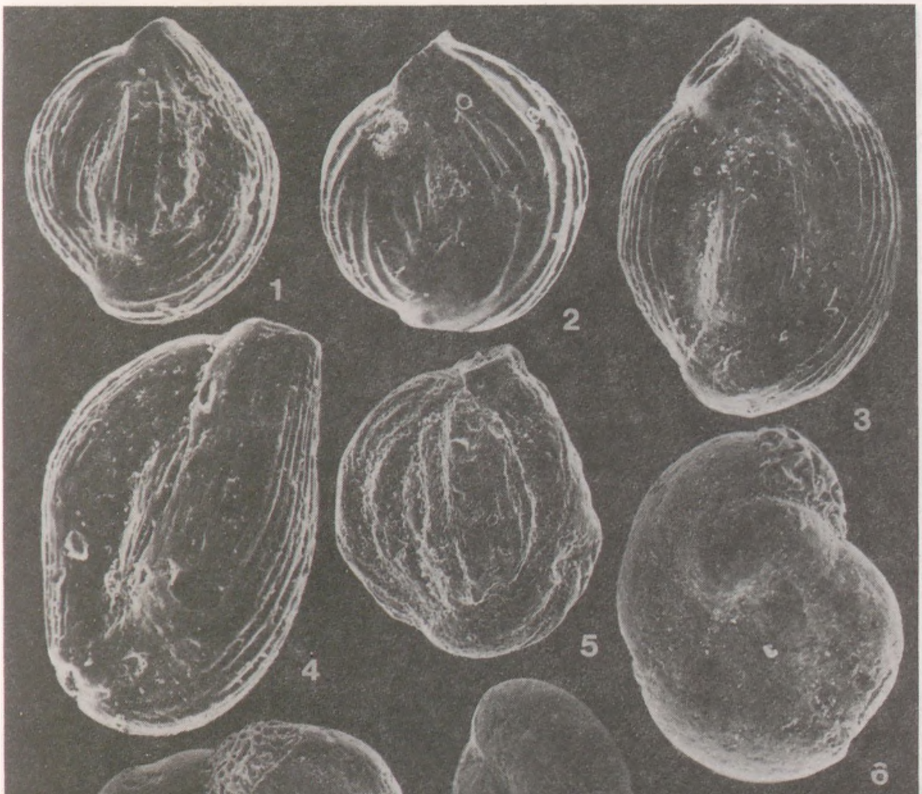
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PLATE V

Fig. 1-3. *Quinqueloculina anagallis* LUCZKOWSKA. Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 41.7-42.6 m;
1,2 - opposite sides;
1 - N: 80x
2 - N: 60x
3 - oblique view of a strongly striated specimen with aperture.
N: 70x

Fig. 4-7. *Quinqueloculina buchiana* D'ORBIGNY. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.1-147.5 m;
4 - front view of quinqueloculine stage;
N: 100x
5 - apertural view of quinqueloculine stage;
N: 90x
5,7 - opposite sides of massiline stage;
6 - N: 60x
7 - N: 50x

Fig. 8-10. *Affinetrina cubanica* (BOGDANOWICH). Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 98.1-99.1 m;
8,9 - opposite sides;
8 - N: 150x
9 - N: 130x
10 - side view with oblique aperture.
N: 200x

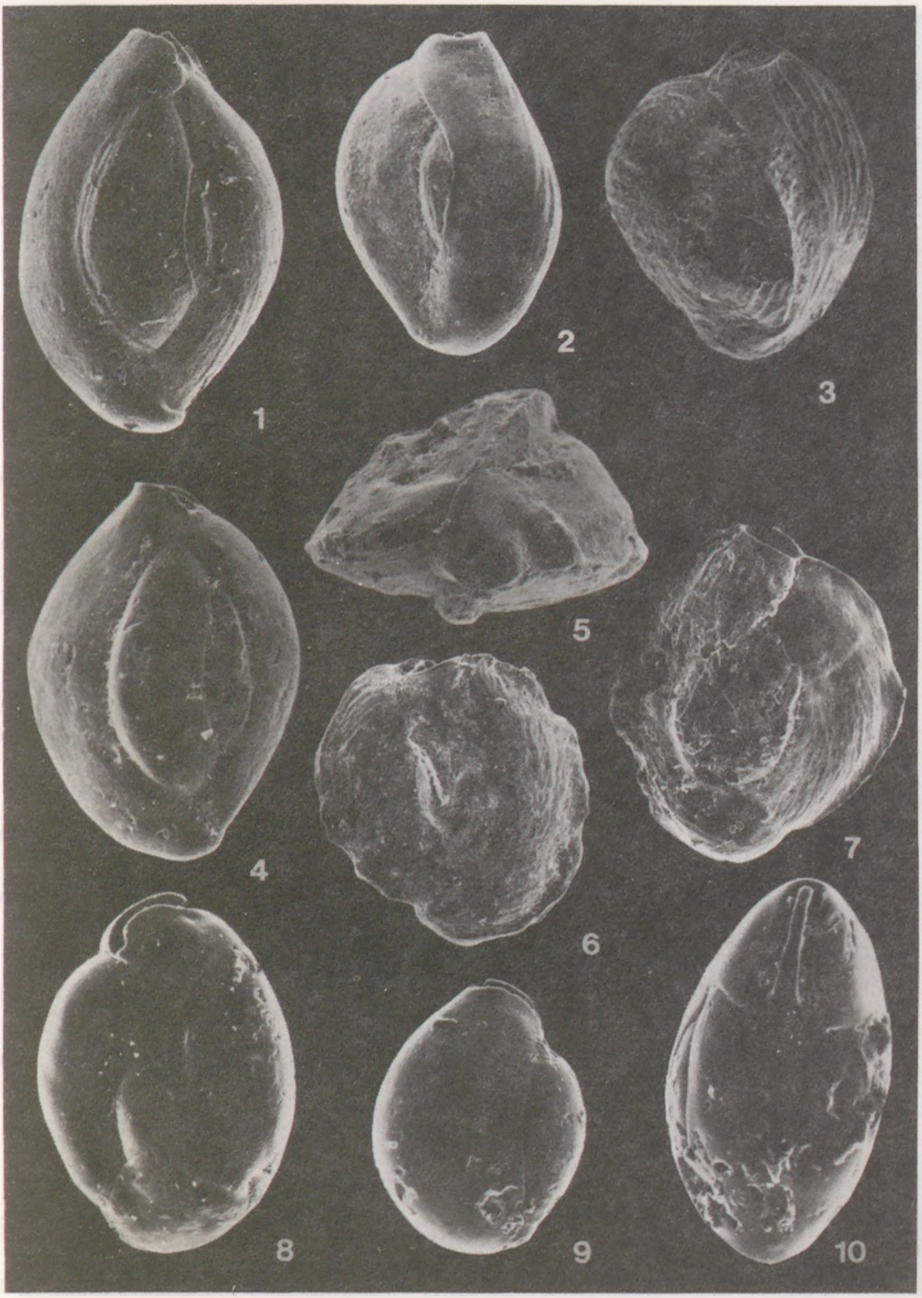
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PLATE VI

Fig. 1-3. *Affinetrina ucrainica* (SEROVA). Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 145.2-145.4 m;

1,2 - opposite sides;

1 - N: 130x

2 - N: 120x

3 - side view with aperture perpendicular to the penultimate chamber, tooth broken.

N: 200x

Fig. 4-5. *Miliolinella banatiana* LUCZKOWSKA. Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 74-80.2 m;

4 - apertural view.

N: 90x

5 - front view.

N: 100x

Fig. 6-8. *Miliolinella selene* (KARRER). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 41.7-42.6 m;

6,7 - opposite sides;

6 - N: 180x

7 - N: 130x

8 - side view with very low aperture and tape-like toothplate.

N: 180x

Fig. 9-10. *Pseudotriloculina consobrina* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.6-150.4 m;

9 - front view;

N: 150x

10 - nearly side view with aperture.

N: 130x

Fig. 11-13. *Pseudotriloculina inflata* (D'ORBIGNY). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 39.8-41.1 m;

11, 12 - opposite sides;

11, 12 - N: 60x

13 - apertural view with large bifid tooth.

N: 70x


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PLATE VII

Fig. 1-2. *Triloculina gibba* D'ORBIGNY. Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 81.5-85.3 m;

1 - front view of a specimen with only two visible chambers;

N: 60x

2 - front view of a slightly eroded specimen.

N: 80x

Fig. 3-4. *Triloculina intermedia* KARRER. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.1-147.5 m;

3 - oblique view of slightly eroded specimen;

N: 60x

4 - nearly apertural view.

N: 100x

Fig. 5-6. *Varidentella latelacunata* (VENGLINSKI). Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 104.5-106 m;

5 - front view;

N: 100x

6 - nearly apertural view.

N: 150x

Fig. 7-9. *Varidentella pseudocostata* (VENGLINSKI). Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 147.6-150.4 m;

7, 8 - front view, aperture is in oblique position.

7 - N: 160x
8 - N: 140x

9 - side view, with aperture.

N: 120x

Fig. 10-11. *Varidentella reussi* (BOGDANOWICH). Sarmatian, *Spirolina austriaca* zone, Perbál-5. borehole, depth 98-104 m;

10 front view;

N: 210x

11 - front view of a specimen ornamented with irregular wrinkles.

N: 160x


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PLATE VIII

Fig. 1-2. *Varidentella rotunda* (GERKE). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 45-52 m;

1, 2 - front views.

1 - N: 100x

2 - N: 130x

Fig. 3. *Articularia articulinoides* (GERKE et ISSAEVA). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 74-80.2 m; Initial part broken, side view of a chamber.

N: 60x

Fig. 4. *Articulina problema* BOGDANOWICH. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 156.8-158.4 m; Specimen with initial part.

N: 100x

Fig. 5. *Articulina aff. nitida* D'ORBIGNY. Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 141.4-142.7 m; initial part broken.

N: 100x

Fig. 6-9. *Spirolina austriaca* D'ORBIGNY. Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 106-109.6 m;

6 - specimen with uncoiled chambers.

N: 60x

7 - aperture of uncoiled part, round and lobately notched;

N: 120x

8 - side view of coiled part with aperture;

N: 110x

9 - front view of a juvenile specimen.

N: 80x

Fig. 10. *Guttulina communis* D'ORBIGNY. Sarmatian, *Elphidium hauerinum* zone, Mány-17. borehole, depth 111.6-113.5 m;

N: 60x

Fig. 11-12. *Oolina mironovi* (BOGDANOWICH). Sarmatian, *Elphidium hauerinum* zone, Mány-22. borehole, depth 134.6-139 m;

11 - front view;

N: 160x

12 - side view.

N: 160x


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PLATE IX

Fig. 1. *Bolivina antiqua* D'ORBIGNY. Sarmatian, *Elphidium hauerinum* zone, Mány-17. borehole, depth 111.6-113.5 m; Fron tview.
N: 150x

Fig. 2. *Bolivina moldavica* DIDKOWSKI. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 141.1-143.3 m; Front view.
N: 150x

Fig. 3. *Bolivina moravica* CICHA et ZAPLETALOVA. Sarmatian. *Elphidium hauerinum* zone, Mány-22. borehole, depth 139.2-141.4 m; Front view.
N: 180x

Fig. 4. *Bolivina sagittula* DIDKOWSKI. Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 99.6-109.6 m; Front view.
N: 100x

Fig. 5. *Bolivina sarmatica* DIDKOWSKI. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 141.1-143.3 m; Front view.
N: 230x

Fig. 6-7. *Cassidulina margareta* KARRER. Sarmatian, *Elphidium hauerinum* zone, Mány-22. borehole, depth 139.2-141.4 m;
6,7 - opposite sides.
N: 210x

Fig. 8. *Bulimina elongata* D'ORBIGNY. Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 89.2-90.4 m;
N: 130x

Fig. 9-10. *Buliminella elegantissima* (D'ORBIGNY). Sarmatian, *Elphidium hauerinum* zone, Mány-17. borehole, depth 111.6-113.5 m;
9 - side view with drop-shape aperture;
N: 180x
10 - side view, opposite to the aperture.
N: 160x

Fig. 11-12. *Fursenkoina acuta* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 169.8-172.3 m;
11 - side view, opposite to the aperture.
N: 160x
11 - side view with missing last chamber and with aperture and denticulate toothplate.
N: 220x

Fig. 13. *Caucasina schischkinskye* (SAMOYLOVA). Sarmatian, *Elphidium hauerinum* zone, Mány-22. borehole, depth 139.2-141.4 m; Elongate specimens.
N: 160x


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PLATE X

Fig. 1. *Caucasina schischkinskye* (SAMOYLOVA). Sarmatian, *Elphidium hauerinum* zone, Mány-22. borehole, depth 139.2-141.4 m; Globular specimen with spines and nodes.

N: 200x

Fig. 2-4. *Rosalina obtusa* D'ORBIGNY. Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 155-157.8 m;

2 - dorsal side;

N: 80x

3 - ventral side, perforate.

N: 110x

4 - ventral side, imperforate and umbilicus is ornamented with granules.

N: 160x

Fig. 5-6. *Schackoinella imperatoria* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 155-157.8 m;

5 - dorsal side;

N: 120x

5 - ventral side.

N: 130x

Fig. 7-8. *Cibicides lobatulus* (WALKER et JACOB). Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 153.1-154 m;

7 - dorsal side;

N: 45x

8 - ventral side.

N: 70x

Fig. 9-12. *Aubignyna simplex* (D'ORBIGNY). 9, 11 - Sarmatian, *Spirolina austriaca* zone, Mány-17. borehole, depth 76.5-76.8 m; 10, 12 - Lower Sarmatian, Elphidium reginum zone, Mány-22. borehole, depth 173-175.9 m;

9, 10 dorsal side;

11, 12 - ventral side.

9-11 - N: 120x


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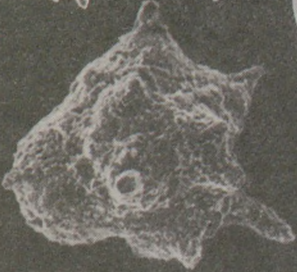
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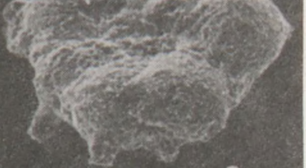
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PLATE XI

Fig. 1-3. *Ammonia beccarii* (LINNÉ). Sarmatian, *Spirolina austriaca* zone, Perbál-5. borehole, depth 98-104 m;

1 - dorsal side;

N: 150x

2 - ventral side;

N: 170x

3 - oblique view of a low trochospiral specimen with aperture and with missing last chambers.

N: 100x

Fig. 4. *Nonion bogdanowiczi* VOLOSHINOVA. Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 170.6-173 m; Side view.

N: 150x

Fig. 5. *Porosononion granosum* (D'ORBIGNY). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 98-104 m; Side view.

N: 80x

Fig. 6-7. *Elphidium aculeatum* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 152.8-153 m;

6 - side view of an adult specimen;

N: 60x

7 - side view of an juvenile specimen.

N: 70x

Fig. 8-9. *Elphidium crispum* (LINNÉ). Sarmatian, *Spirolina austriaca* zone, Mány-22. borehole, depth 41.7-42.6 m;

8 - side view;

N: 80x

9 - apertural view.

N: 60x

Fig. 10. *Elphidium fichtelianun* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Perbál-5. borehole, depth 177.2-178.2 m; Side view.

N: 70x

Fig. 11-12. *Elphidium flexuosum reussi* MARKS. Sarmatian, *Elphidium reginum* zone, Mány-17. borehole,d epth 147.1-147.5 m;

11 - side view;

N: 120x

12 - apertural view.

N: 130x


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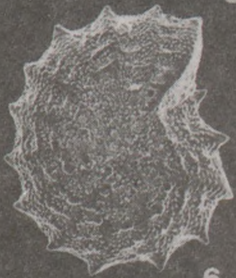
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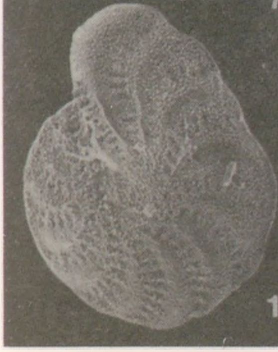
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PLATE XII

Fig. 1-5. *Elphidium hauerinum* (D'ORBIGNY). 1-3 - Sarmatian, *Elphidium hauerinum* zone, Perbál-5. borehole, depth 128.8-134.4 m; 4,5 - Lower Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 149.9-153.3 m;

1, 2 - side view;
3 - oblique apertural view;
4, 5 - "Siamese" twins specimen.

1-5 - N: 140x

Fig. 6-8. *Elphidium macellum* (FICHTEL et MOLL). Sarmatian, *Elphidium reginum* zone, Mány-22. borehole, depth 170-173 m;

6 - side view;
N: 70x
7 - apertural view;
N: 100x
8 - apertural view of a "Siamese" twins specimen.
N: 60x

Fig. 9-10. *Elphidium obtusum* (D'ORBIGNY). Sarmatian, *Spirolina austriaca* zone, Perbál-5. borehole, depth 98-104 m;

9 - apertural view;
N: 120x
10 - side view.
N: 85x

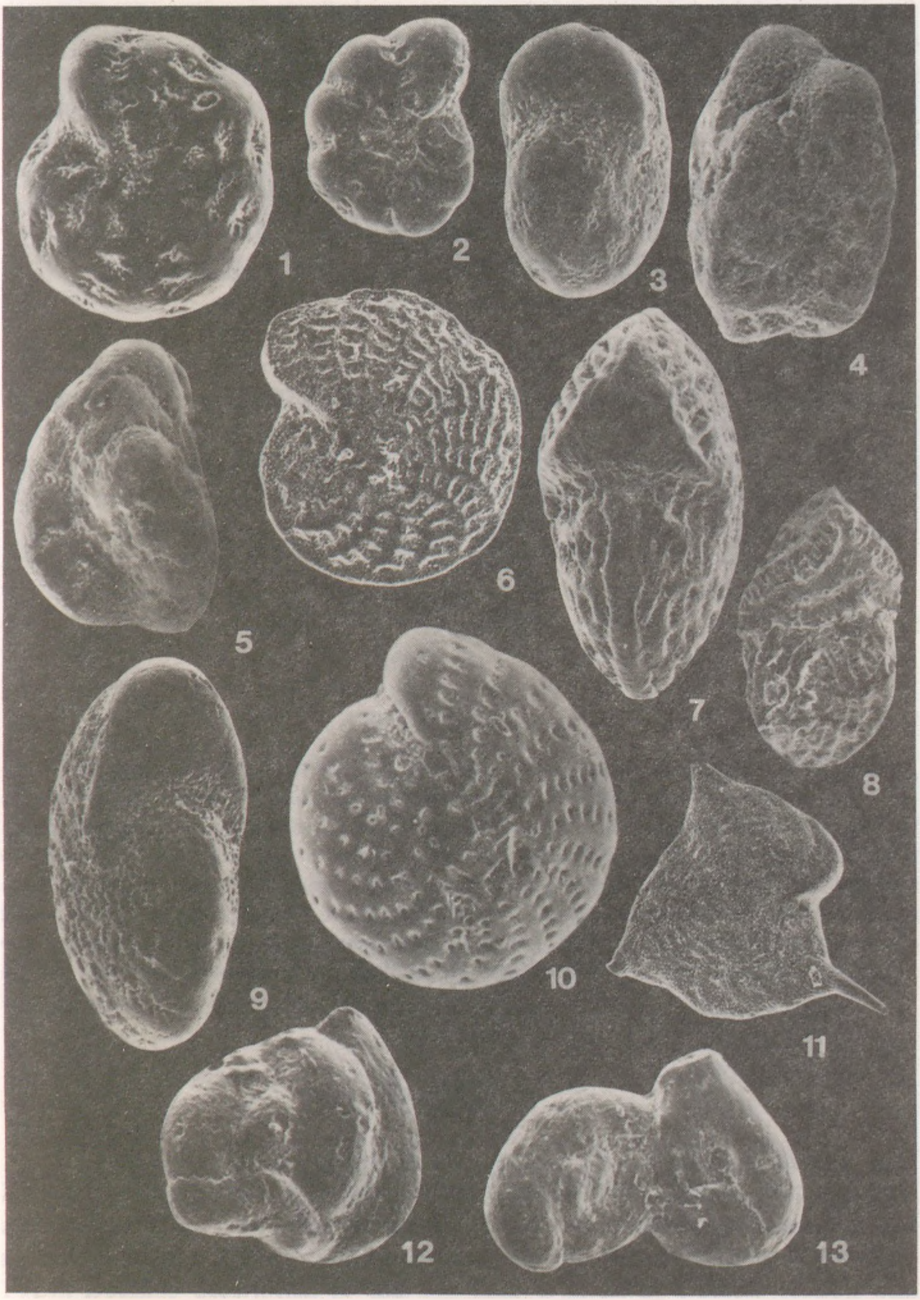
Fig. 11. *Elphidium reginum* (D'ORBIGNY). Sarmatian, *Elphidium reginum* zone, Mány-17. borehole, depth 150.8-151.8 m; Side view.

N: 30x

Fig. 12-13. *Miliolidea sp.*, Sarmatian, *Spirolina austriaca* zone, Perbál-5. borehole, depth 75.2-78.2 m;

12 - specimen with irregular chamber arrangement.
13 - twins specimen.

12-13 - N: 100x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NEW DATA PROVE LATE APTIAN – EARLY ALBIAN AGE OF KÖSZÖRŰKŐBÁNYA CONGLOMERATE MEMBER, GERECSE MOUNTAINS, HUNGARY

by

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(Received: 15th January, 1989)

Abstract

The coarsening-upward clastic sequence of Gerecse Mountains had long been considered as Lower Cretaceous shallow marine deposit, but recently its deep-sea origin becomes obvious. The latest sedimentological and palaeontological studies of the uppermost, conglomeratic unit have proved sedimentation in a submarine channel of a deep-sea fan. The nannoplankton assemblage from the intercalated siltstone layers shows Late Aptian – Early Albian age. Further investigations are necessary concerning the facies and the age of all Lower and Middle Cretaceous clastic deposits in the Gerecse Mountains as well as its relationship to the Rossfeld Formation in the Northern Calcareous Alps.

Introduction

Cretaceous clastic deposits in the Gerecse Mountains have already been known for more than a hundred years (HANTKEN, 1868). Not only the ammonite-rich marl but also the sandstone and the conglomerate were regarded as shallow marine sediments of Neocomian age (HOFMANN, 1884; SOMOGYI, 1914). Detailed description of this sequence is given by FÜLÖP (1958), who considered it as a result of gradual infilling of a shallow marine bay during Berriasian – Barremian intervall.

CSÁSZÁR and HAAS (1984) referred to the turbidity origin (PETTIJOHN – POTTER, 1964) of Bersek Marl and Lábatlan Sandstone Formations, but they didn't deal with Köszörűkőbánya Conglomerate Member. KÁZMÉR (1987) explained the genesis of the conglomerate by submarine mass-gravity transport (READING, 1978).

During the latest sedimentological study of the Conglomerate Member (SZTANÓ, 1988) some palaeontological investigations were carried out, too.

Geological setting

After a short interruption in sedimentation, Upper Tithonian limestones were followed by the initial breccia member of the Bersek Marl. This formation is built up by alternations of thick marl and thin sandstone layers. Large abrasional surfaces also occur. Upward turbiditic sandstone strata become abundant (Lábatlan Sandstone Formation), occasionaly with graded bedding, sole-marks, trace fossils and slump structures. These layers are rich in nektonic and planktonic fossils. Unfortunately the transition between Lábatlan Sandstone and the Köszörűkőbánya Conglomerate Member cannot be seen now. According to FÜLÖP (1958) the uppermost part of the Bersek hill section was a conglomerate layer which might have correlated with Köszörűkőbánya Member.

Different types of sandstones and conglomerates [suggesting resedimentation in fan environment (DAVIES – WALKER, 1974)] were described from some boreholes of Western Gerecse, named Neszmély Formation (CSÁSZÁR, personal communication). In addition in the foreground area a few outcrops counted to Lábatlan Sandstone show similar lithological and sedimentological features. Our knowledge about the age and the palaeogeographical connections of these clastics of Gerecse Mts is insufficient now.

More than a century ago HANTKEN (1868) pointed to the resemblance between Rossfeld Beds and these clastics of Gerecse Lower Cretaceous. In the Alp-Carpathian region there are other analogous development in the Ivanscica Mts. of the Dinarides. Both the Rossfeld Beds and the turbidites of Ivanscica Mts. bear high amount of ophiolithic detritus, with the dominance of chrome spinel in the heavy mineral spectra (DECKER et al., 1987). Unfortunately in the heavy mineral spectrum of Köszörűkőbánya Conglomerate we weren't able to identify chomre spinels. So thorough investigations are badly needed to prove the direct palaeogeographical connections between these deposits.

General sedimentary character of Köszörűkőbánya Conglomerate

Poorly stratified conglomerates alternate with greenish-grey sandstone and grey laminated siltstones in the unique outcrop of this conglomeratic unit *(fig. 1)*.

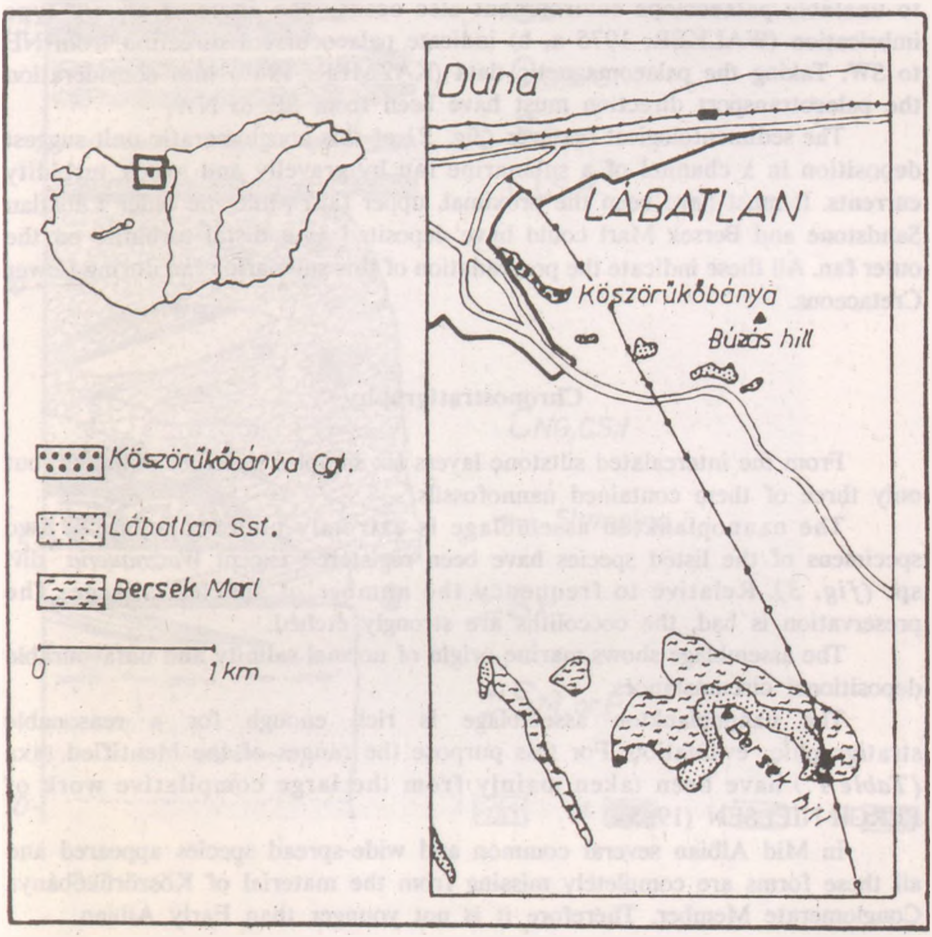

Fig. 1. Some outcrops of Lower and Middle Cretaceous formations in the northeastern foreground of Gerecse Mountains

The stratified, medium-to-coarse grained sandstone is pebbly, sometimes massive (HEIN, 1982). Occurrences of solitary cross-bedding of planar or trough type refer to traction currents. Thin strata of matrix supported, inversely graded conglomerates are also intercalated.

The clast supported, imbricated and graded conglomerate of channel-fill origin (WALKER, 1975 a, b) was incised into the underlying siltstone, producing scour marks. In this cherty conglomerate limestone boulders are abundant as well as large, up to 2 m long, intraformational rip-up-clasts of underlying sandstone and siltstone. Slump structures (KOSTER – STEEL, 1984) referring to unstable palaeoslope environment also occur. The angle of a/p/a/i/ type imbrication (WALKER, 1975 a, b) indicate palaeocurrent direction from NE to SW. Taking the palaeomagnetic data (KÁZMÉR, 1987) into consideration the palaeotransport direction must have been from SE to NW.

The sedimentological features *(fig. 2)* of this conglomeratic unit suggest deposition in a channel of a submarine fan by gravelly and sandy turbidity currents. It must have been the proximal, upper fan, while the older Lábatlan Sandstone and Bersek Marl could have deposited as a distal turbidite on the outer fan. All these indicate the progradation of this submarine fan during Lower Cretaceous.

Chronostratigraphy

From the intercalated siltstone layers six samples have been studied, but only three of them contained nannofossils.

The nannoplankton assemblage is extremly poor, only one or two specimens of the listed species have been registered except *Watznaueria* div. sp. *(fig. 3)*. Relative to frequency the number of species is large. The preservation is bad, the coccoliths are strongly etched.

The assemblage shows marine origin of normal salinity and unfavourable depositional circumstances.

The nannoplankton assemblage is rich enough for a reasonable stratigraphic evaluation. For this purpose the ranges of the identified taxa *(Table I.)* have been taken mainly from the large compilative work of PERCH-NIELSEN (1985).

In Mid Albian several common and wide-spread species appeared and all these forms are completely missing from the material of Köszörűkőbánya Conglomerate Member. Therefore it is not younger than Early Albian.

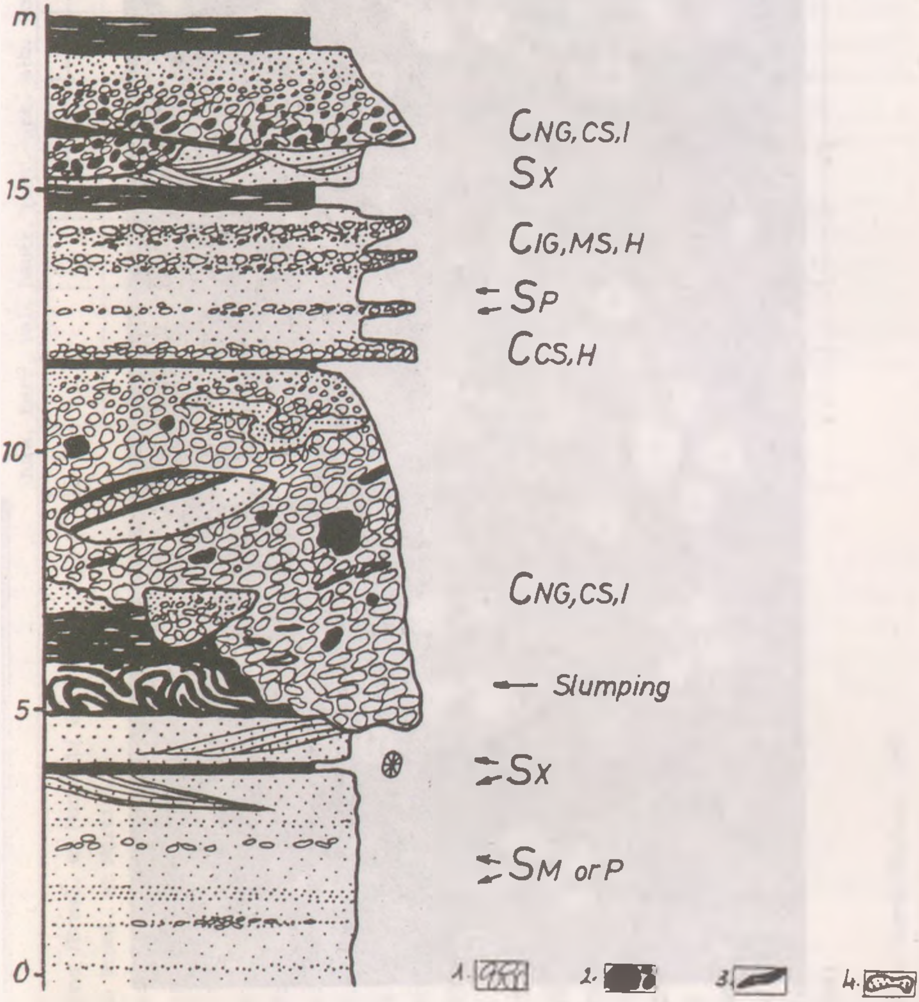

Fig. 2. Schematic section shows the most important sedimentological and lithological features of Köszörűkőbánya Member. C= conglomerate: NG= normal-, IG= inverse graded, CS= clast-, MS= matrix supported, I= imbricated, H= subhorizontal clasts; S= sandstone: P= pebbly, M= massive and, X= cross-stratified. Particles: 1= chert, 2= limestone, 3= siltstone, 4= sandstone rip-up-clasts, 5= Late Aptian – Early Albian nannoplankton assemblage.

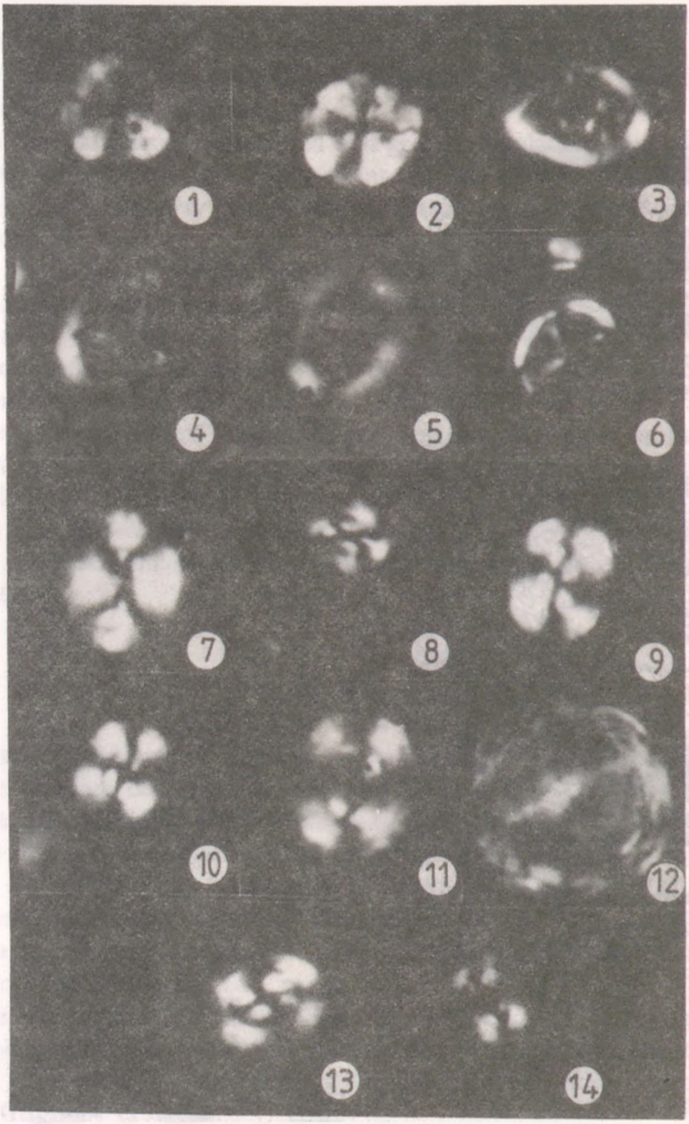

Fig. 3. Microscopic photographs of nannoplanktons from Köszörűkőbanya, magnification: 3000x (photos by M. BÁLDI-BEKE)

1. *Radiolithus planus* STOVER, +N, 2. *Radiolithus planus* STOVER, +N, the same specimen rotated by 45°, 3. *Rhagodiscus splendens* (DEFL.) +N, 4. *Cretarhabdus conicus* BRAML. et MARTINI, +N, 5. *Cretarhabdus conicus* BRAML. et MARTINI, +N, 6. *Chiastozygus amphipons* (BRAML. et MARTINI), +N, 7. *Watznaueria biporta* BUKRY, +N, 8. *Watznaueria barnesae* (BLACK), +N, 9. *Watznaueria barnesae* (BLACK), +N, 10. *Watznaueria barnesae* (BLACK), +N, 11. *Watznaueria barnesae* (BLACK), IIN, 12. Coccosphaera, probaby *Watznaueria* sp. not collapsed due to rapid burying, 13. *Watznaueria* sp., +N, 14. *Watznaueria* sp., +N.

Table I. Nannoplankton assemblage from Köszörűkőbánya, Lábatlan

	Jura.	berr.	val.	hautr.	barr.	apt.	alb.	cenom.	turon
Chiastozygus amphipons /Braml. et Martini/ Gartner					----	----	----	----	----
Cretarhabdus conicus Braml. et Martini		----	----	----	----	----	----	----	----
Cyclagelosphaera margereli Noël	----	----	----	----	----	----	----	----	----
Ellipsagelosphaera cf. fossacincta Black	----	----	----	----	----				
cf. britannica /Stradner/ Perch-Nielsen	----	----	----	----	----	----	----	----	----
Glaukolithus diplogrammus /Defl./ Reinhardt			----	----	----	----	----	----	----
compactus /Bukry/ Perch-Nielsen									
Haqius circumradiathus /Stover/ Roth				----	----	----	----	----	----
Microstaurus chiastius /Worsley/ Grün		----	----	----	----	----	----	----	
Nannoconus Steinmanni Kamptner	-	----	----	----	----	- -	- -		
Parhabdolithus embergeri /Noël/ Stradner	--	----	----	----	----	----	----	----	?
Placozygus fibuliformis /Reinhardt/ Hoffmann									
Prediscosphaera sp. ind.						--	----	----	----
Radiolithus planus Stover							----	--	
Rhagodiscus asper /Stradner/ Reinhardt		----	----	----	----	----	----	----	----
splendens /Defl./ Verbeek		----	----	----	----	----	----	----	----
Stoverius anchylosus /Stover/ Perch-Nielsen					? - -	- - --	----	----	- - ?
baldiae /Stradner et Adamiker/ Perch-Nielsen							----		
Vekshinella angusta /Stover/ Verbeek					----	----	----	----	----
Watznaueria barnesae /Black/ Perch-Nielsen	--	----	----	----	----	----	----	----	----
biporta Bukry	--	----	----	----	----	----	----	----	----
Zeugrhabdotus erectus /Defl./ Reinhardt	--	----	----	?					
"Zygolithus crux" Defl.		----	----	----	----	----	----	----	----

After Perch-Nielsen, 1985

Among the identified taxa the youngest species having its first occurrence is *Radiolithus planus* (STOVER). It is known only from Albian age. *Eprolithus floralis* (STRADNER) the one resembling species has its first appearance in Mid Aptian and it has nine radial elements too, but it is higher in shape. The uncertain range of *Stoverious baldiae* covers Albian. The earliest known *Prediscosphaera* species is from Late Aptian, but the genus is more common and characteristic from Early Albian upwards.

These data fix the stratigraphic position of Köszörűkőbánya conglomerate as Late Aptian – Early Albian, though Early Albian age is more probable.

In addition to the nannoplankton studies, the badly preserved *Orbitolina* fauna from siltstones and calcareous sandstones of Köszörűkőbánya conglomerate refers to Late Aptian – Albian age (GÖRÖG, personal communication). The small, simple and spherical embrionic apparatus, the zigzag shaped radial zone and marginal chambers dissected by flat secondary septa are characteristic of Middle Cretaceous forms, too. Smaller foraminifer had not been found yet.

Summary

It have been proved that Köszörűkőbánya Conglomerate Member, earlier believed Barremian, deposited during Late Aptian – Early Albian intervall, so a hiatus appeared on the stratigraphic column of Lower – Middle Cretaceous units of Gerecse Mountains *(fig. 4)*. Today we know little about sedimentation and deposits of this intervall. Perhaps Neszmély Formation might have filled up this gap, but further investigations are necessary.

Acknowledgements

We thank DR. CSÁSZÁR for drawing our attention to deposits of Köszörűkőbánya and for helpful discussions.

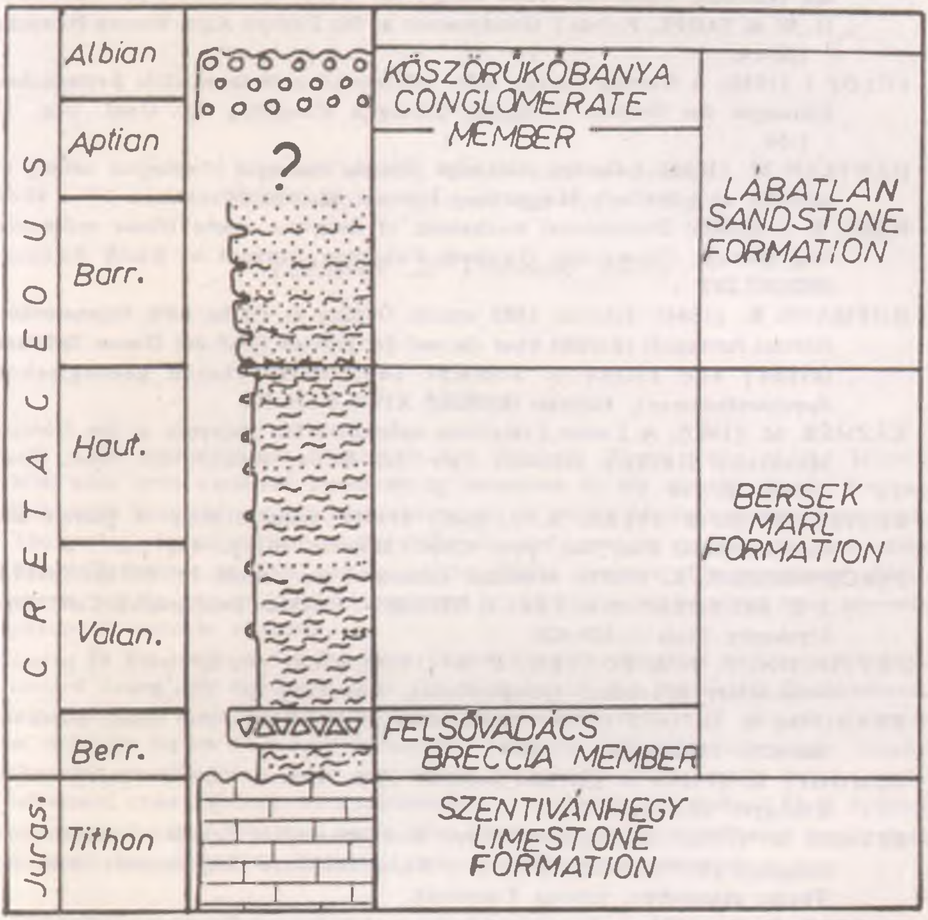

Fig. 4. Stratigraphy of Lower and Middle Cretaceous formations in Gerecse Mountains

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LATE NEOGENE TRANSPRESSION IN THE NORTHERN THRUST ZONE, MECSEK MTS., HUNGARY

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(Received: 20th February, 1989)

Abstract

The compressional features in the Northern Thrust Zone of the Mecsek Mts. have been explained previously by successive dip-slip tectonic phases. I argue that these features can be best understood in terms of transpressional tectonics. The geological cross-sections of the study area are based on raw material exploration data and indicate an E-W striking positive flower structure. The complexity of the system can be due to zones of weakness in the basement, inherited from previous phases of tectonic evolution.

To the south of the Northern Thrust Zone an elongated and narrow trough formed during the Neogene. Here the thickness of the continental fluvial/alluvial, lacustrine and marine sedimentary succession exceeds 1000 m. I propose a model of strike-slip furrow basin for this markedly deformed and asymmetric trough. Gravity deposits, synsedimentary folds are related to episodic displacements on the main left-lateral strike-slip fault. As a consequence of wrenching, the footwall block uplifted and it was the main source of clastic influx for the adjacent basin, although longitudinal drainage also played an important role in sedimentary evolution.

Introduction

The Mecsek region is an elevated Upper Paleozoic-Mesozoic block in the southwestern part of the Pannonian Basin, which is outcropping from the Miocene to Quaternary basin fill. Its northern margin is made up by the Northern Thrust Zone (NTZ), which is a Mesozoic horst covering an area of about 15 km by 5 km with an elongation of E-W strike (insets of *Fig. 1*). It is considered the structurally most complex region of the Mecsek Mts. (WEIN, 1965). This complexity originated from superposition of different tectonic phases, and the younger deformations are influenced by the older lines of weakness.

The two-stage Austrian orogenic phase affected the Mecsek Mts. in the Cretaceous (VADÁSZ, 1935, WEIN, 1964, 1965, 1966, NÉMEDI VARGA, 1983). It deformed the Mesozoic strata into large amplitude, NW-vergent asymmetric folds and produced NW-directed thrusts. There was, however, a period of Cretaceous extension characterized by phonolite intrusions and normal faults perpendicular to the strike of the fold-belt (NÉMEDI VARGA, 1983).

Due to the large stratigraphic hiatus between the Upper Cretaceous and the Lower Miocene series there are only indirect evidences for a Paleogene(?) tectonic phase. Deformation due to a WNW-directed compressional stress field can be observed at different Mesozoic sites in the Mecsek Mts. and no trace of it could be found in Miocene rocks (BERGERAT and CSONTOS, 1989). The deformation is characterized by E-W striking right-lateral and NW-SW to N-S striking left-lateral faults.

The most important tectonic phase in the structural evolution of the NTZ took place in the Neogene (WEIN, 1964, 1965, 1966, MAUL, 1971, NÉMEDI VARGA, 1973, 1983, BERGERAT and CSONTOS, 1989). The development of the whole Pannonian region during this time interval was dominated by extensional normal faults and related transcurrent faults (HORVÁTH and ROYDEN, 1981, ROYDEN et al. 1983, HORVÁTH et al. 1987). Faulting culminated during the Middle and Late Miocene, but locally minor activity continued during the Pliocene. RUMPLER and HORVÁTH (1988) show that late Miocene through Pliocene compressional structures can also be found in the Pannonian Basin, and they are probably related to discontinuous and/or convergent strike-slip faults.

The purpose of this paper is to demonstrate transpressional structural development during the Neogene in the NTZ and to examine the tectonic control on sedimentation in this area.

Stratigraphy of the Northern Thrust Zone

The pre-Tertiary basement of the study area is composed of Mesozoic rocks. For a detailed description of the Triassic and Jurassic carbonates and Lower Cretaceous mafics, the reader is referred to WEIN (1965). To understand the Late Cenozoic evolution of the NTZ it is important to briefly summarize the stratigraphy of the Neogene series. The systematic investigation of these deposits in the eastern Mecsek was carried out by HÁMOR (1971). Based on his monograph a simplified synthetic stratigraphic column has been constructed for the NTZ. *(Fig. 2)*. HÁMOR (1971) suggested three major sedimentary cycles in the Miocene:

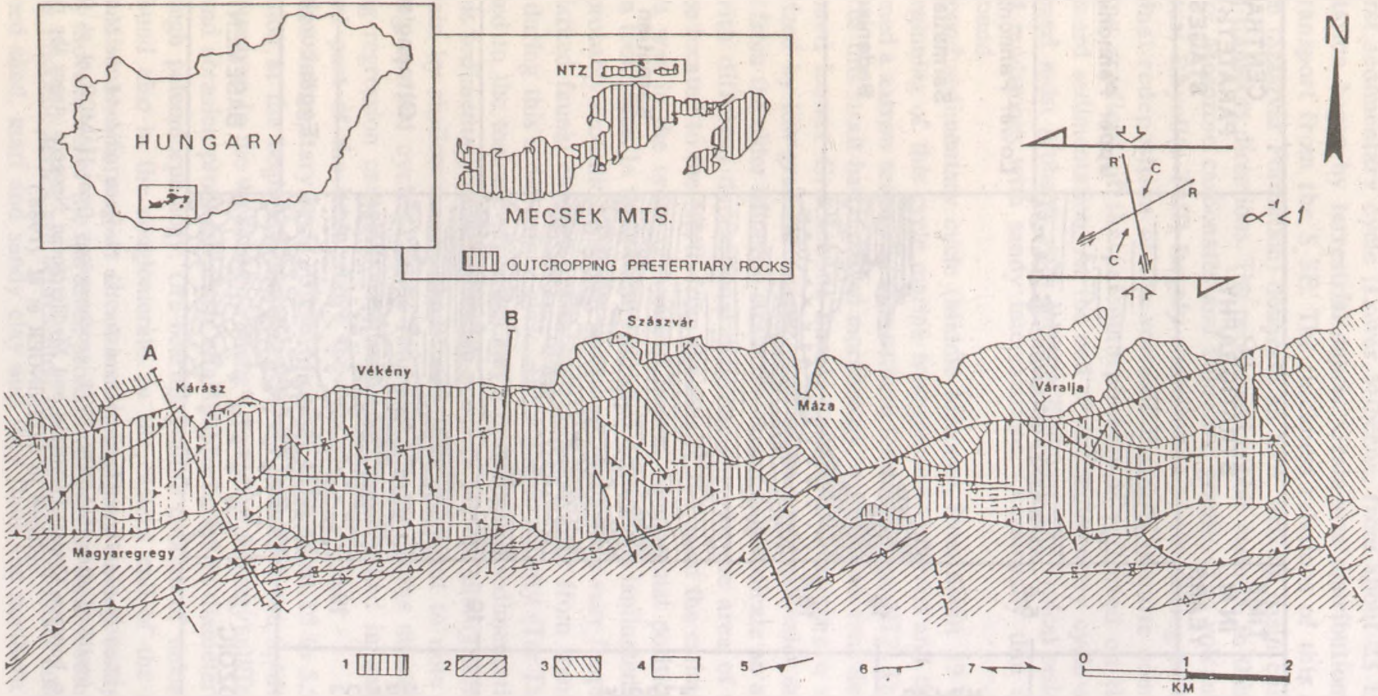

Fig. 1. Simplified geologic map of the Northern Thrust Zone. Insets show location of map. Diagram shows the orientation pattern of faults during sinistral simple shear under transpression (from SANDERSON and MARCHINI, 1984). C, compression axis, R,R', RIEDEL shears or strike-slip fault, 1, Mesozoic, 2, Miocene, 3, Pliocene, 4, Quaternary, 5, thrust, 6, normal fault, 7, wrench fault.

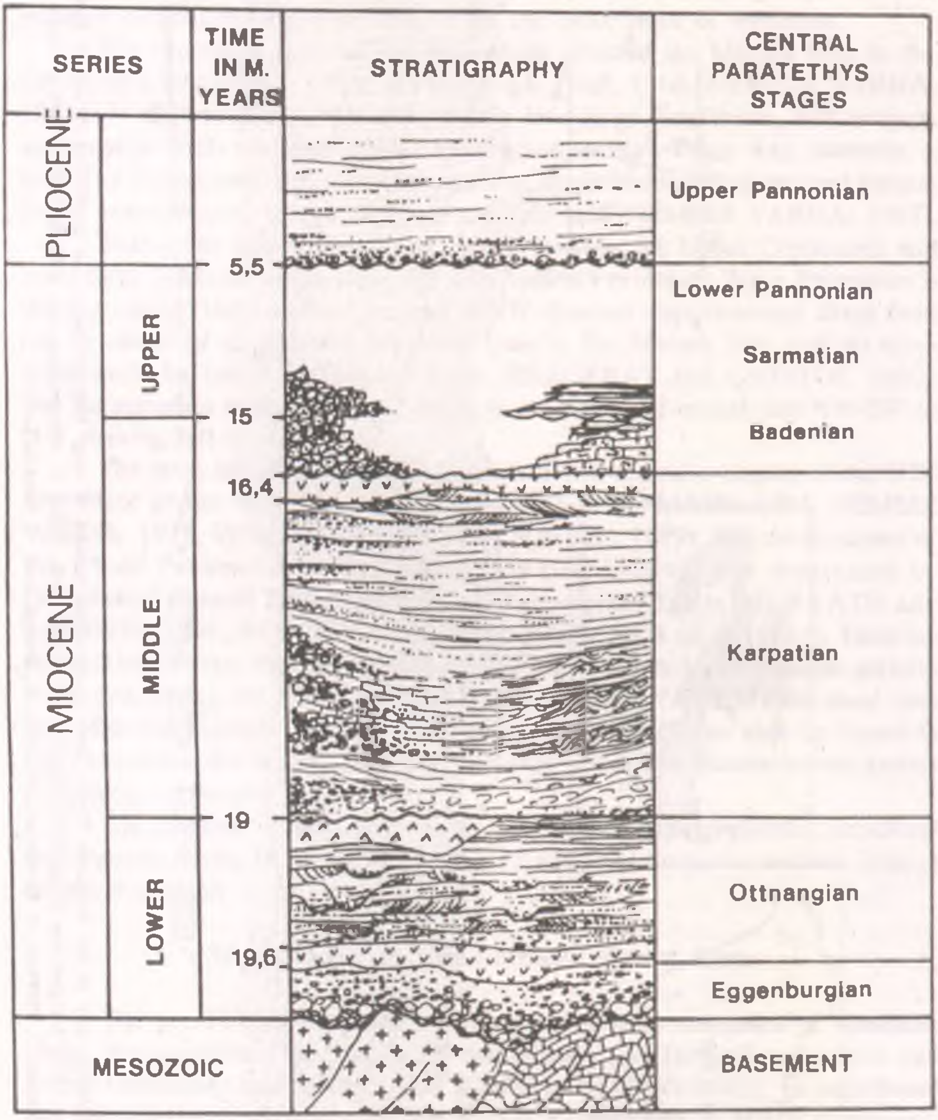

Fig. 2. Simplified synthetic stratigraphic column for the Neogene series of the Northern Thrust Zone (modified after HÁMBOR 1971, geochronology from HÁMOR et al. (1987)). For correlation between Central Paratethys and Mediterranean Neogene stages the reader is referred to STEININGER et al. (1988.)

First sedimentary cycle (Lower Miocene, from about 23 to 19 Ma). Sedimentation began by terrestrial debris. Grain-size distributions indicate fluvial transport from the S-SE. The thickness relations of this sandstone succession (Szászvár Formation) delineate an E-W striking basin characterized by lateral-transport directions. The pebble and cobble material in these deposits consists of Mesozoic carbonates and Paleozoic granite. The volcanic activity (Gyulakeszi Rhyolite Tuff) largely contributed to the filling of this basin. Intrabasinal redeposition of the volcanic material is quite common. The decreasing gradient of the paleomorphology is reflected on the overall fining-upward sedimentation. At the end of the sedimentary cycle continental lakes formed most probably with interior drainage. The typical sediments are laminated mudstones with sandy intercalations. Occasionally thin coal seams can be found.

Second sedimentary cycle (Middle Miocene, from about 19 to 15 Ma). At the beginning of this cycle marine transgression occurred and the elongate basin formed a narrow seaway in the southern foreland of the NTZ. The northern shoreline of this strait had a cliffed morphology, with alluvial fans derived from the exposed Lower Cretaceous basalt upland. The southern shore was characterized by low-gradient coastal plain made up of polymict sand, partly reworked from the older Miocene strata. Thickness data indicate an asymmetric graben with different depositional environments. In the area of maximum subsidence located to the North from the axis of the basin the estimated depth of the sea was in the order of hundred meters. In marginal position lagoonal deposition took place. In these local, restricted depressions laminated mudstones formed, probably recording seasonal variations. Slumps are very frequent in this strata. Marked faunal changes are thought to be resulted from transgressional episodes during this sedimentary cycle. The volcanic activity (Tar Dacite Tuff) was related to the tectonic processes and influenced the sedimentation. At the end of this sedimentary cycle regression occured. Marine silts (Tekeres Schlier) are overlain by shallow-marine sandstones. It is important to note that some coarsening-upward cycles can be found in the sandstone succession. The continuing regression caused by tectonic uplift has resulted in emergence of the central part of the basin above the sea level.

Third sedimentary cycle (Upper Miocene, from about 15 to 5,5 Ma). The transgression at the beginning of this cycle did not reach the uplifted central terrain. However, in the western end of the area (Magyaregregy) cliffed seashore formed, and abrasion produced clasts attaining several m in diameter indicating a very rough paleomorphology. Ore-bearing granite cobbles of unknown origin can be found also in the conglomerate. In the eastern end of the study area (Hidas) coal seams formed at the same time. This strata recorded vertical oscillatory movements of the sea level, probably caused by local tectonic activity.

The Pliocene series are represented by transgressive basal conglomerate, fine-grained sand, marl and sandy clay and they flank the northern margin of the NTZ (KLEB, 1973). A foredeep with E-W strike formed during this time. The depth of it exceeds 600 m (WEIN, 1965).

Structure of the Northern Thrust Zone and previous concepts about its formation.

Fig. 1 shows a simplified tectonic map of the NTZ after WEIN (1965). His surface mapping was carried out in 1:5000 scale and he took into consideration all the subsurface data which was available from the intensive coal mining and raw material exploration in the area. Two geological cross-sections presented in *Fig. 3/a* and *Fig. 4/a* are redrawn after WEIN (1965). These sections clearly demosntrate the structural complexity of the NTZ.

WEIN (1964, 1966) proposed a model of successive north and south directed dip-slip tectonic phases to explain the structural development of the region *(Fig. 5)*. In his model the formation of the narrow, deep Miocene graben was due to regional N–S extension *(Fig. 5/A)*. This asymmetric and elongate trough was superimposed on the Mesozoic basement. In the Upper Miocene the thick sedimentary infill of the graben was folded and overthrust by Mesozoic rocks during the Attican orogenic phase *(Fig. 5/B)*. According to WEIN (1964) this compressional episode generated all the S-vergent thrusts in the NTZ and thus formed an asymmetric "wedge structure". Thrust planes are usually very steep, even overturned locally (see *Fig. 4*).

After the Attican phase, during the uppermost Miocene and Pliocene, another extensional basin formed to the North of the NTZ *(Fig. 5/C)*. At the end of the Pliocene (Rhodanian compressional phase) the Mesozoic of the NTZ was thrust onto this throught *(Fig. 5/D)*. It is proven by drillhole data (WEIN, 1965). The magnitude of the overthrust exceeds 1 km along a low-angle, S-dipping fault plane. All of these led to the development of a symmetric "wedge structure". WEIN (1965) thought all the N-vergent Neogene thrusts as a result of the Rhodanian tectonic stage and considered them rejuvenated Cretaceous faults.

In contrast, HÁMOR (1971, p. 332) concluded that there was no evidence for structures originated during the Attican phase in the region. In his model terrestrial deposition began along NE-trending normal faults during the Savian orogenic cycle in the Early Miocene. Later, in the Middle Miocene two-stage Styrian phase created dominantly NW striking faults. HÁMOR (1971) similarly to WEIN (1964, 1965) considered the Pliocene Rhodanian phase as the most important period in the Neogene structural evolution of the NTZ. However, in contrast to WEIN (1964), he postulated that the S-vergent and N-vergent compressional structures formed contemporaneously during the Rhodanian phase. Finally, during the Quaternary the whole area suffered an uplift of some hundred meters.

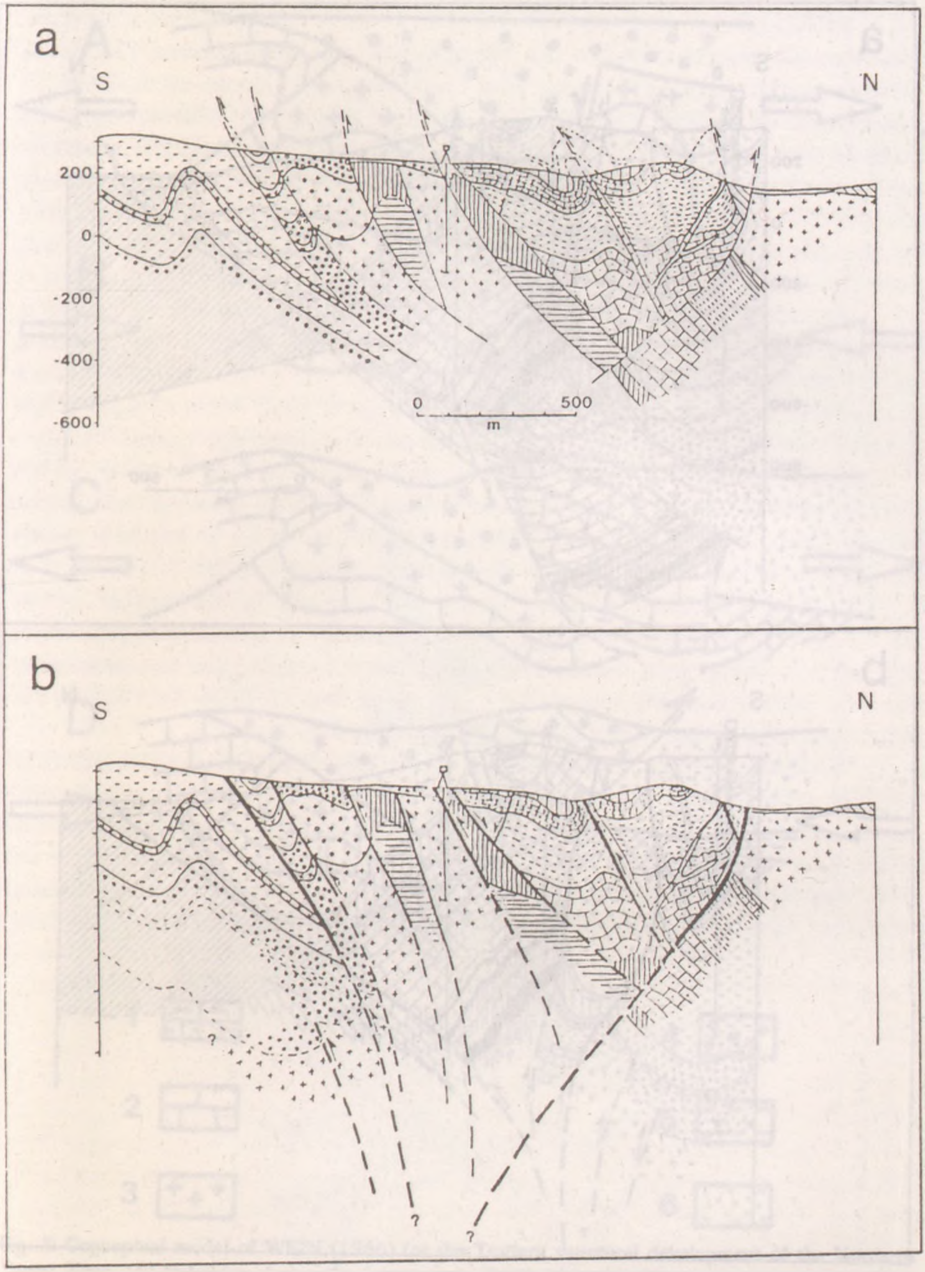

Fig. 3. (a) Geological cross-section A across Northern Thrust zone (from WEIN, 1965). See Fig. 1 for location of profile.
(b) Interpreted version of cross-section A indicating a positive flower structure (HARDING, 1985).

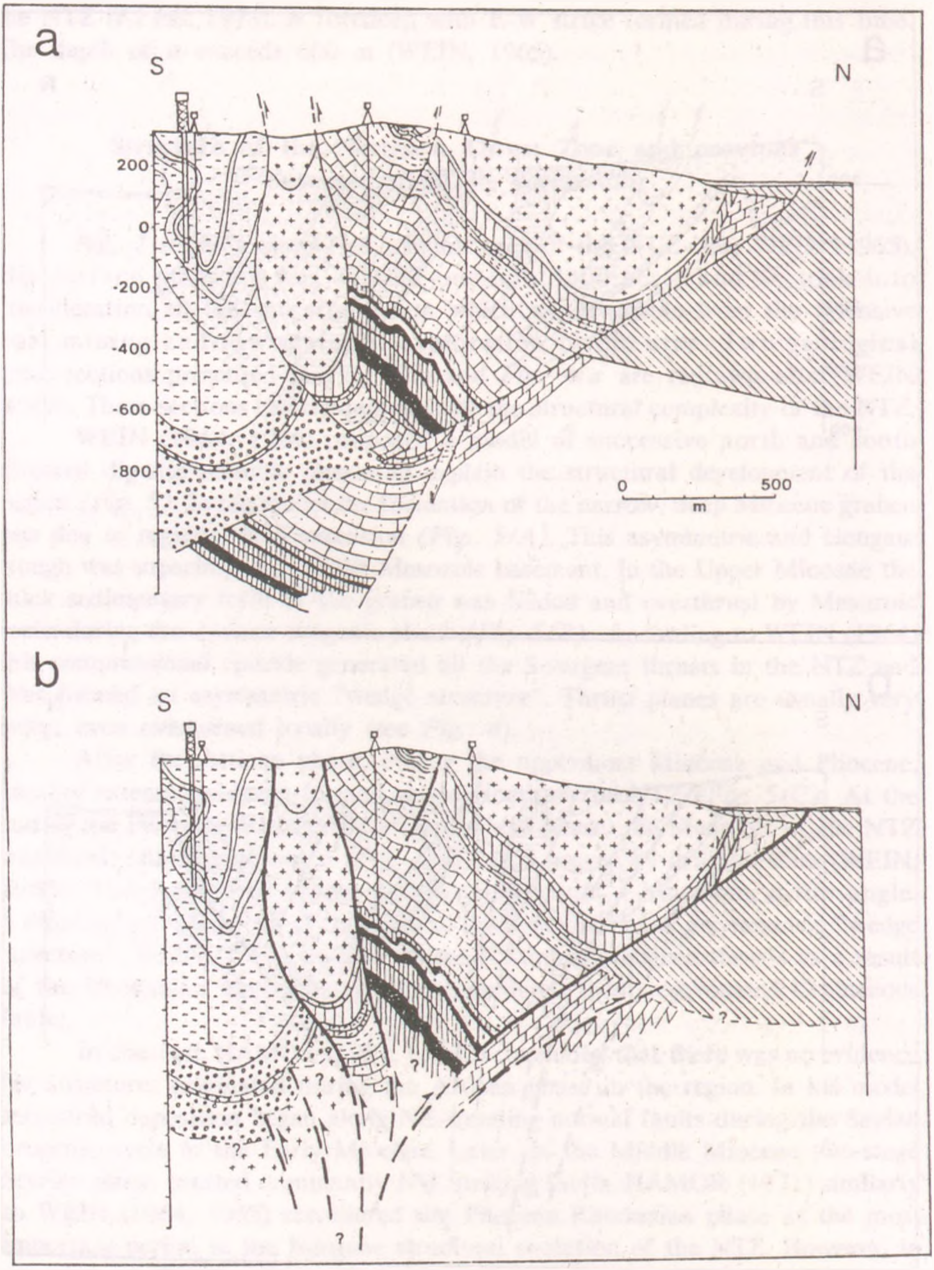

Fig. 4. (a) Geological cross-section B across Northern Thrust Zone (from WEIN, 1965). See Fig. 1 for location of profile
(b) Interpreted version of cross-section B indicating a positive flower structure (HARDING, 1985) or palm-tree structure (SYLVESTER and SMITH, 1976.)

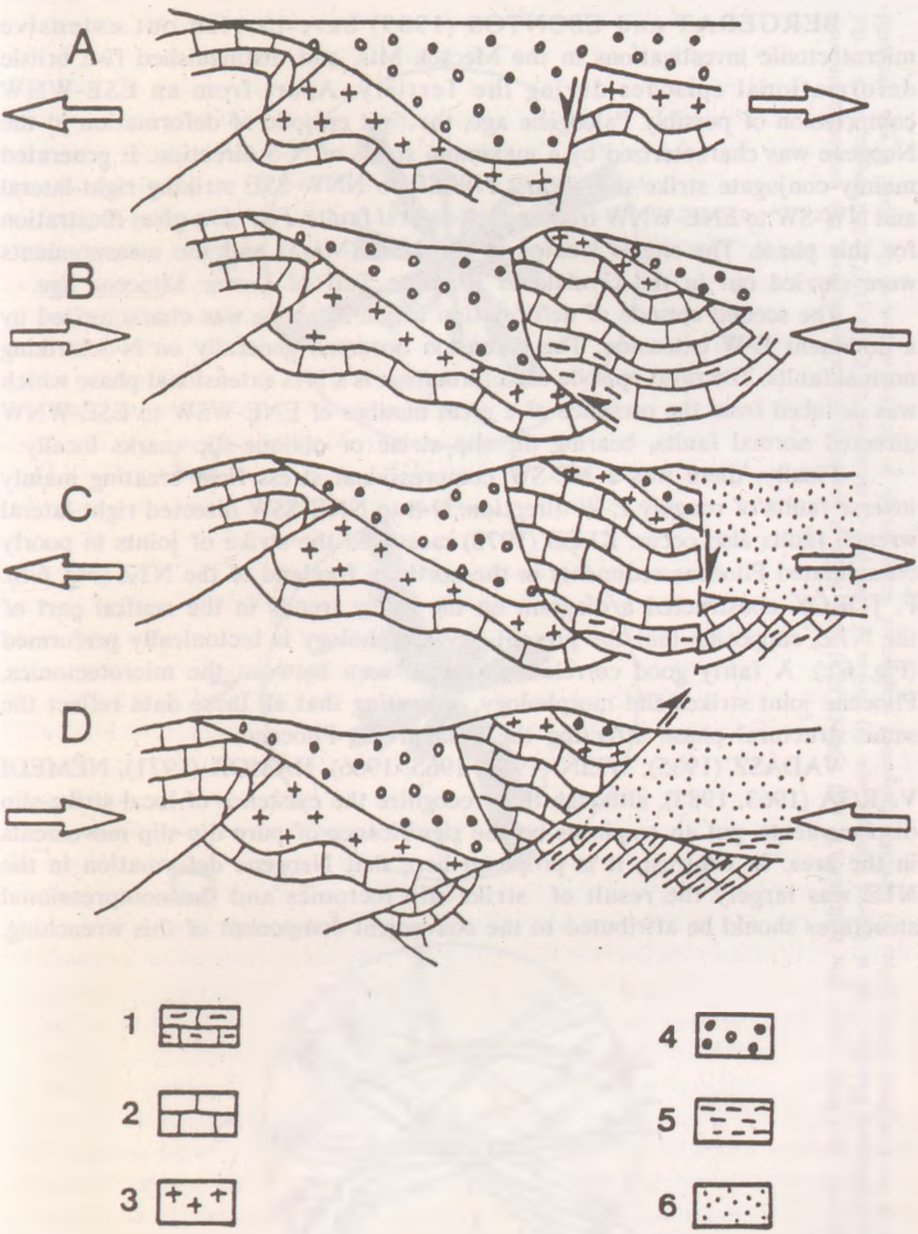

Fig. 5. Conceptual model of WEIN (1966) for the Tertiary sturctural development of the Northern Thrust Zone. (A) Extension during the Lower and Middle Miocene. (B) Compression in the Upper Miocene (Attican orogenic phase) and formation of an asymmetric "wedge structure". (C) Extension during the Pliocene. (D) Compression at the end of the Pliocene (Rhodanian orogenic phase) and formation of a symmetric "wedge structure" Legend: 1, Triassic, 2, Jurassic, 3, Lower Cretacous 4, Early to Middle Miocene, 5, Upper Miocene, 6, Pliocene.

BERGERAT and CSONTOS (1989) have carried out extensive microtectonic investigations in the Mecsek Mts. and distinguished five brittle deformational episodes during the Tertiary. Apart from an ESE-WNW compression of possibly Paleogene age, the first episode of deformation in the Neogene was characterized by a maximum stress of N-S direction. It generated mainly conjugate strike-slip shears: NW-SE to NNW-SSE striking right-lateral and NW-SW to ENE-WNW trending left-lateral faults. *Fig. 6/a* gives illustration for this phase. The site is located in the NTZ (Máza) and the measurements were carried out in the Gyulakeszi Rhyolite Tuff of Lower Miocene age.

The second episode of deformation in the Neogene was characterized by a dominant E-W extension. The extension occurred generally on N-S striking normal faults. The third episode of deformation is a N-S extensional phase which was deduced from the presence of a great number of ENE-WSW to ESE-WNW directed normal faults, bearing dip-slip striae or oblique-slip marks locally.

Finally, there was a NE-SW compressional stress field creating mainly inverse faults of roughly E-W direction. N-S to NNE-SSW directed right-lateral wrench faults also occur. KLEB (1973) measured the strike of joints in poorly consolidated Pliocene sediments in the northern foreland of the NTZ (Fig. 6/b). F. TÖRÖK constructed a diagram on the valley trends in the central part of the NTZ, supposing that the present-day morphology is tectonically preformed (Fig. 6/c). A fairly good correlation can be seen between the microtectonics, Pliocene joint strikes and morphology, indicating that all these data reflect the same structural phase affecting the area in the Pliocene.

VADÁSZ (1935), WEIN (1964, 1965, 1966), HÁMOR (1971), NÉMEDI VARGA (1963, 1983), although they recognize the existence of local strike-slip displacements, put an emphasis on the significance of pure dip-slip movements in the area. In contrast, it is proposed here that Neogene deformation in the NTZ was largely the result of strike-slip tectonics and the compressional structures should be attributed to the convergent component of this wrenching.

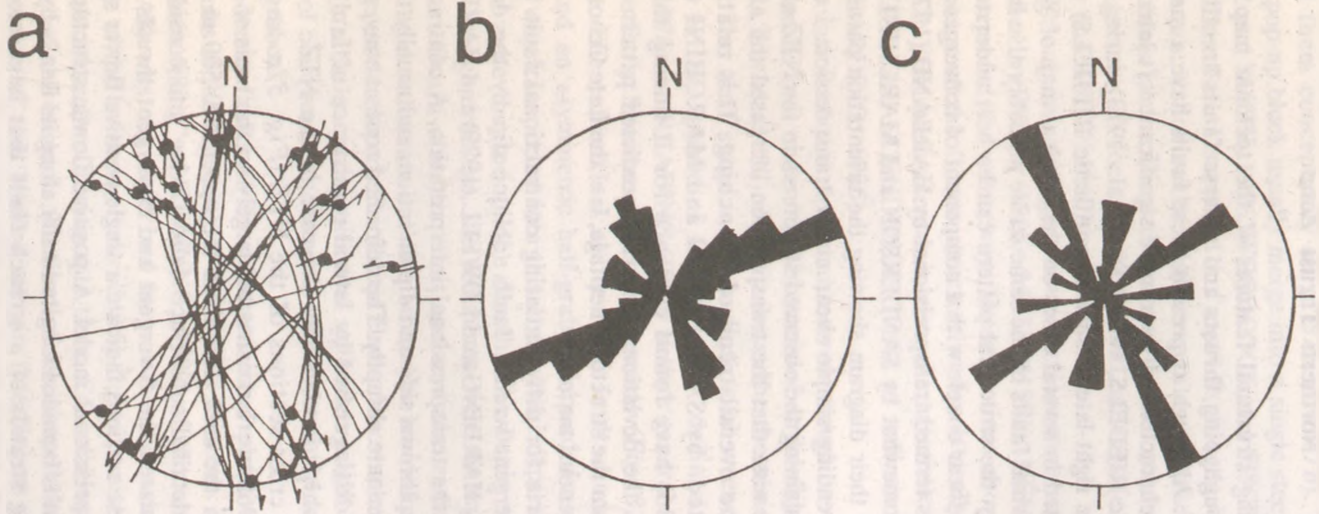

Fig. 6. (a) Microtectonic data from Máza after BERGERAT and CSONTOS (1989). Schmidt projection, lower hemisphere. The measurements were carried out on the Gyulakeszi Rhyolite Tuff of Lower Miocene age. (b) Strikes of fault planes measured by KLEB (1973) in Pliocene sands in the northern foreland of the Northern Thrust Zone. (c) Direction frequency diagram of valley trends in the central part of the Zone. It was computed by. F. TÖRÖK.

Tectono-sedimentary model for the Late Cenozoic evolution of the Northern Thrust Zone

The most striking structural features of the tectonic map of the NTZ *(Fig. 1)* are the throughgoing thrusts and reverse faults trending generally between N40° – N90°. Although at present these faults have a marked reverse separation, they were characterized by a more significant left-lateral strike-slip displacement (synthetic RIEDELS, WILCOX et al., 1973) during their earlier activity. The conjugate right-lateral shears (antithetic RIEDELS) strike to the NNW as it was indicated in several cases on the original map of WEIN (1965). I speculate, that the normal faults of the same strike probably also have a dextral component. In this way the structural pattern can be best understood in terms of a left-lateral simple-shear couple with a component of convergence. This class of strike-slip faults was termed transpressional by HARLAND (1971). The term has been generalized somewhat by SANDERSON and MARCHINI (1984). *Fig. 1* is a reproduction of their diagram showing the orientation patterns of faults during sinitral E-W trending simple shear under transpression. I consider this model plausible for explaining the observed structures in the NTZ of the Mecsek Mts. It is important to note that the transpression increased the angle between the RIEDELS and the overall trend of wrenching. This relationship was theoretically predicted by SANDERSON and MARCHINI (1984), and NAYLOR et al. (1986) have found evidence for it during their sandbox experiments. Hovewer, the deviations from the predicted pattern in the NTZ might have resulted from the structural heritage, i. e. the Late Cenozoic shearing deformed an inhomogenous material.

Structural criteria for differentiating contractional fault blocks (pure reverse-slip) and convergent wrench faults (oblique-slip by the dominance of wrenching) are given by HARDING and LOWELL (1979) and HARDING (1985) and they also support the transpressional interpretation. A contractional block fault has a consistent upthrown side and dip direction, and usually the boundary faults intersect and terminate abruptly. The deformed zone at convergent wrench faults, in contrast, is distinguished by lateral persistence of faults, including changes in vergence which is obviously the case in the NTZ.

The geological cross-sections of the NTZ (*Fig. 3/a* and *Fig. 4/a*) published by WEIN (1965) were constructed largely on the basis of data coming from the coal mines in the area. Therefore the upper 400-500 m parts of the profiles are based on detailed subsurface data. Taking into consideration that HÁMOR (1971) postulated the S-vergent and N-vergent thrusts and reverse faults synchronous, these sections indicate a single positive flower structure and this supports the transpressional model. A positive flower structure is defined as a linear antiform that is bounded longitudinally along its flanks by the upward and outward diverging strands of a wrench fault that have mostly reverse separations (HARDING, 1985). Since the lower portions of the profiles are poorly known and were constructed only tentatively by WEIN (1965), I reinterpreted them conceptually (*Fig. 3/b* and *4/b*). The flower "petals" bounding the pop-up block usually merge into a single steep fault plane at depth (SYLVESTER and SMITH, 1976, WOODCOCK and FISCHER, 1986, NAYLOR et al. 1986). Therefore I supposed a "root" fault-zone beneath the structure on which the whole horizontal displacement was taken up. Moreover, my interpreation takes into account the convex-upward geometry of fault branches which is characteristic for transpressional settings (e. g. LOWELL, 1972, SYLVESTER and SMITH, 1976).

Although only two geological corss-sections were repeated here, the many others, published by WEIN (1965), MAUL (1971), NÉMEDI VARGA (1971) should be interpreted the same way. These sections show high variability, the internal geometry of the flower structure varies laterally from place to place along the NTZ. This phenomenon is also characteristic for flower structures (e. g. DuPLESSIS and CLENDENIN, 1988) as well as the fault architecture asymmetry (HARDING, 1985).

The evolution of the elongated, narrow trough in the southern foreland of the NTZ can be best understood in terms of strike-slip furrow basin defined by MONTENAT et al. (1987). *Fig.* 7. shows the theoretical evolution of basins of this type. The first stage in the evolution of wrench furrows (Fig. 7/A) corresponds to the "phase of transtension" defined by MITCHELL and READING (1978) and READING (1980) in their general strike-slip cycle model. I ascribed the Early Miocene paleoenvironments *(Fig. 8)* of the studied basin to this stage. The subvertical oblique-slip faults had a dominant dip-slip component and an asymmetric half-graben formed during this time. Most of the basin fill was transported into this continental depression by rivers and the source areas were located to the South. The basin was characterized by longitudinal through-drainage, the sediments were transported to the West by an axial river. Grain-size distributions and the ratio of channel fill and fine-grained flood sediments indicate an earlier braided axial river from which a meandering one developed. The abrupt channel movements (avulsions) recorded by frequent intrabasinal redeposition of sediments might have originated during the episodes of oblique-slip movements on the dominant northern boundary fault of the half-graben.

The normal faults of the transtensional phase reactivated mostly as strike-slip faults at the beginning of the Middle Miocene. This intermediate stage ("phase of basin filling" of READING, 1980) of the wrench furrow evolution (see *Fig. 7/B*) was characterized by marine sedimentation *(Fig. 8)*. The northern edge of the basin was controlled by the most mobile wrench fault which defined a paleoshoreline during this time. Coarse clastics from the uplifted footwall reached the basin in the form of fan shaped debris cones and aprons. The conglomerate of this faulted margin interfingers with fine-grained mud sediments of the basin interior.

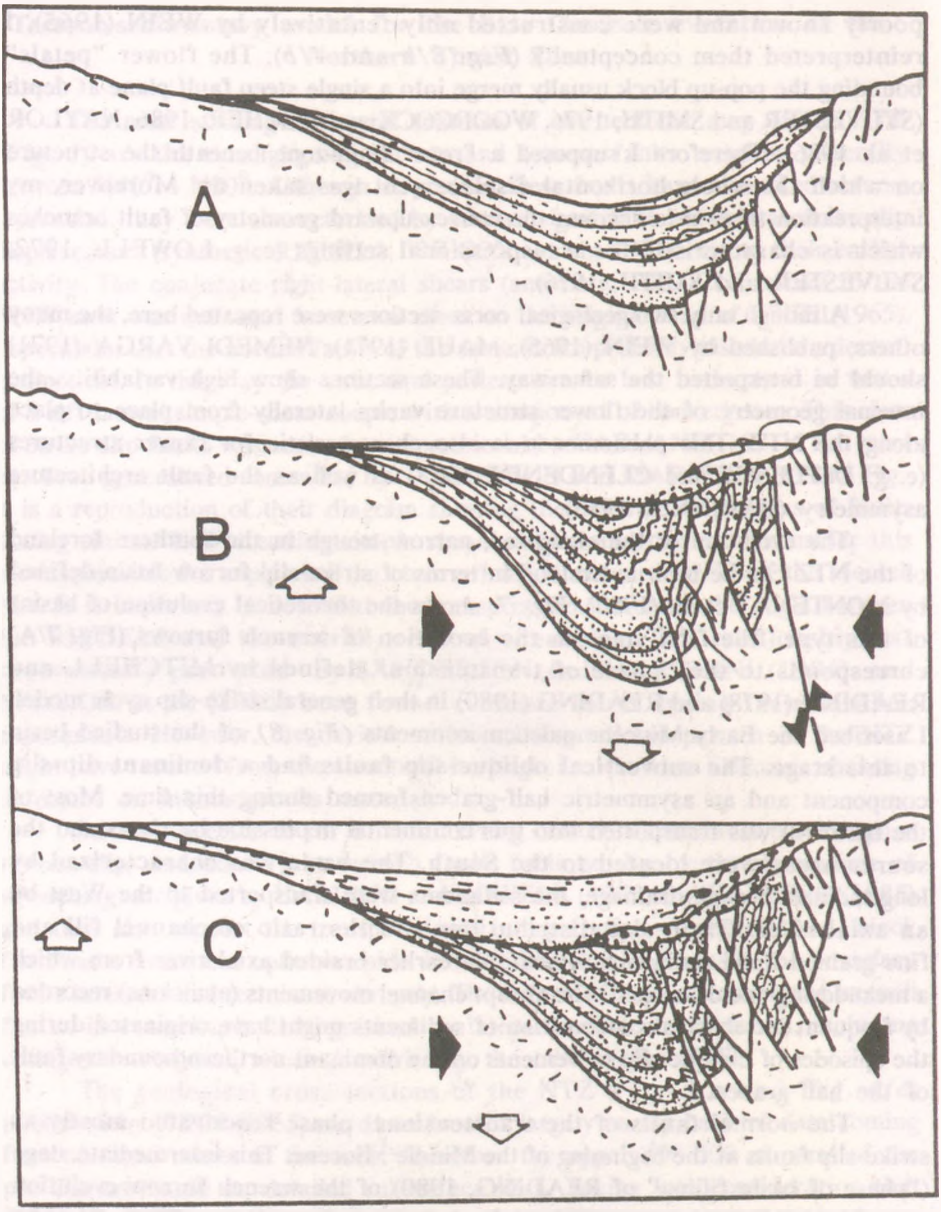

Fig. 7. Theoretical evolution of a wrench fault furrow basin after MONTENAT et al. (1987). (A) Formation of the furrow by transtensional tectonics. (B) Early synsedimentary tectonics controlled by reverse faults, drag faults, inducing a large mobility of basement detached blocks. (C) Raising of the first furrow inducing a centrifugal migration of the maximum subsidence axis. This model is considered plausible for the interpretation of tectono-sedimentary evolution of the NTZ.

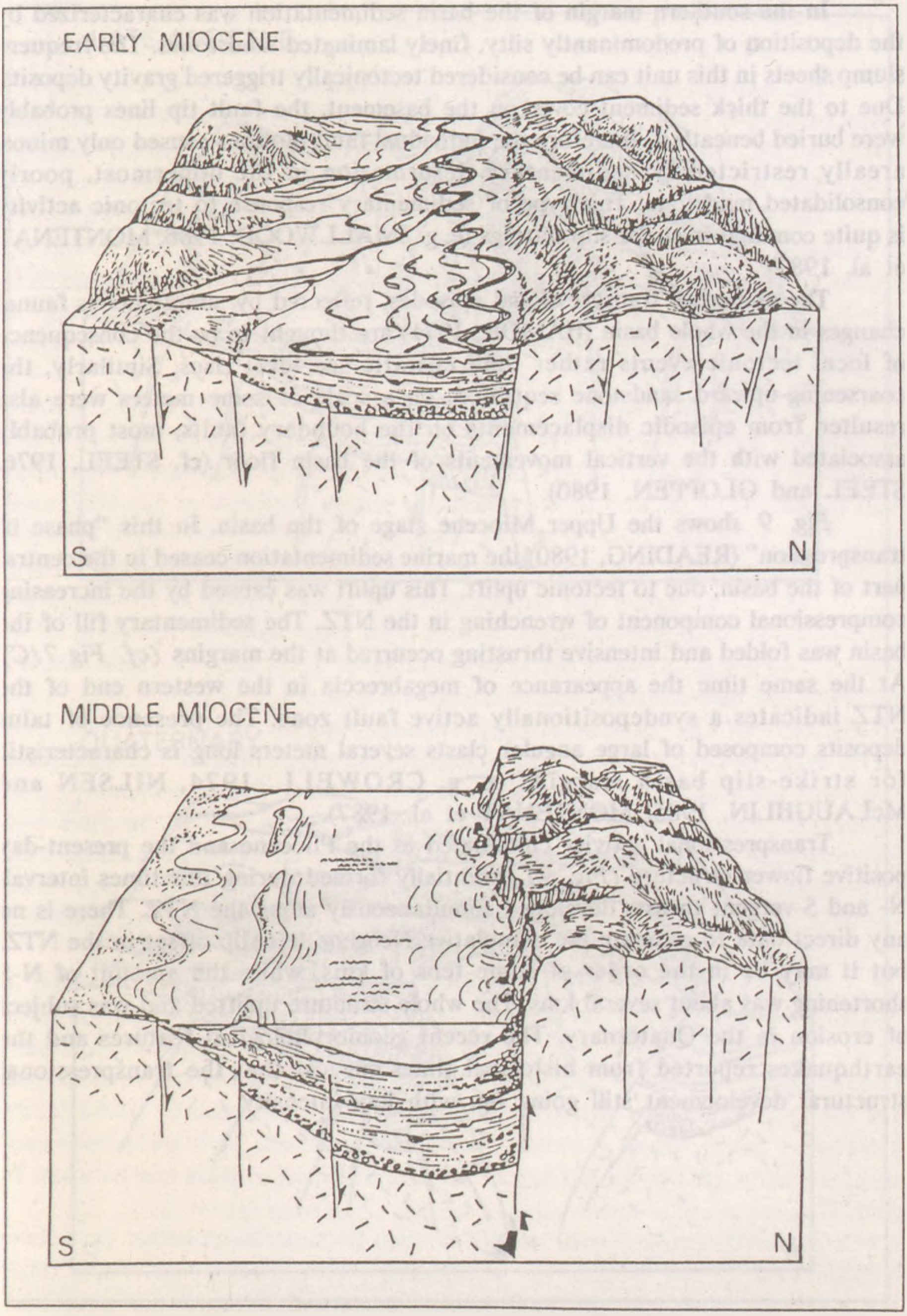

Fig. 8. Reconstructed Early Miocene and Middle Miocene paleoenvironments of the Northern Thrust Zone and its surroundings.

In the southern margin of the basin sedimentation was characterized by the deposition of predominantly silty, finely laminated mudstones. The frequent slump sheets in this unit can be considered tectonically triggered gravity deposits. Due to the thick sediment cover on the basement, the fault tip lines probably were buried beneath it, therefore the individual fault motions caused only minor, areally restricted synsedimentary deformation in the uppermost, poorly consolidated mudstone. This type of sedimentary response to tectonic activity is quite common in strike-slip settings (e. g. SMALLWOOD, 1986, MONTENAT et al. 1987).

The numerous transgressional episodes, reflected by simultaneous faunal changes in the whole basin (HÁMOR, 1971) are thought to be the consequence of local tectonic events rather than eustatic sea level rises. Similarly, the coarsening-upward sandstone sequences on a scale of some meters were also resulted from episodic displacements on the boundary faults, most probably associated with the vertical movements of the basin floor (cf. STEEL, 1976, STEEL and GLOPPEN, 1980).

Fig. 9 shows the Upper Miocene stage of the basin. In this "phase of transpression" (READING, 1980) the marine sedimentation ceased in the central part of the basin, due to tectonic uplift. This uplift was caused by the increasing compressional component of wrenching in the NTZ. The sedimentary fill of the basin was folded and intensive thrusting occurred at the margins *(cf. Fig 7/C)*. At the same time the appearance of megabreccia in the western end of the NTZ indicates a syndepositionally active fault zone. The presence of talus deposits composed of large angular clasts several meters long is characteristic for strike-slip basin margins (e. g. CROWELL, 1974, NILSEN and McLAUGHLIN, 1985, MONTENAT et al. 1987).

Transpressional activity culminated in the Pliocene and the present-day positive flower structure *(Fig. 9)* essentially formed during this times interval. N- and S-vergent thrusts developed simultaneously along the NTZ. There is no any direct data to estimate the cumulative Neogene left-slip offset in the NTZ, but it may be in the order of some tens of kms, while the amount of N-S shortening was about several kms. The whole structure uplifted and was subject of erosion in the Quaternary. The recent geomorphological features and the earthquakes reported from historical times suggest that the transpressional structural development still going on, with less intensity.

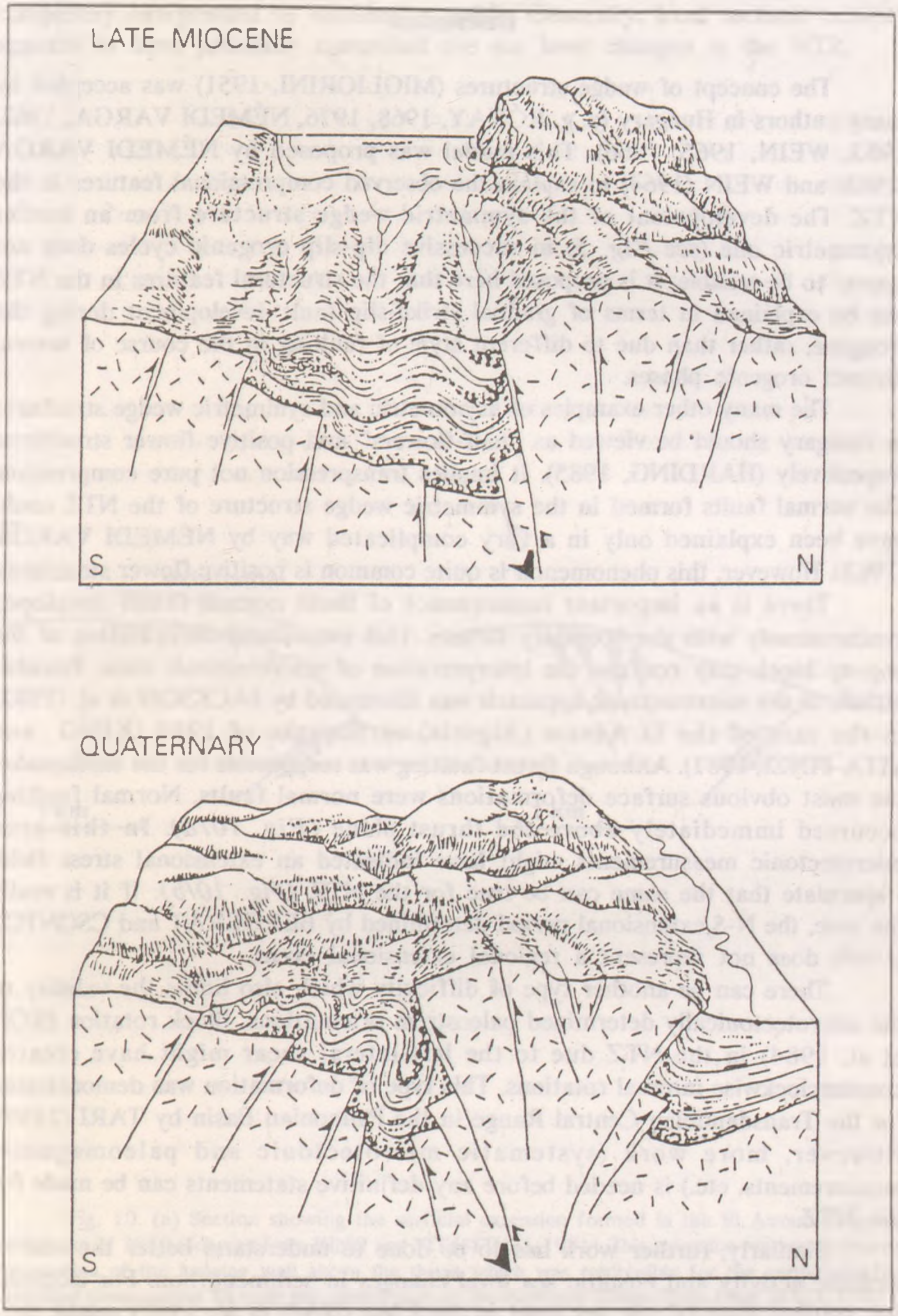

Fig. 9. Reconstructed Upper Miocene and Quaternary paleoenvironments of the Northern Thrust Zone and its surroundings.

Discussion

The concept of wedge structures (MIGLIORINI, 1951) was accepted by many authors in Hungary (e. g. KÓKAY, 1968, 1976, NÉMEDI VARGA, 1963, 1983, WEIN, 1965, 1966). This model was proposed by NÉMEDI VARGA (1963) and WEIN (1964) to explain the observed compressional features in the NTZ. The development of the symmetric wedge structure from an earlier asymmetric one (see *Fig. 5*) in successive dip-slip orogenic cycles does not appear to be tenable. It is proposed here that the structural features in the NTZ can be explained in terms of gradual strike-slip fault development during the Neogene, rather than due to different style of faulting in the course of several distinct orogenic phases.

The many other examples of asymmetric and symmetric wedge structures in Hungary should be viewed as "half-flowers" and positive flower structures, respectively (HARDING, 1985). It implies transpression not pure compression. The normal faults formed in the symmetric wedge structure of the NTZ could have been explained only in a very complicated way by NÉMEDI VARGA (1963). However, this phenomenon is quite common is positive flower structures.

There is an important consequence of these normal faults developed synchronously with the boundary thrusts. This extensional deformation of the pop-up block may confuse the interpretation of microtectonic data. Possible pitfalls in the microtectonic approach was illustrated by JACKSON et al. (1982) in the case of the El Asnam (Algeria) earthquake of 1980 (KING and VITA-FINZI, 1981). Although thrust faulting was responsible for the earthquake, the most obvious surface deformations were normal faults. Normal faulting occurred immediately above the thrust plane *(Fig. 10/a)*. In this area microtectonic measurements might have indicated an extensional stress field. I speculate that the same can be true for the NTZ *(Fig. 10/b)*. If it is really the case, the N-S extensional period determined by BERGERAT and CSONTOS (1989) does not represent a regional extensional event.

There can be another type of difficulty which also limits the validity of the microtectonically determined paleostress orientations. Block rotation (RON et al. 1984) in the NTZ due to the left-lateral shear might have created counterclockwise internal rotations. This type of deformation was demonstrated for the Transdanubian Central Range in the Pannonian Basin by TARI (1989). However, more work (systematic microtectonic and paleomagnetic measurements, etc.) is needed before any definitive statements can be made for the NTZ.

Similarly, further work has to be done to understand better the role of tectonic activity and eustatic sea level changes in sedimentation. For example, the marked drop of the sea level at 16,5 Ma (HAQ et al. 1987) might have contributed to the regressional event caused by tectonic uplift at the end of the Karpathian *(Fig. 2)*. The global transgression soon after this regression was completely overprinted by continuing uplift. Generally, local tectonic activity appears to have primarily controlled the sea level changes in the NTZ.

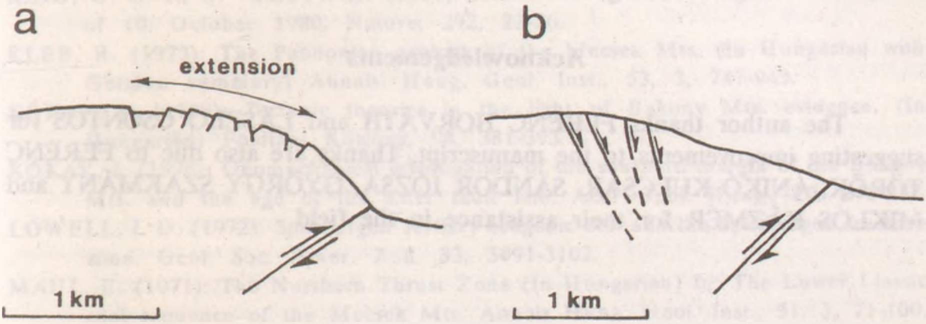

Fig. 10. (a) Section showing the surficial extension formed in the El Asnam (Algeria) earthquake of 1980 (adapted from KING and VITA-FINZI, 1981). This extension represents internal deformation of the hanging wall above the thrust which was responsible for the earthquake. (b) Simplified cross-section through the central part of the Northern Thrust Zone from MAUL (1971). It is proposed here that the presence of normal faults can be explained in the same way as in the case of El Asnam. See text for details.

Conclusions

The first Neogene period of tectonic activity occurred during the Lower Miocene in the southern foredeep of the Northern Thrust Zone, Mecsek Mts. Transtensional tectonics formed an asymmetric half-graben characterized by continental sedimentation. Rapid subsidence of the basin floor in the Middle Miocene has resulted in marine sedimentation typical of strike-slip basins. During the Upper Miocene and Pliocene folding and local uplift above the sea level of the basin fill occurred, due to transpression. The overall tectono-sedimentary evolution of the basin is characteristic for a strike-slip furrow basin.

The geological cross-secrtions and the map view of structural features of the NTZ indicate a throughgoing positive flower structure trending to the East. It has been formed during the Pliocene as a consequence of left-lateral transpression.

Acknowledgements

The author thanks FERENC HORVÁTH and LÁSZLÓ CSONTOS for suggesting improvements to the manuscript. Thanks are also due to FERENC TÖRÖK, ANIKÓ KULCSÁR, SÁNDOR JÓZSA, GYÖRGY SZAKMÁNY and MIKLÓS KÁZMÉR for their assistance in the field.

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UPPER EOCENE ECHINOIDEA FROM BUDA HILLS, HUNGARY

by

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(Received: 6th March, 1989)

Abstract

Five localities in Buda Hills, Budapest, yielded 1820 specimens of echinoids: 43 species of 22 genera were recognized. Six types of host rocks are interpreted as six environments; *Nummulites* limestone, sandy limestone, *Nummulites-Discocyclina* limestone, marly *Nummulites-Discocyclina* limestone, Bryozoa marl and Buda Marl indicate a gradual change from nearshore to deep water, quiet environment.

The fauna is characteristic for the Upper Eocene; Middle Eocene and Lower Oligocene species are subordinate. Comparisons with described faunas indicate Southern Alpine affinity.

Introduction

Upper Eocene formations of the Buda Hills are rich in echinoids. Collection and publication of the fauna started in the 19th century. A pioneer worker was ELEK PÁVAY (1874), who studied the echinoid fauna of the Bryozoa and Buda Marls, and described several new species. At the turn of the century and during the first decades of the 20th century faunal lists were published only on the echinoids of the *Nummulites-Discocyclina* limestone. A list of the Martinovics-hegy locality was published by LŐRENTHEY (1897) and another by LŐWY (1928). The study of SZÖRÉNYI (1929) played an extremely important role in the investigation of the Buda Hills echinoids. Describing the fauna of the Buda Marl, a detailed discussion was provided on the material of new collections, too.

The following decades brought little new information. BOKOR (1939) studied a small fauna from isolated Eocene outcrops SE of Páty. SZÖRÉNYI, following her monograph (1964) on the echinoid fauna of the Bakony Mts. started to examine the Buda Hills material, but she could not complete her work.

A modern systematic study of the Upper Eocene echinoid fauna from the Buda Hills was attempted by the author, with palaeoecological, biostratigraphical, and palaeobiogeographical interpretation. The study was based on the material in the Museum Department of the Hungarian Geological Institute, supplemented by minor new collections.

Stratigraphy

BALÁZS et al. (1981) published a synthesis of structural and facies problems of Eocene/Oligocene boundary formations in Hungary. They ranged the Middle and Upper Eocene strata of the Buda Hills into a "Buda Hills epicontinental-terrigenous-carbonate facies".

The terrigenous-carbonate Upper Eocene formations unconformably overlie Triassic limestone and dolomite, and Middle Eocene Miliolina limestone and marl; they are overlain by conformable Oligocene or disconformable Neogene and Quaternary sediments.

The bipartite Upper Eocene transgression (DUDICH, 1959) occupied most of Buda Hills. At the bottom of the stratigraphic column there are conglomerates of Triassic dolomite, limestone and chert pebbles, which turn into red algal-*Nummulites-Discocyclina* limestones of variable microfacies types (KÁZMÉR, 1982). The limestone is conformably overlain by Bryozoa marl (Mátyás Hill); the latter may be separated from the limestone by a conglomerate bed (Martinovics Hill).

The species *Nummulites fabianii* indicates Upper Eocene, Priabonian age of the *Nummulites-Discocyclina* limestone, corresponding to the *N. fabianii-Dyscocyclina* horizon (KOPEK-KECSKEMÉTI-DUDICH, 1966) of the Transdanubian Midmountains (KÁZMÉR, 1982).

The Bryozoa and Buda Marls belong to the *Isthmolithus recurvus* Zone of Priabonian stage (nannoplankton: BÁLDI-BEKE, 1970).

Localities

The studied echinoid fauna has been collected from five localities in Buda Hills:

1. Solymár, Várerdő Hill (1351 specimens)
2. Páty, Mézes Valley, Főkút Spring (221)
3. Budapest, Szépvölgy (91)
4. Budapest, Martinovics Hill (49)
5. Budapest, Vár-hegy (Castle Hill, 108)

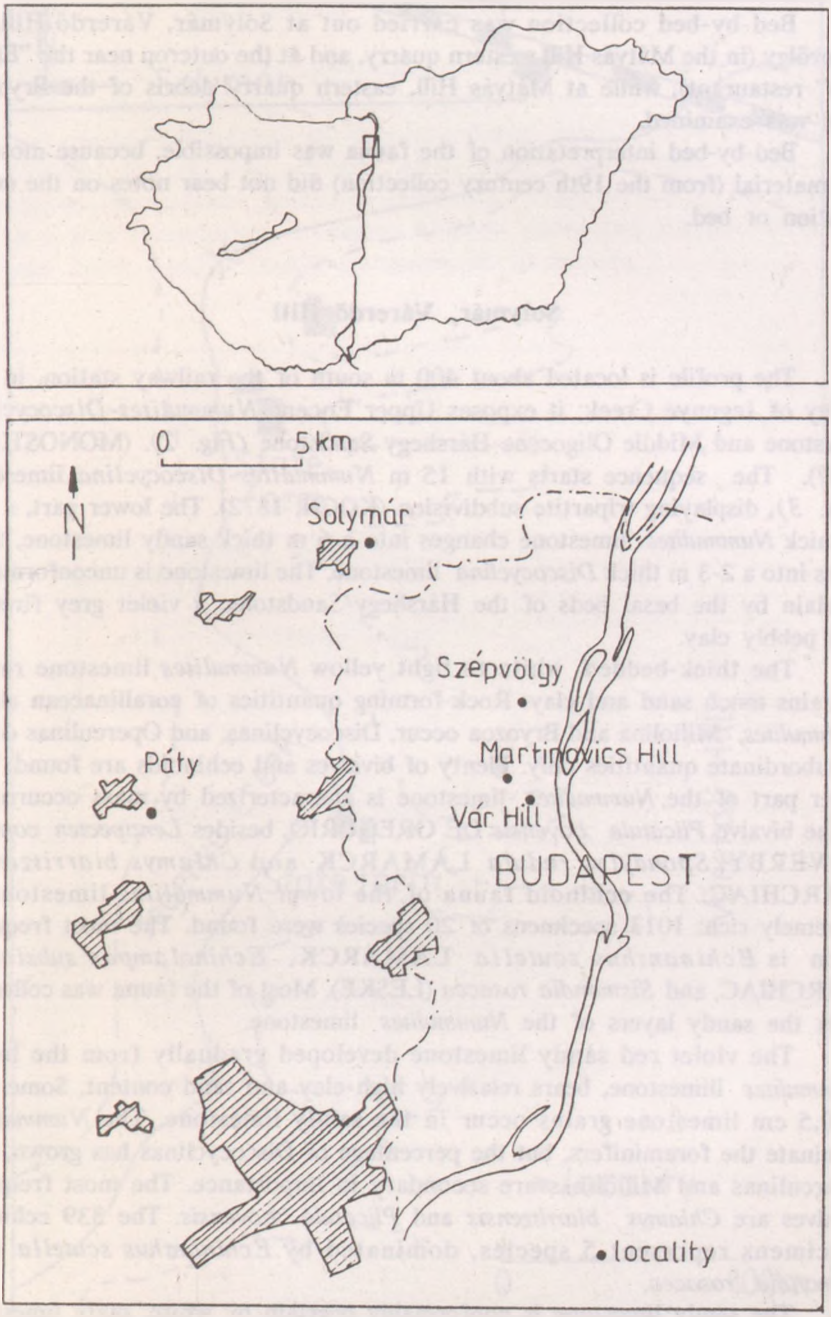

Fig. 1. Upper Eocene echinoid localities in Buda Hills.

Bed-by-bed collection was carried out at Solymár, Várerdő Hill, at Szépvölgy (in the Mátyás Hill western quarry, and at the outcrop near the "Erdei Lak" restaurant), while at Mátyás Hill, eastern quarry debris of the Bryozoa marl was examined.

Bed-by-bed interpretation of the fauna was impossible, because most of the material (from the 19th century collection) did not bear notes on the exact location or bed.

Solymár, Várerdő Hill

The profile is located about 400 m south of the railway station, in the valley of Jegenye Creek; it exposes Upper Eocene *Nummulites-Discocyclina* limestone and Middle Oligocene Hárshegy Sandstone *(Fig. 2)*. (MONOSTORI, 1967). The sequence starts with 15 m *Nummulites-Discocyclina* limestone *(Fig. 3)*, displaying tripartite subdivision (KOCH, 1872). The lower part, a 5-6 m thick *Nummulites* limestone changes into a 6 m thick sandy limestone, then turns into a 2-3 m thick *Discocyclina* limestone. The limestone is unconformably overlain by the basal beds of the Hárshegy Sandstone, a violet grey fireclay and pebbly clay.

The thick-bedded, white to light yellow *Nummulites* limestone rarely contains much sand and clay. Rock-forming quantities of corallinacean algae, *Nummulites,* Miliolina and Bryozoa occur. Discocyclinas, and Operculinas occur in subordinate quantities only. Plenty of bivalves and echinoids are found. The lower part of the *Nummulites* limestone is characterized by mass occurrence of the bivalve *Plicatula bovensis* DE GREGORIO, besides *Lentipecten corneus* SOWERBY, *Spondylus radula* LAMARCK and *Chlamys biarritzensis* D'ARCHIAC. The echinoid fauna of the lower *Nummulites* limestone is extremely rich: 1013 specimens of 20 species were found. The most frequent form is *Echinanthus scutella* LAMARCK, *Echinolampas subsimilis* D'ARCHIAC, and *Sismondia rosacea* (LESKE). Most of the fauna was collected from the sandy layers of the *Nummulites* limestone.

The violet red sandy limestone developed gradually from the lower *Nummulites* llimestone, bears relatively high clay and sand content. Some mm to 0,5 cm limestone grains occur in the sandy limestone. The *Nummulites* dominate the foraminifers, but the percentage of Discocyclinas has grown, too. Operculinas and Miliolinas are secondary in importance. The most frequent bivalves are *Chlamys biarritzensis* and *Plicatula bovensis*. The 339 echinoid specimens represent 5 species, dominated by *Echinanthus scutella* and *Sismondia rosacea.*

The sandy limestone is conformably overlain by white, platy limestone (2-3 m), without megafossils. The Priabonian limestone sequence is overlain by Hárshegy Sandstone.

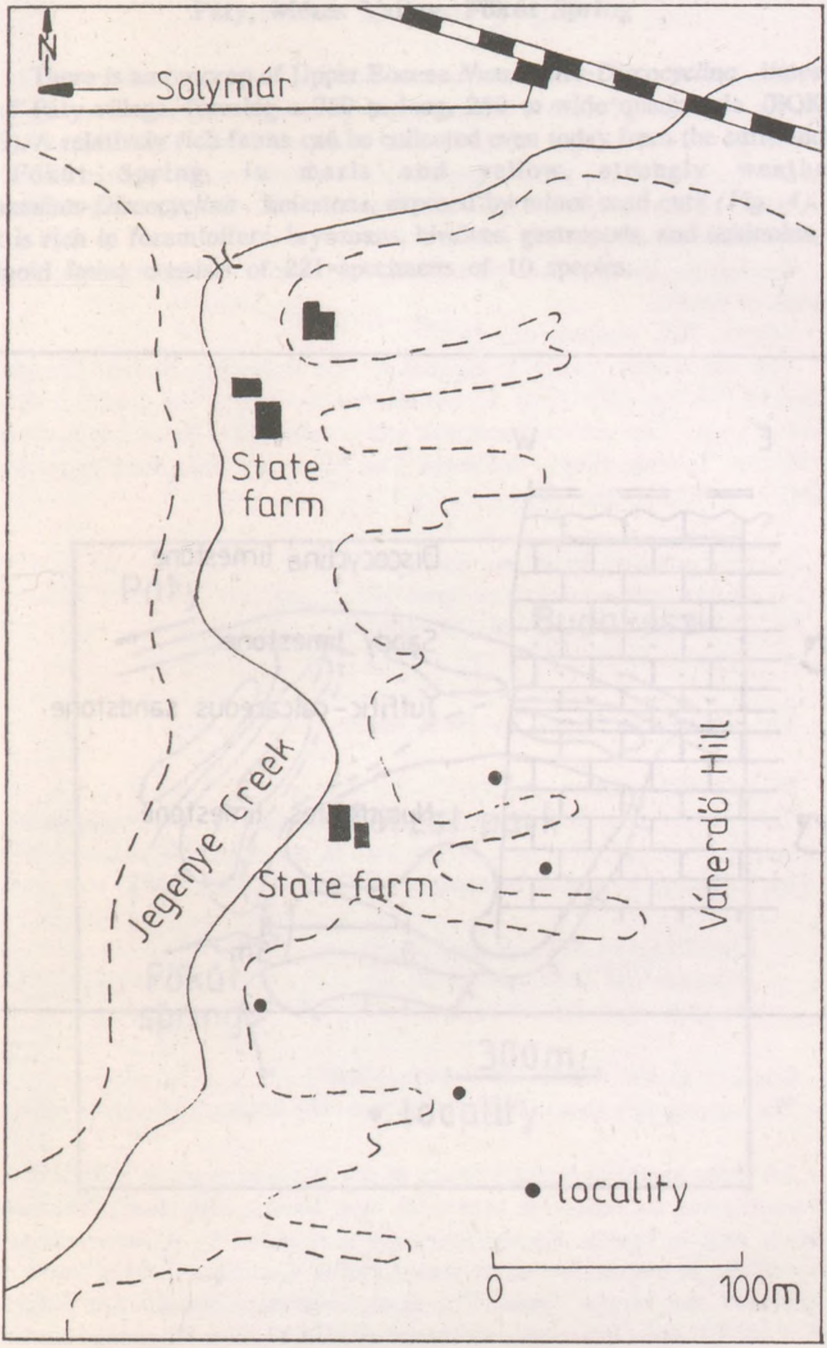

Fig. 2. Localities at Solymár, Várerdő Hill

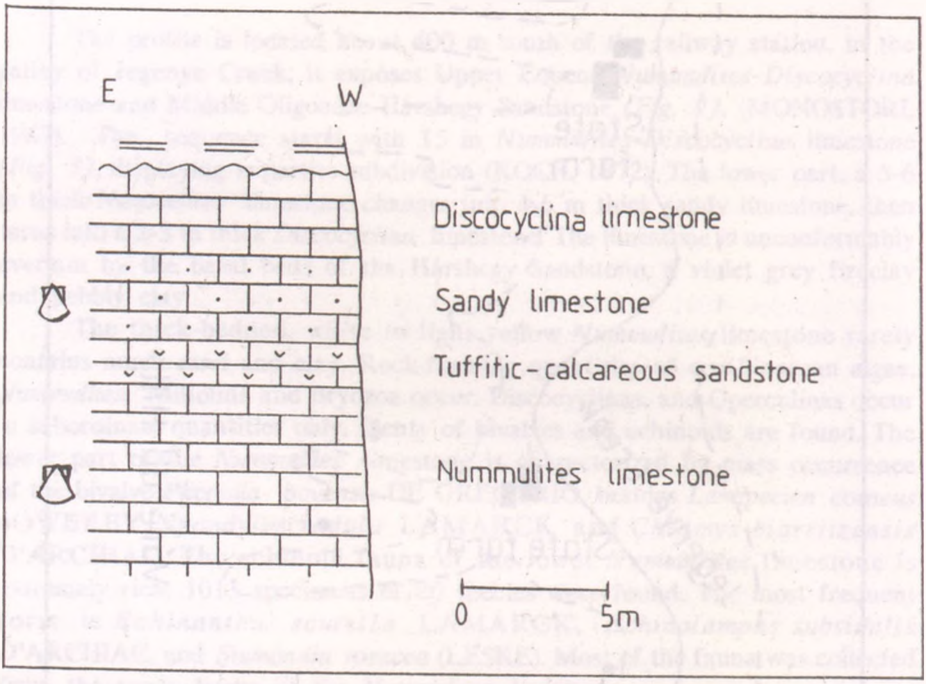

Fig. 3. Upper Eocene profile at Solymár, Várerdő Hill.

Páty, Mézes Valley, Főkút Spring

There is an outcrop of Upper Eocene *Nummulites-Discocyclina* limestone SE of Páty village, forming a 750 m long, 250 m wide quadrangle. (BOKOR, 1939). A relatively rich fauna can be collected even today from the surroundings of Főkút Spring, in marls and yellow, strongly weathered *Nummulites-Discocyclina* limestone, exposed by minor road cuts *(Fig. 4)*. The rock is rich in foraminifers, bryozoans, bivalves, gastropods, and echinoids. The echinoid fauna consists of 221 specimens of 10 species.

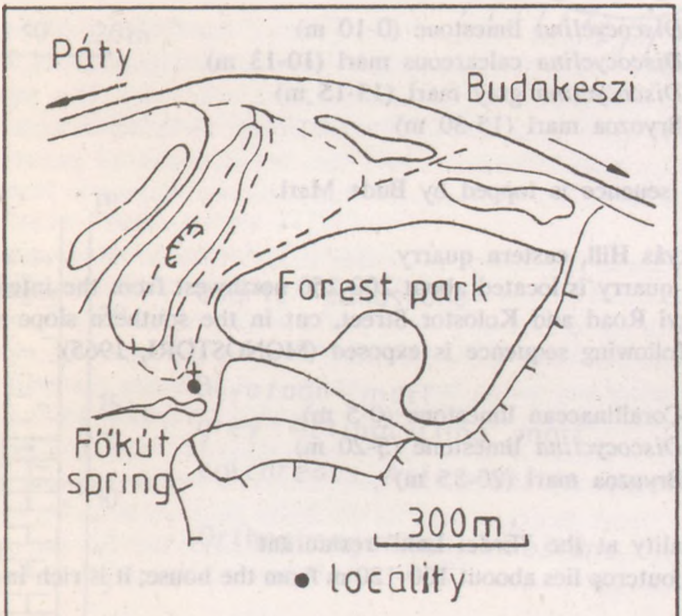

Fig. 4. Localities at Páty, Főkút Spring.

Budapest, Szépvölgy (Schöntal)

Most of the echinoid fauna of the Bryozoa marl in the Museum of the Hungarian Geological Institute was collected in the quarries and other exposures of Szépvölgy, but the exact localities are usually missing. These localities are discussed together in the present paper; as the matrix or filling material of the fossils show, all specimens are from the Bryozoa Marl, therefore this unification hopefully does not affect the interpretation.

Revisiting the possible localities, only three of them yielded larger amounts of fossils.

Mátyás Hill, western quarry

The abandoned quarry is located by the Szépvölgy Road, opposite the entrance of Pálvölgy Cave *(Fig. 5)*. At the western end of the quarry a tectonic contact of Upper Eocene conglomerates and corallinacean limestone is observed with Middle Triassic cherty dolomite. The following beds were recorded by KÁZMÉR (1982) in the quarry:

- *Discocyclina* limestone (0-10 m)
- *Discocyclina* calcareous marl (10-13 m)
- *Discocyclina* grey marl (13-15 m)
- Bryozoa marl (15-30 m)

The seuence is topped by Buda Marl.

Mátyás Hill, eastern quarry

The quarry is located about 200-250 northwest from the intersection of Mátyáshegyi Road and Kolostor Street, cut in the southern slope of Mátyás Hill. The following sequence is exposed (MONOSTORI, 1965):

- Corallinacean limestone (0-5 m)
- *Discocyclina* limestone (5-20 m)
- Bryozoa marl (20-35 m)

Locality at the "Erdei Lak" restaurant

The outcrop lies aboout 100-120 m from the house; it is rich in echinoids.

All three localities yielded fauna of the Bryozoa marl. It is light to dark grey, weathering to yellowish brown or light brown, silty marl. The rock is extremely rich in fossils. Foraminifers are dominated by Asterocyclinas and Discocyclinas. Bryozoans occur in rock-forming quantity. Certain levels yield rich echinoid and bivalve fauna. The most frequent echinoids are *Schizaster lorioli* PÁVAY and *Opissaster szechenyii* (PÁVAY). The 92 specimens belong to 8 species.

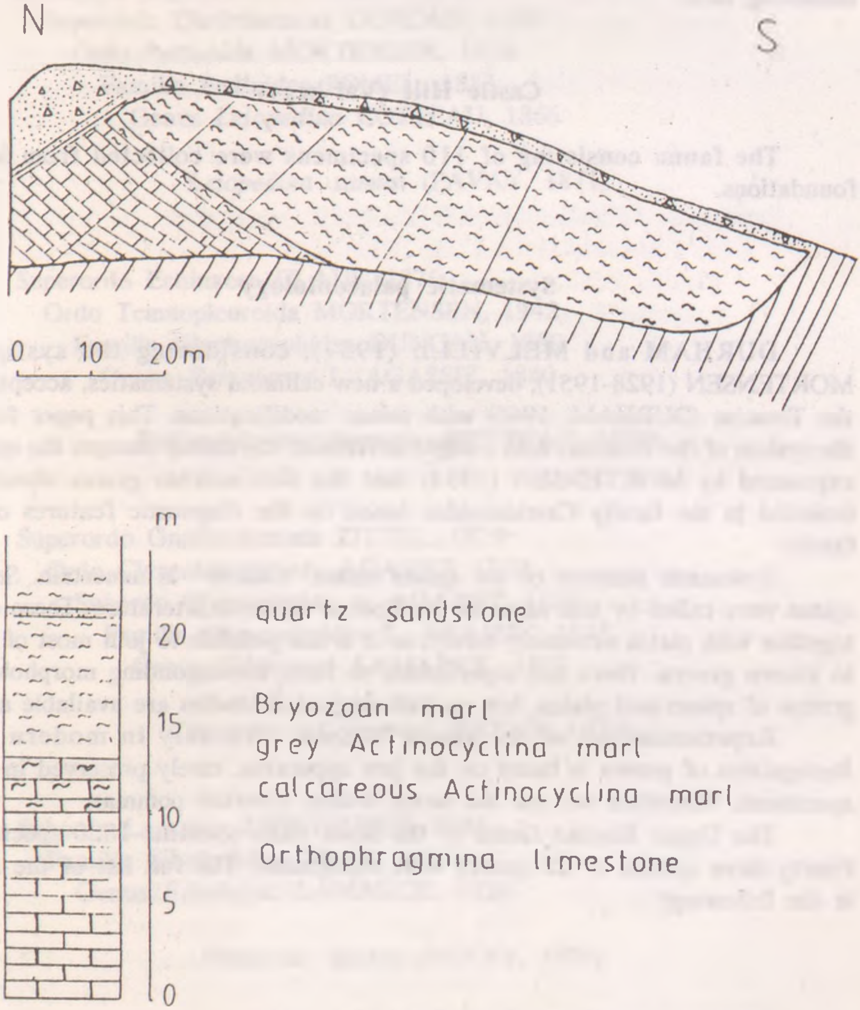

Fig. 5. Sequence at Mátyás Hill, western quarry (after KÁZMÉR, 1982)

Martinovics Hill (former Kis-Sváb Hill)

The moderately rich echinoid fauna was collected from the *Nummulites-Discocyclina* limestone and from the Bryozoa marl. Fourty-two echinoids of the former one belong to 11 species, while 7 specimens from the latter marl belong to 3 species. The abandoned quarries are not available for collecting now.

Castle Hill (Vár-hegy)

The fauna consisting of 110 specimens were collected from house foundations.

Systematic palaeontology

DURHAM and MELVILLE (1957), considering the system of MORTENSEN (1928-1951), developed a new echinoid systematics, accepted by the Treatise (DURHAM, 1966) with minor modifications. This paper follows the system of the Treatise, with a slight difference: the author accepts the opinion expressed by MORTENSEN (1984) that the *Echinanthus* genus should be included in the family Cassiduloidae based on the diagnostic features of the family.

Systematic position of the spines called *"Cidaris"* is uncertain. Several spines were called by this name in the Eocene echinoid lliterature. These occur together with plates extremely rarely, so it is not possible to join most of them to known genera. There are experiments to form corresponding morphological groups of spines and plates, but no well-supported studies are available as yet.

Representatives of the genus *"Cidaris"* live only in modern seas. Recognition of genera is based on the jaw apparatus, rarely preserved in fossil specimens. Therefore we use the name within inverted commas.

The Upper Eocene fauna of the Buda Hills contains 1820 specimens. Fourty-three species of 22 genera were recognized. The full list of the fauna is the following:

Subclassis Perischoechinoidea M'COY, 1849
  Ordo Cidaroidea CLAUS, 1880
    Familia Cidaridae GRAY, 1825
      Subfamilia Cidarinae GRAY, 1825
        Genus *Cidaris* LESKE, 1778

"Cidaris" hungarica PÁVAY, 1874
"Cidaris" oosteri LAUBE, 1868
"Cidaris" pseudoserrata COTTEAU, 1862
"Cidaris" subularis D'ARCHIAC, 1846

Subclassis Euechinoidea BRONN, 1860
  Superordo Diadematacea DUNCAN, 1889
    Ordo Pedinoida MORTENSEN, 1939
      Familia Pedinidae POMEL, 1883
        Genus *Leiopedina* COTTEAU, 1866

Leiopedina samusi (PÁVAY, 1871)

Superordo Echinacea CLAUS, 1876
  Ordo Temnopleuroida MORTENSEN, 1942
    Familia Glyphocyphidae DUNCAN, 1889
      Genus *Echinopsis* L. AGASSIZ, 1840

Echinopsis meridanensis (COTTEAU, 1863)

Superordo Gnathostomata ZITTEL, 1879
  Ordo Clypeasteroida A. AGASSIZ, 1872
    Subordo Clypeasterina A. AGASSIZ, 1872
      Familia Clypeasteridae L. AGASSIZ, 1835
        Genus *Clypeaster* LAMARCK, 1801

Clypeaster cf. corvini (PÁVAY, 1874)

Subordo Laganina MORTENSEN, 1948
  Familia Fibulariidae GRAY, 1885
    Genus *Fibularia*, LAMARCK, 1816

Fibularia dacica (PÁVAY, 1874)

Familia Laganidae A. AGASSIZ, 1873
  Genus *Peronella* GRAY, 1855

Peronella transilvanica (PÁVAY, 1871)

Genus *Sismondia* DESOR, 1858

Sismondia rosacea (LESKE, 1778)

Subordo Scutellina HAECKEL, 1896
Familia Scutellidae GRAY, 1825
Genus *Scutella* LAMARCK, 1816

Scutella tenera LAUBE, 1868

Superordo Atelostomata ZITTEL, 1879
Ordo Cassiduloida CLAUS, 1880
Familia Echinolampadidae GRAY, 1851
Genus *Echinolampas* GRAY, 1825

Echinolampas archiaci COTTEAU, 1883
Echinolampas benoisti COTTEAU, 1890
Echinolampas blaviensis COTTEAU, 1889
Echinolampas cf. *escheri* L. AGASSIZ, 1839
Echinolampas giganteus PÁVAY, 1871
Echinolampas globulus LAUBE, 1868
Echinolampas cf. *luciani* TARAMELLI, 1873-74
Echinolampas montevialensis SCHAUROTH, 1865
Echinolampas obesus BITTNER, 1880
Echinolampas subsimilis D'ARCHIAC, 1846

Familia Cassidulidae L. AGASSIZ et DESOR, 1874
Genus *Cassidulus* LAMARCK, 1801

Cassidulus testudinarius (BRONGNIART, 1882)

Genus *Echinanthus* LESKE, 1778

Echinanthus pellati COTTEAU, 1863
Echinanthus scutella (LAMARCK, 1801)
Echinanthus aff. *scutella* (LAMARCK, 1801)

Ordo Holasteroida DURHAM et MELVILLE, 1957
  Familia Holasteridae PICTET, 1857
    Genus *Titanaster* SZÖRÉNYI, 1929

Titanaster labiostoma SZÖRÉNYI, 1929

Ordo Spatangoida CLAUS, 1876
  Subordo Hamiasterina A. G. FISCHER, 1966
    Familia Hemiasteridae CLARCK, 1917
      Genus *Hemiaster* L. AGASSIZ, 1847

Hamiaster ? arpadis (PÁVAY, 1874)

Genus *Opissaster* POMEL, 1883

Opissaster szechenyii (PÁVAY, 1874)

Familia Pericosmidae LAMBERT, 1905
  Genus *Pericosmus* L. AGASSIZ, 1847

Pericosmus budensis PÁVAY, 1874

Familia Schizasteridae LAMBERT, 1905
  Genus *Schizaster* L. AGASSIZ, 1836

Schizaster ambulacrum (DESHAYES, 1860)
Schizaster lorioli PÁVAY, 1874
Schizaster lucidus LAUBE, 1868
Schizaster vicinalis L. AGASSIZ, 1847

Genus *Parabrissus* BITTNER, 1880

Parabrissus pseudoprenaster BITTNER, 1880

Subordo Micrasterina A. G. FISCHER, 1966
  Familia Brissidae GRAY, 1855
    Genus *Brissopsis* L. AGASSIZ, 1847

Brissopsis haynaldi (PÁVAY, 1874)

Genus *Eupatagus* L. AGASSIZ, 1847

Eupatagus cranium (KLEIN, 1754)

Genus *Macropneustes* L.A GASSIZ, 1847
  Subgenus *Deakia* PÁVAY, 1874

Deakia cordata PÁVAY, 1874
Deakia ovata PÁVAY, 1872
Deakia rotundata PÁVAY, 1874

Genus *Trachypatagus* POMEL, 1869

Trachypatagus hantkeni (PÁVAY, 1874)

Familia Spatangidae GRAY, 1825
  Genus *Atelospatangus* KOCH, 1884

Atelospatangus gardinalei (OPPENHEIM, 1899)
Atelospatangus cf. *transilvanicus* KOCH, 1884

Genus *Semipetalion* SZÖRÉNYI, 1963

Semipetalion anomon SZÖRÉNYI, 1963

Palaeoecology

Several aothors share the opinion that echinoid faunas are especially suitable for palaeoecological interpretation, mostly due to their benthic mode of life. Besides the sea bottom type, several other factors affect the distribution of echinoids, like salinity, water temperature, depth and agitation. Their complex skeleton bears several adaptive characters indicative of ancient sedimentary environments.

Palaeoenvironmental reconstructions are carried out two ways: either we draw conclusions from the fossil on the condiditons of sedimentation, or sedimentary characters help us to understand ancient habitats (AGER, 1963). Applying the two methods together we should consider ecological conditions of modern relatives, sedimentary characters of the embedding rocks and data on the associated fauna.

Actualistic reconstruction of the Upper Eocene environment in Buda Hills is greatly facilitated by the fact, that 10 genera of 22 live in Recent seas (10 families of 13 also live today).

Up to now the most detailed study on echinoid palaeoecology is the monograph of MORTENSEN (1928-1951). His observations on Recent faunas enabled him to publish thorough discussions on the ecology of each species, and to make conclusions on their relatives on the generic and family level. General data on the ecological factors of more than 800 Recent species were published by MOORE (1966) and SMITH (1984). MOORE (1966) considered water temperature, salinity, photic conditions, hydrostatical pressure, agitation, and food availability as the most important factors in echinoid distribution, while SMITH (1984) counts on sea bottom quality, hydrodynamic system, predators, salinity, temperature, availabled food, depth, behaviour and chance.

MORTENSEN (1928-1951) provided data on the sea bottom, temperature, depth and sometimes agitation for each family and genus. DURHAM et al. (1966) completed MORTENSEN's data by some ecological factors.

Actualistic comparisons should take in mind that ecological needs may change with time.

Examining number of individuals and species in the *Nummulites* limestone at Solymár, the *Nummulites-Discocyclina* limestone at Martinovics-hegy, the marly *Nummulties-Discocyclina* limestone at Páty, in the Bryozoa and Buda Marls, definite distinctions can be made. The *Nummulites* limestone and sandy limestone are dominated by Cassiduloida and Clypeasteroida orders, the *Nummulites-Discocyclina* limestone of Martinovics-hegy is characterized by Cassiduloida and Spatangoida, the marly *Nummulites-Discocyclina* limestone at Páty is dominated by Clypeasteroida and Spatangoida, while the Bryozoa and Buda Marls yielded representatives of the order Spatangoida *(Fig. 6)*

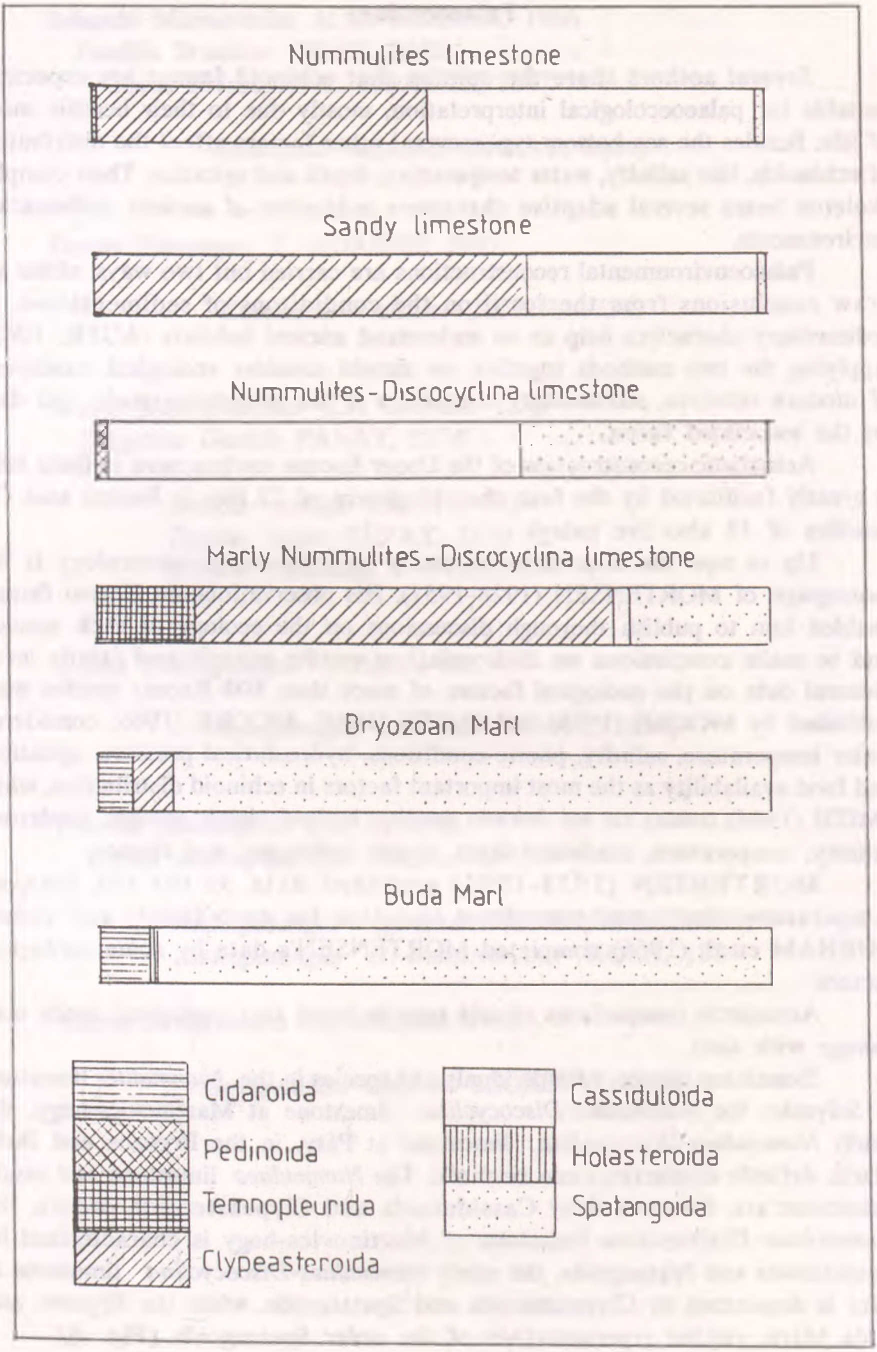

Fig. 6. Distribution of representatives of seven echinoid orders in six rock types.

Table 1. Distribution of genera in rock types

	A	B	C	D	E	F
"Cidaris" hungarica						+
"Cidaris" oosteri	+					
"Cidaris" pseudoserrata					+	
"Cidaris" subularis	+					+
Leiopedina samusi			+			
Echinopsis meridanensis				+		
Clypeaster cf. *corvini*					+	
Fibularia dacica					+	
Peronella transilvanica				+		
Sismondia rosacea	+	+		+		
Scutella tenera		+				
Echinolampas archiaci	+		+			
Echinolampas bernoisti	+			+		
Echinolampas plaviensis	+	+	+			
Echinolampas cf. *escheri*			+			
Echinolampas giganteus	+					
Echinolampas globulus	+		+			
Echinolampas cf. *luciani*				+		
Echinolampas montevialensis	+		+	+		
Echinolampas obesus	+					
Echinolampas subsimilis	+		+			
Echinolampas sp.			+	+		
Cassidulus testudinarius	+					
Echinanthus pellati	+					
Echinanthus scutella	+	+	+	+		
Echinanthus aff. *scutella*	+	+				
Titanaster labiostoma						+
Hemiaster ? arpadis						+
Opissaster szechenyii				+	+	
Pericosmus budensis						+
Schizaster ambulacrum			+	+		
Schizaster lorioli				+	+	
Schizaster locidus			+			
Schizaster vicinalis				+		
Parabrissus pseudoprenaster	+					
Brissopsis haynaldi					+	
Brissopsis sp.				+		
Eupatagus cranium	+					
Deakia cordata						+

Deakia ovata					+	+
Deakia rotundata						+
Trachypatagus hantkeni					+	+
Atelospatangus gardinalei	+					
Atelospatangus cf. *transilvanicus*	+					
Semipetalion anomon	+					

A *Nummulites* limestone
B Sandy marl
C *Nummulites-Discocyclina* limestone
D Marly *Nummulites-Discoyclina* limestone
E Bryozoan marl
F Buda Marl

The six Echinoidea biofacies types, based on differences in number of specimens and species are the followings:

1. *Nummulites* limestone (Solymár)
2. Sandy limestone (Solymár)
3. *Nummulites-Discocyclina* limestone (Martinovics Hill)
4. Marly *Nummulites-Discocyclina* limestone (Páty)
5. Bryozoa marl (Szépvölgy and Martinovics Hill)
6. Buda Marl (Vár-hegy)

The *Nummulites* limestone at Solymár was deposited in shallow, agitated water. The echinoids there had a semi-burrowing way of life. The organic-rich sediment provided a favourable habitat for mud-feeder echinoids. Differences in the sea bottom are shown by biometrical variations of *Echinanthus scutella* *(Fig. 7);* since echinoids are very sensitive to the conditions of their immediate habitat, the size differences should have been caused by minute differences in their microenvironment. Varying height was observed on specimens with uniform length and width. Observations of SMITH (1984) on Recent echinoids indicate, that higher forms burrow somewhat deeper in more coarse sediments, while the lower ones burrow less deep is finer sediments *(Fig. 8)*.

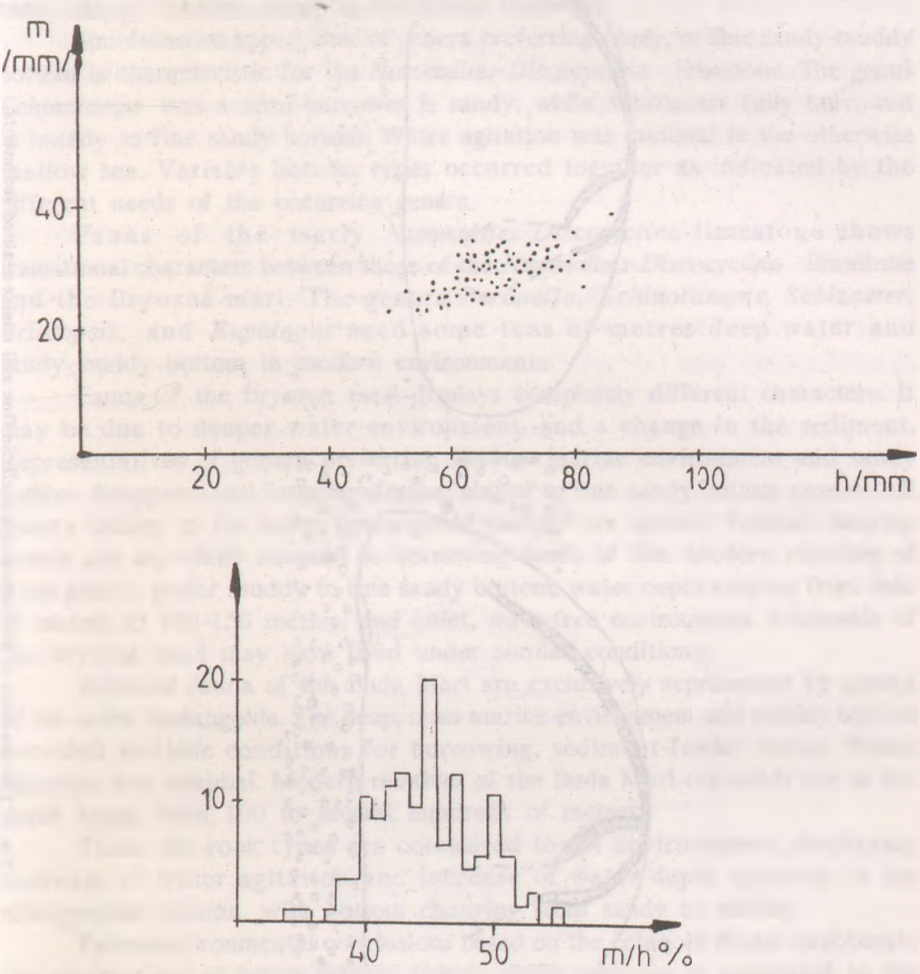

Fig. 7. Length/height plot of *Echinanthus scutella* (upper figure) and distribution by the H/L ratio (lower figure).

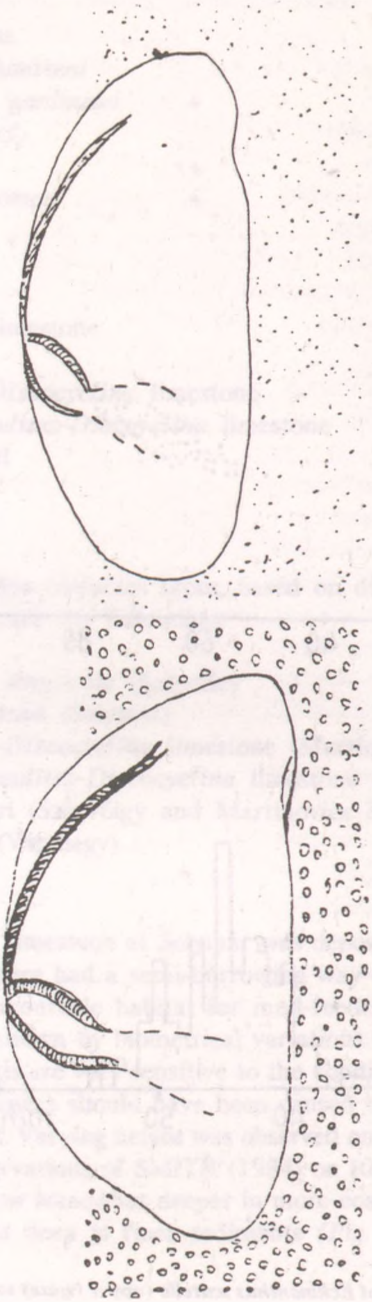

Fig. 8. Life position of *Echinanthus scutella* in fine and coarse-grained sediments.

Echinoid fauna of the sandy limestone at Solymár is poorer than that of the *Nummulites* limestone. Increased clay content produced disappearance of certain genera and appearance of new genera. Only two specimens of *Echinolampas* were found: this genus is sensitive to clay content. Representatives of the family Scutellinae, which prefer a few metres deep, agitated water over sandy-clayey bottom, occur in the sandy limestone.

Simultaneous appearance of genera preferring sandy, or fine sandy-muddy bottom is characteristic for the *Nummulites-Discocyclina* limestone. The genus *Echinolamps* was a semi-burrower is sandy, while Schizasters fully burrowed in muddy to fine sandy bottom. Water agitation was minimal in the otherwise shallow sea. Variable bottom types occurred together as indicated by the different needs of the occurring genera.

Fauna of the marly *Nummulties-Discocyclina* limestone shows transitional characters between those of the *Nummulites-Discocyclina* limestone and the Bryozoa marl. The genera *Peronella, Echinolampas, Schizaster, Brissopsis*, and *Eupatagus* need some tens of metres deep water and sandy-muddy bottom in modern environments.

Fauna of the Bryozoa marl displays completely different characters. It may be due to deeper water environment, and a change in the sediment. Representatives of genera preferring shallow marine environment and sandy bottom disappear, and forms preferring clayey to fine sandy bottom appear. All genera belong to the order Spatangoida (except the spines). Fasciola-bearing genera are especially adapted to burrowing mode of life. Modern relatives of these genera prefer muddy to fine sandy bottom, water depth ranging from tens of metres to 100-150 metres, and quiet, wave-free environment. Echinoids of the Bryozoa marl may have lived under similar conditions.

Echinoid fauna of the Buda Marl are exclusively represented by genera of the order Spatangoida. The deep, open marine environment and muddy bottom provided suitable conditions for burrowing, sediment-feeder forms. Water agitation was minimal. Modern relatives of the Buda Marl echinoids live in the depth range from 100 to several hundreds of metres.

These six rock types are correlated to six environments, displaying decrease of water agitation and increase of water depth upwards in the stratigraphic column, with bottom changing from sandy to muddy.

Palaeoenvironmental conclusions based on the echinoid fauna corroborate the observations of MONOSTORI (1965, 1967), and can be correlated to the carbonate microfacies types of KÁZMÉR (1982).

Palaeopathology

Pathological echinoids were first mentioned by SZÖRÉNYI (1931, 1973) from the Hungarian Eocene. She recognized traces of ontogenetical disturbances of the right-side anterior petal of an *Echinanthus* from Solymár and on petals of echinoids from the Bakony Mts. Twelve pathological specimens with the same features as described by SZÖRÉNYI have been observed by the author in the Solymár material. In addition, traces if injures made by several organisms were recognized on several specimens of the species *Echinanthus scutella.*

Three groups of injuries are recognized according to shape, size and frequency of occurrence:

1. Boring traces frequently occur in pore zones, in zones between the pore zones and along the petals. Rare borings occur in interpetal zones, mostly in the regions bordered by the distal terminations of petals. Diameter of borings range from 0,8 to 1,6 mm, with a circular outline. They cross the corona, except in one or two cases. The plate was slightly thickened around a boring with cylindrical outline *(Fig. 9).*

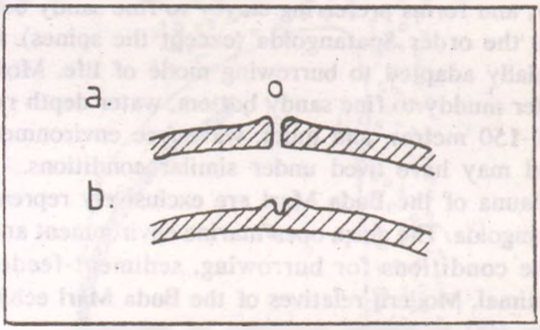

Fig. 9. Cross-section of injuries of Group 1 /1x/:
a: hole crossing the corona
b: hole not crossing the corona

2. A single specimen forms this group. The boring is cylindrical with 2,4 mm diameter. The plate conspicuously thickened around the boring. *(Fig. 10).*

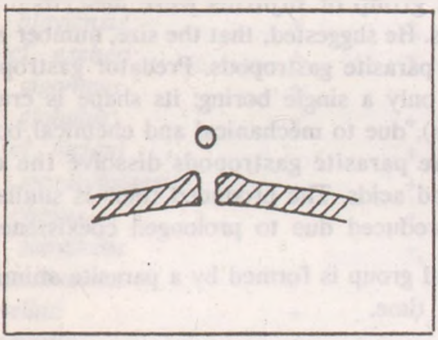

Fig. 10. Cross-section of injuries of Group 2 /1x/.

3. Oval injuries with 3-5,5 mm length and 1-3 mm width. A single specimen suffered this kind of injuries *(Fig. 11/a)*.

There are six injuries. One of them does not cross the corona, but there is a circular hole at the end of the oval depression. The injuries crossing the corona slightly taper inwards. There is no thickening around the holes *(Fig. 11/b)*.

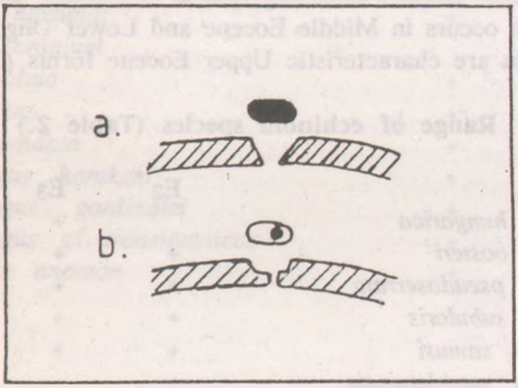

Fig. 11. Injuries of Group 3: /1x/:
a: hole crossing the corona
b: hole partly crossing the corona.

Sizes and morphologies of the injuries suggest the following conclusions:

– The first group of injuries were described by KIER (1981) on Cretaceous echinoids. He suggested, that the size, number and shape of the holes indicate borings by parasite gastropods. Predator gastropods can be excluded, since they produce only a single boring: its shape is crater-like (Naticids) or cylindrical (Muricids), due to mechanical and chemical borint (BISHOP, 1975). Contrary to this the parasite gastropods dissolve the carbonate corona by applying enzymes and acids. The produced trace is similarly cylindrical, but a bulging margin is produced due to prolonged coexistence (SMITH, 1984).

– The second group is formed by a parasite animal, which lived on the echinoid for a long time.

– The oval injuries of the third group show no thickening of the margins of the borings; we suggest that these were formed after the death of the echninoid. It is corroborated by the relatively large size and great number of the borings. The borers may have used the corona as a solid bottom and probably for scavenging.

Biostratigraphy

Tertiary echinoids are mostly suitable for palaeoecological studies. The long range of species hinders biostratigraphical evaluation. Some of the species in the Buda Hills occurs in Middle Eocene and Lower Oligocene formations, but most of them are characteristic Upper Eocene forms *(Table 2).*

Range of echinoid species (Table 2.)

	E_2	E_3	Ol_1
"Cidaris" hungarica		+	
"Cidaris" oosteri	+	+	+
"Cidaris" pseudoserrata	+	+	+
"Cidaris" subularis	+	+	+
Leiopedina samusi	+	+	
Echinopsis meridanensis	+		
Clypeaster cf. *corvini*		+	
Fibularia dacica		+	
Peronella transilvanica		+	
Sismondia rosacea		+	
Scutella tenera		+	+
Echinolampas archiaci	+		

	E_2	E_3	Ol_1
Echinolampas benoisti	+	+	
Echinolampas blaviensis	+	+	
Echinolampas cf. *escheri*	+	+	
Echinolampas giganteus	+		
Echinolampas globulus	+	+	
Echinolampas cf. *luciani*		+	
Echinolampas montevialensis		+	
Echinolampas obesus		+	
Echinolampas subsimilis		+	+
Cassidulus testudinarius	+		
Echinanthus pellati	+	+	
Echinanthus scutella	+	+	
Echinanthus aff. *scutella*		+	
Titanaster labiostoma		+	
Hemiaster ? arpadis		+	
Opissaster szechenyii		+	
Pericosmus budensis		+	
Schizaster ambulacrum		+	+
Schizaster lorioli		+	
Schizaster lucidus	+	+	
Schizaster vicinalis	+	+	+
Parabrissus pseudoprenaster		+	
Brissopsis haynaldi		+	+
Eupatagus cranium	+		
Deakia cordata		+	
Deakia ovata		+	
Deakia rotundata		+	
Trachypatagus hantkeni		+	
Atelospatangus gardinalei		+	
Atelospatangus cf. *transilvanicus*		+	
Semipetalion anomon		+	

Palaeobiogeography

Palaeobiogeographical interpretation is mostly hindered by the variable degree of study of the neighbouring faunas. There are no modern, synthesizing monographs from the last decades; our comparisons are based on the revisions published in the first decades of the twentieth century.

Data on geographical-geological units were compared to the unified faunal list of Buda Hills, considering the differences in palaeoecology. Due to different aspects of studies, scattering of species number, different level of knowledge, and palaeoecological differences we do not apply the method of calculating coefficients to compare faunas. Number of species described from classical Upper Eocene localities and common species with the Buda Hills are shown in *Table 3*.

Number of species described from and common with forms in the Buda Hills (Table 3.)

Locality (author, year)	Species	Common species
Buda Mts.	43	–
Catalonia (LAMBERT, 1927)	35	4
Biarritz (COTTEAU, 1884-1894)	71	12
Provence (LAMBERT, 1918)	57	5
Southern Alps (OPPENHEIM, 1902)	52	19
Transylvanian Basin (KOCH, 1884)	33	9

Acknowledgements

SÁNDOR MIHÁLY and MIKLÓS KÁZMÉR helped in solving paleontological and geological problems; other workers at the Department of Palaeontology, Eötvös University and at the Museum of the Hungarian Geological Institute helped in innumerable ways, which is gratefully acknowledged herein.

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STUDY OF LATE EOCENE BIVALVES FROM BUDA HILLS

by

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(Received: 18th November, 1988)

Abstract

This paper complete our knowledge of Late Eocene bivalves of Buda Hills. The 370 specimens, collected from 5 localities, belong to 21 species of 15 genera. This study was carried out from palaeoecological, palaeobiogeographical and biostratigraphical points of view. The five rock types containing this bivalve assemblage, correspond to four different palaeoecological environments. Ascending in the sequence the bivalve assemblage of different rock types indicates increase of sea depth. Results of palaeobiogeographical studies are in good agreement with survey supposing South Alpine connections. This fauna is typical of Late Eocene age and species confined only to the Middle Eocene or the Oligocene were not recorded.

Introduction

Although the Late Eocene mollusc fauna of Buda Hills has been thoroughly investigated for some 120 years, no compreshensive monograph was published. It was high time to carry out an up-to-date study of this fauna from palaeoecological, palaeobiogeographical and biostratigraphical points of view.

KOCH (1872) gave a description of Várerdő Hill sequence at Solymár and also mentioned its fauna.

HOFMANN's activity (1873) was very important in contributing to the knowledge of bivalves of Buda Hills. He gave the first descriptions of these bivalves while he studied the Paleogene deposits of Buda region.

LŐRENTHEY (1897) dealt mainly with Tertiary crustaceans, but he also published a large list of mollucs.

LŐVY (1928) not only listed the fauna of Martinovics Hill but gave ecological evaluations as well.

BOKOR (1939) investigated the deposits of the western magin of Buda Hills and mentioned eleven bivalve species belonging to Eocene.

There was much less contribution to the knowledge of Late Eocene bivalves of this region later in this century.

In the last few decades DUDICH (1959), MONOSTORI (1965, 1967), WEIN (1977) and KÁZMÉR (1982) investigated the geology, mineralogy, microfacies and tectonics of Upper Eocene formations. BÁLDI (1986) published new data on the sedimentology, the palaeontology and the age of Buda Marl.

Specimens, studied in this paper, are from the Museum of the Hungarian Geological Institute, the Department of Palaeontology of Eötvös Unviersity and from supplementary collections by the author.

Geological setting

According to BALÁZS et al. (1981) the Upper Eocene of Buda Hills belongs to the epicontinental terrigenous-carbonate development. These sediments discordantly overlie on Triassic dolomites, limestones and Middle Eocene Miliolina limestone.

Late Eocene sea transgressed into Buda region in two steps (DUDICH, 1959). The sequence starts with conglomerate and the *Nummulites* – coralline algae – *Discocyclina* limestone gadually took place. Bryozoan Marl covers this limestone (KÁZMÉR, 1982) either with successive transition on the Mátyás Hill or discordantly with basal conlgomerates on the Martinovics Hill. The next unit is Buda Marl, which underlies the following Oligocene sequences or the Neogene and the Quaternary.

The limestone containing *Nummulites fabianii* indicates Priabonian age. According to KOPEK et al. (1969) it is the *N. fabianii* – *Discocyclina* level (no. XIV) of Transdanubian Central Range.

BÁLDI-BEKE (1970) put Bryozoan and Buda Marls into the Insthomolithus recurvus zone of Priabonian on the basis of similar nannoplankton assemblages.

Localities

Studied specimens were derived from five localities *(Fig. 1)*.:

1. Várerdő Hill at Solymár *(Fig. 2)*.
2. Szépvölgy
3. Martinovics Hill
4. Vár Hill
5. Németvölgyi road.

Specimens were collected layer by layer except for the eastern quarry of Mátyás Hill, where the collection was from the scree of the silicified marl. Unfortunately the bulk of the specimens were gathered decades ago without exact identification of the place or the layer. Due to the same reason individuals from Szépvölgy were considered as one unit.

Sixty-three specimens from Várerdő Hill, 189 from Szépvölgy, 90 from Martinovics Hill, 12 from Vár Hill and 16 from Németvölgyi road were examined.

1. Várerdő Hill at Solymár

Eocene and Oligocene deposits crop out in the valley of Jegenye Creek. The dateiled geological description is given by MONOSTORI (1967). *Nummulites* - *Discocyclina* limestone underlies the Oligocene Hárshegy Sandstone by angular unconformity *(Fig. 3)*.

According to KOCH (1872) the *Nummulites* - *Discocyclina* limestone can be divided into three parts, which are the following from the bottom to the top:

- *Nummulites* limestone
- sandy limestone
- *Discocyclina* limestone.

Thick strata of the light brown *Nummulites* limestone are cropping out at 7 m of thickness. The uppermost one metre is oolithic with fine lime mud matrix, carbonate content is 70-100 % (MONOSTORI, 1967).

This rock is rich in corraline algae, *Nummulites* and Miliolina species.

The dominant bivalve species are *Chlamys*, *Plicatula bovensis* DE GREGORIO and *Lentipecten corneus* (SOWERBY). *Spondylus* and *Ostrea* species are abundant as well. There are many Echinoidea in the upper part of *Nummulites* limestone. The most frequent species are *Echinanthus scutella* LAMARCK, *Echinolampas subsimilis* D'ARCHIAC and *Sismondia rosacea* LESKE.

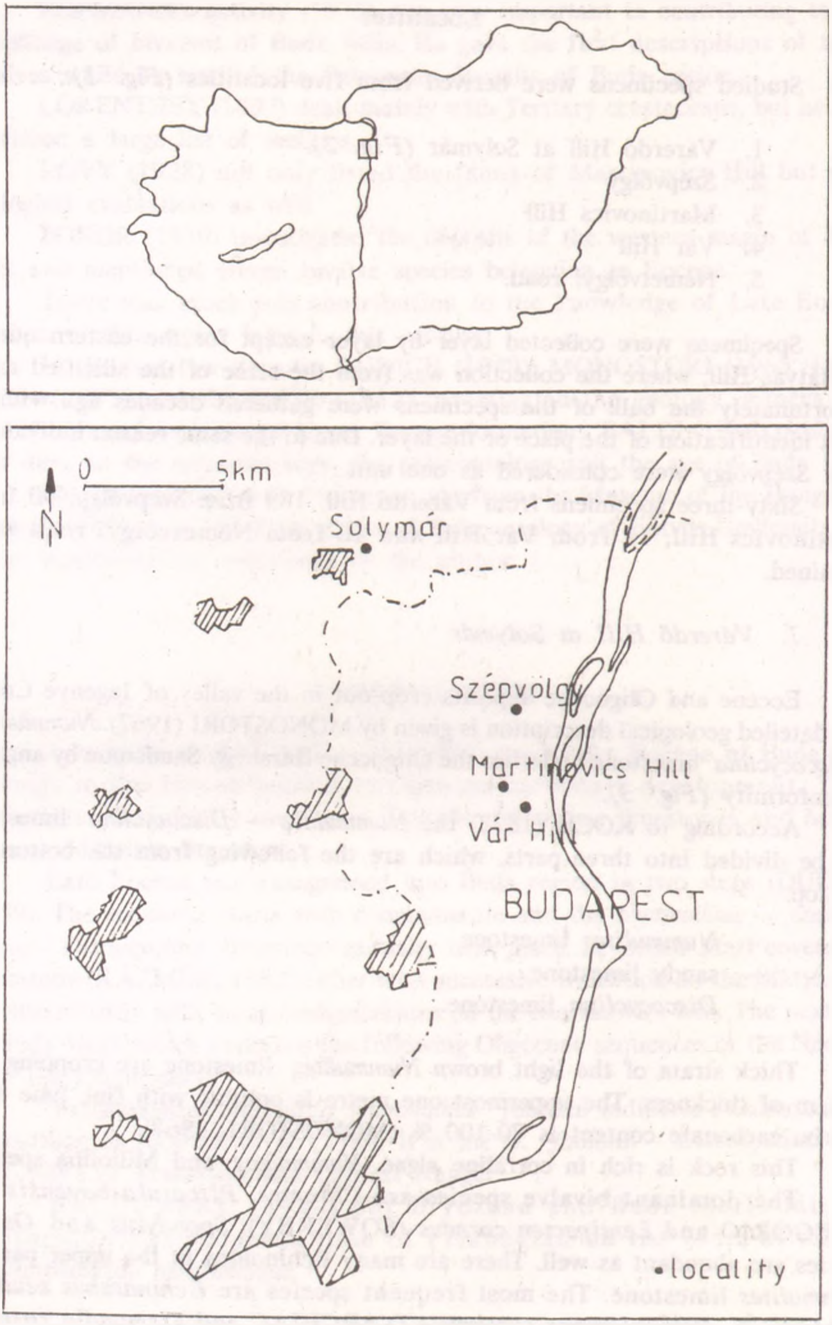

Fig. 1. Upper Eocene mollusc localities in Buda Mts.

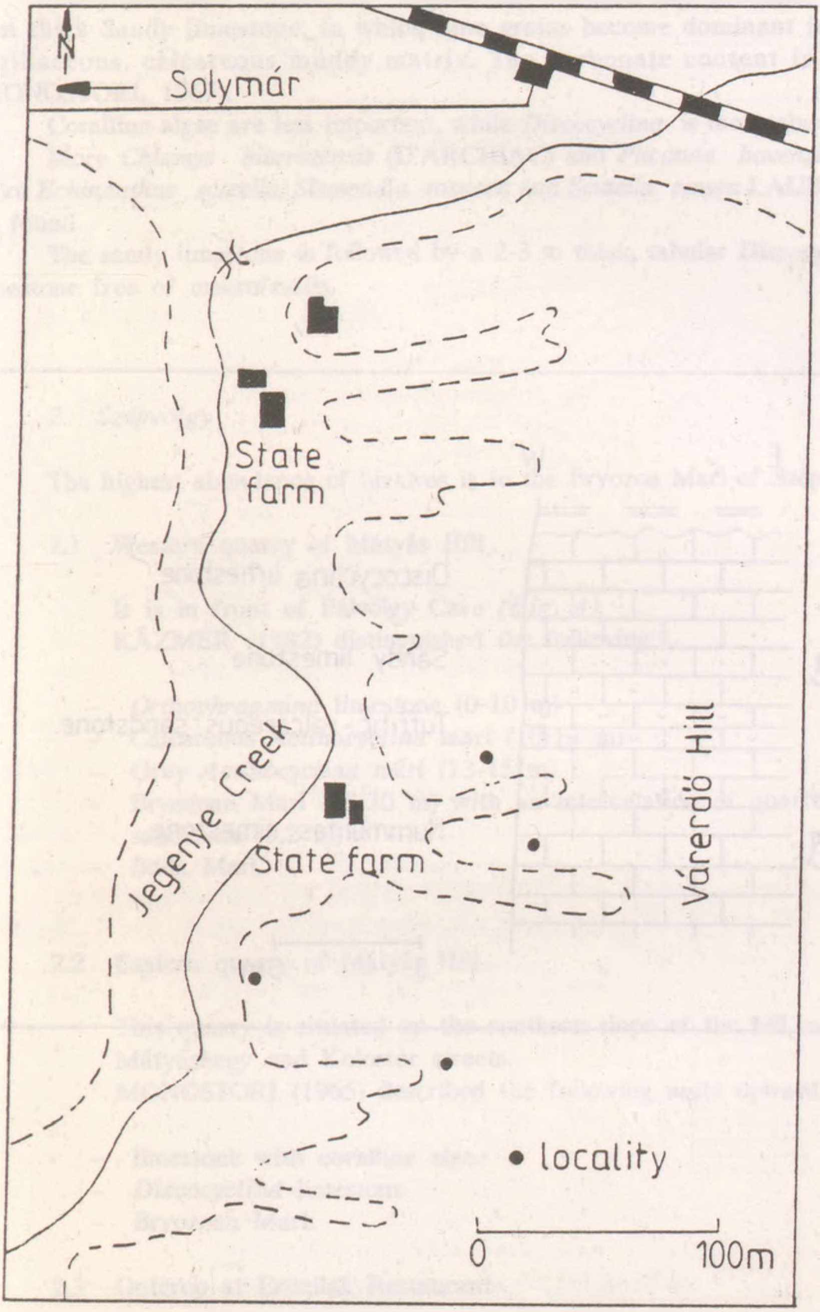

Fig. 2. Localities at Solymár, Várerdő Hill

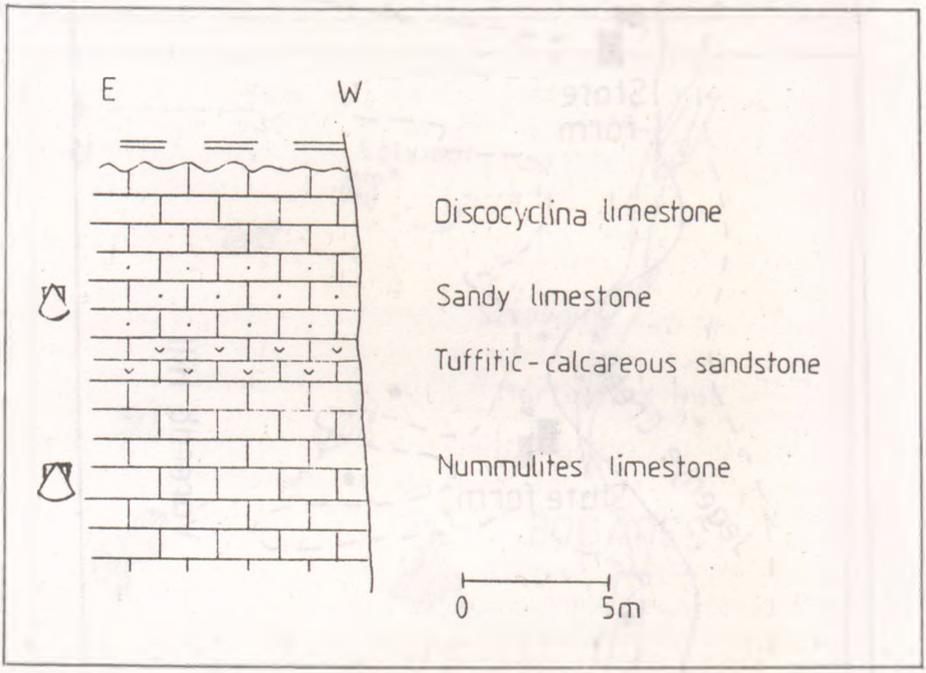

Fig. 3. Upper Eocene sequence at Solymár

The *Nummulites* limestone is gradually changed into the lilac – red, 6 m thick Sandy limestone, in which lime grains become dominant in red, argillaceous, calcareous muddy matrix. The carbonate content is 70 % (MONOSTORI, 1967).

Coralline algae are less important, while *Discocyclina* is more abundant.

More *Chlamys biarritzensis* (D'ARCHIAC) and *Plicatula bovensis* and more *Echinanthus scutella, Sismondia rosacea* and *Scutella tenera* LAUBE can be found.

The sandy limestone is followed by a 2-3 m thick, tabular *Discocyclina* limestone free of macrofossils.

2. *Szépvölgy*

The highest abundance of bivalves is in the Bryozoa Marl of Szépvölgy.

2.1 Western quarry of Mátyás Hill

It is in front of Pálvölgy Cave *(Fig. 4).*
KÁZMÉR (1982) distinguished the following:

- *Orthophragmina* limestone (0-10 m)
- Calcareous *Actinocyclina* marl (10-13 m)
- Grey *Actinocyclina* marl (13-15 m)
- Bryozoan Marl (15-30 m) with an intercalation of quartzose sandstone (0.2 m)
- Buda Marl.

2.2 Eastern quarry of Mátyás Hill

This quarry is situated on the southern slope of the hill, near to Mátyáshegy and Kolostor streets.
MONOSTORI (1965) described the following units upward:

- limestone with coralline algae
- *Discocyclina* limestone
- Bryozoan Marl.

2.3 Outcrop at Erdeilak Restaurant

The Bryozoan Marl crops out 100 m westward from the restaurant.

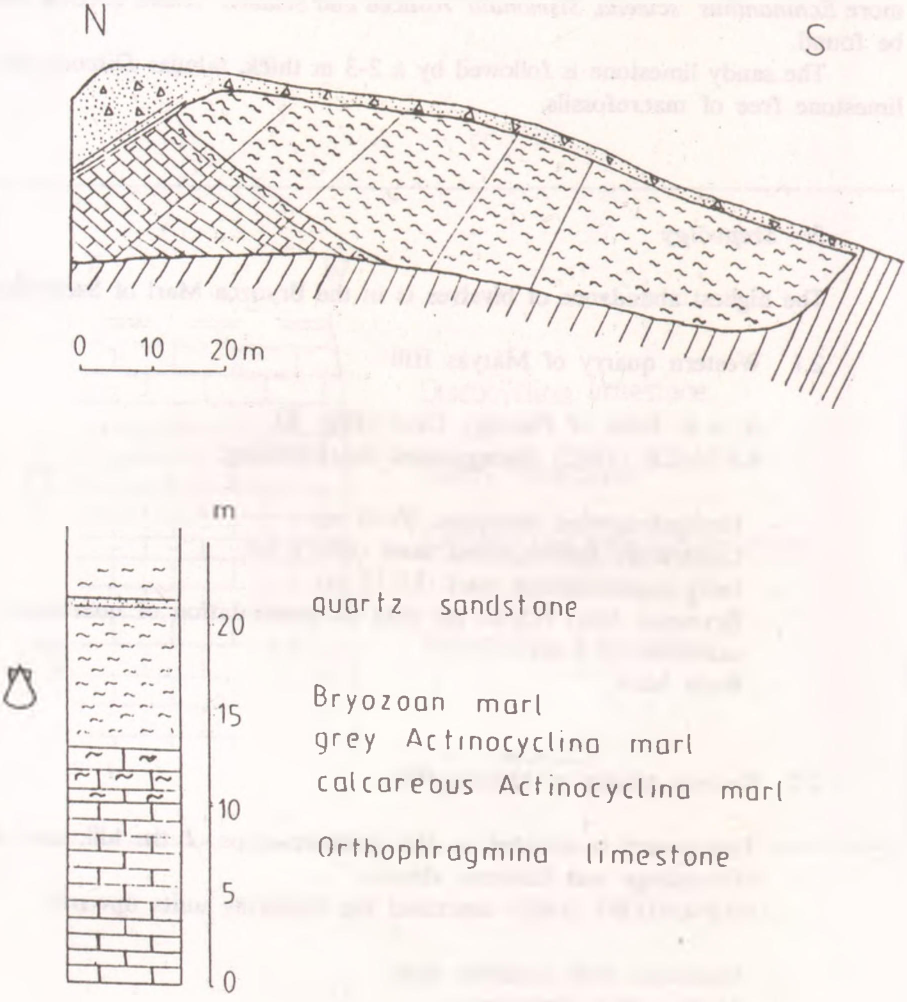

Fig. 4. Mátyás Hill, western quarry. Sequence after KÁZMÉR, 1982.

In this three last localities the Bryozoa Marl contained the bivalve fauna. The light grey, silty marl is rich in fossils. The dominant foraminifer genera are *Actinocyclina* and *Discocycllina.* Bryozoa are rock-forming. The 75 % of the bivalve fauna is *Chlamys biarritzensis.* From the rich Echinoidea assemblage *Schizaster lorioli* PÁVAY and *Opissaster szecsenyii* (PÁVAY) are the most frequent species.

Considerable part of the specimens were gathered from presently unknown outcrops of Martinovcs Hill, Vár Hill and Németvölgy road.

3. *Martinovics Hill*

Ninety specimens were collected from the *Nummulites – Discocyclina* limestone. Although this assemblage is smaller in abundance, it is greater in number of species. The 90 specimens belong to 10 species.

4., 5. *Vár Hill and Németvölgy road*

Twelve individuals from Vár Hill and sixteen from Németvölgy road were collected in the Buda Marl form house foundations.

General character of the bivalve fauna

The 370 specimens of this bivalve fauna belong to 21 species of 15 genera. Moulds and embedded shells made the determination more difficult, therefore the internal morphological features could not be studied. Many shells were etched so the external ornaments were missing. Due to the bad preservation 130 specimens were ranged only into genera.

Our determinations are in good agreement with the system of Treatise (MOORE, 1969). Table 1. contains the complete fauna list.

Table 1. Complete list of the studied fauna

Phylum Mollusca
  Calssis Bivalvia LINNÉ, 1758
    Subclassis Pteriamorphia BEURLEN, 1944
      Ordo Arcoida STOLICZKA, 1871
        Superfamilia Limopsacea DALL, 1895
          Familia Glycymerididae NEWTON, 1922
            Subfamilia Glycymeridinae NEWTON, 1922
              Genus *Glycymeris* DA COSTA, 1778

Glycycmeris sp.

Ordo Mytiloida FÉRUSSAC, 1822
  Superfamilia Mytilacea REFINESQUE, 1815
    Familia Mytilidae RAFINESQUE, 1815
      Subfamilia Lithophaginae ADAMS and ADAMS, 1857
        Genus *Lithophaga RÖDING, 1798*

Lithophaga zignoi (OPPENHEIM), 1900-1901

Subfamilia Modiolinae KEEN, 1958
  Genus *Modiolus* LAMARCK, 1799

Modiola modioloides (BELLARDI), 1852
Modiola cf. *subcarinata* LAMARCK, 1806

Superfamilia Pinnacea LEACH, 1819
  Familia Pinnidae LEACH, 1819
    Genus *Pinna* LINNÉ, 1758

Pinna cf. *margaritacea* LAMARCK,

Ordo Pterioida NEWELL, 1965
  Subordo Pteriina NEWELL, 1965
    Superfamilia Pectinacea RAFINESQUE, 1815
      Familia Pectinidae RAFINESQUE, 1815
        Genus *Lentipecten* MARWICK, 1928

Lentipecten corneus (SOWERBY), 1821

Genus *Propeamussium* DE GREGORIO, 1884

Propeamussium semiradiatus (MAYER), 1861
Parvamussium fallax (KOROBKOV), 1939

Genus *Chlamys* RÖDING, 1798

Chlamys biarritzensis (D'ARCHIAC), 1847
Chlamys aff. *multicarinata* (DESHAYES), 1824
Chlamys subdiscors (D'ARCHIAC), 1847

Familia Spondylidae GRAY, 1826
  Genus *Spondylus* LINNÉ, 1758

Spondylus bifrons MÜNSTER, 1840
Spondylus buchi PHILIPPI, 1847
Spondylus cf. *cisalpinus* BRONGNIART, 1823
Spondylus radula LAMARCK, 1806

Familia Plicatulidae WATSON, 1930
  Genus *Plicatula* LAMARCK, 1801

Plicatula bovensis DE GREGORIO, 1894

Subordo Ostreina FÉRUSSAC, 1822
  Superfamilia Ostreacea RAFINESQUE, 1815
    Familia Grypheidea VYALOV, 1936
      Subfamilia Pycnodonteinae STENZEL, 1959
        Genus *Pycnodonta fischer* DE WALDHEIM, 1835

Pycnodonta brongniarti (BRONN), 1831

Familia Ostreidae LAMARCK, 1818
  Subfamilia Ostreinae RAFINESQUE, 1815
    Genus *Cubitostrea* SACCO, 1897

Cubitostrea cf. *plicata* SOLANDER,

Subfamilia Lophinae VYALOV, 1936
  Genus *Lopha* BOLTEN in RÖDING, 1798

Lopha martinsi (D'ARCHIAC), 1848

Classis Heterodonta NEUMAYR, 1884
  Ordo Veneroida ADAMS and ADAMS, 1856
    Superfamilia Lucinacea FLEMING, 1828
      Familia Lucinidea FLEMING, 1828
        Subfamilia Lucininae FLEMING, 1828
          Genus Lucina BRUGUIÈRE, 1797

Lucina sp.

Superfamilia Carditacea FLEMING, 1820
  Familia Carditidae FLEMING, 1828
    Subfamilia Carditesiane CHAVAN, 1966
      Genus *Cardites* LINK, 1807

Cardites sp.

Superfamilia Crassatellacea FÉRUSSAC, 1822
  Familia Crassatellidae FÉRUSSAC, 1822
    Subfamilia Crassatellinae FÉRUSSAC, 1822
      Genus *Crassatella* LAMARCK, 1799

Crassatella curata DESHAYES,
Crassatella subtumida BELLARDI, 1852

Subclassic Anomalodesmata DALL, 1889
  Ordo Pholadomyoida NEWELL, 1965
    Superfamilia Pholadomyacea GRAY, 1847
      Familia Pholadomyidae GRAY, 1847
        Genus *Pholadomya* SOWERBY, 1823

Pholadomya loczyi TAEGER, 1909

Biostratigraphy

For drawing biostratigraphical conclusions in the Late Eocene, plankton foraminifer and nannoplankton assembalges are more suitable than bivalves. The nannoplankton studies were carried out by BÁLDI-BEKE (1970).

Buda Marl containing *Variamussium fallax* is comparable with *Variamussium fallax* zone of Late Eocene described by Soviet stratigraphiers.

The presence of this species let more precise correspondence between Paleogene of Buda and Crimea, Caucasus and Rhodope regions (BÁLDI, 1983).

The great bulk of bivalves from Buda Hills indicate Late Eocene, but some of them existed in Middle Eocene or in Oligocene as well. Species confining only to the Middle Eocene or the Oligocene were not indentified.

Ranges of identified species are shown in *Table 2.*

Table 2. Ranges of identified species

	E_2	E_3	Ol_1
Chlamys biarritzensis (D'ARCH.)		x	x
Chlamys subdiscors (D'ARCH.)	x	x	x
Crassatella curata DESH.	x	x	
Crassatella subtumida BELL.	x	x	
Cubitostrea cf. *plicata* SOL.	x	x	
Lentipecten corneus (SOW.)	x	x	x
Lithophaga zignoi (OPP.)		x	
Lopha martinsi (D'ARCH.)	x	x	x
Modiola modioloides (BELL.)		x	
Modiola cf. *subcarinata* LAM.	x	x	
Parvamussium fallax (KOR.)	x	x	x
Pholadomya loczyi TAEG.	x	x	
Pinna cf. *margaritacea* LAM.	x	x	
Plicatula bovensis DE GREG.		x	
Propeamussium semiradiatus (MAY.)		x	x
Pycnodonta brongniarti (BRONN)	x	x	x
Spondylus bifrons MÜNST.	x	x	x
Spondylus buchi PHIL.	x	x	x
Spondylus cf. *cisalpinus* BRONGN.	x	x	x
Spondylus radula LAM.	x	x	

Palaeobiogeography

Twenty one species of the studied fauna were suitable for palaeobiogeographical reconstruction. There were only few comparable assemblages elaborated from different points of view or show different ecological or stratigraphical features, so the reconstruction was difficult to do. Statistical evaluation could not be carried out, as well.

Monographs with comparable faunal assemblages are only about the Transylvanian (MÉSZÁROS, 1957), Priabonian (PICCOLI et MOCELLIN, 1962) and Biarritzian (BOUSSAC, 1911) Late Eocene mollucs.

Taking into consideration the number of species in common of these four localities *(Table 3)*, preliminary conclusions could be done.

This study, corresponding to KECSKEMÉTI (1980), proves that our bivalve assemblage belongs to the Mediterranean province.

Table 3. Number of species in common

	Number of species	Number of species in common
Buda Hills	21	–
Priabona	62	12
Transylvania	65	11
Biarritz	34	5

After Piccoli et Mocellin, 1962 ; Mészáros 1957; Boussac, 1911.

Palaeoecology

Study of fossils is useful in reconstruction of palaeoenvironments as well as in drawing conclusions about the conditions of sedimentation. In addition we can get information about the habitat of animals from the characters of sediments (AGER, 1963). In this paper both methods were used.

Studying the recent environmental circumstances: water depth, quality of sediments, temperature, salinity and hydrodynamics, we can draw conclusions about ancient life. It made the actualistic evaluations easy that 13 from the 15 identified genera are still living in the seas.

Our knowledge of the recent life is due to the excellent description of DAVITASHVILI and MERKLIN (1966). Not only the environmental demands of recent forms, but also the sedimentological and palaeontological data were taken into consideration.

Fig. 5. shows the distribution of the characteristic bivalve genera of the main rock types. *Chlamys* is the dominant genus in *Nummulites* and sandy limestones of Solymár, in *Nummulites – Discocyclina* limestone and Bryozoan Marl. In the Buda Marl the most abundant genus is *Propeamussium.*

The palaeoecological conclusions were taken concerning the different abundance and number of species in the five rock types *(Table 4).*

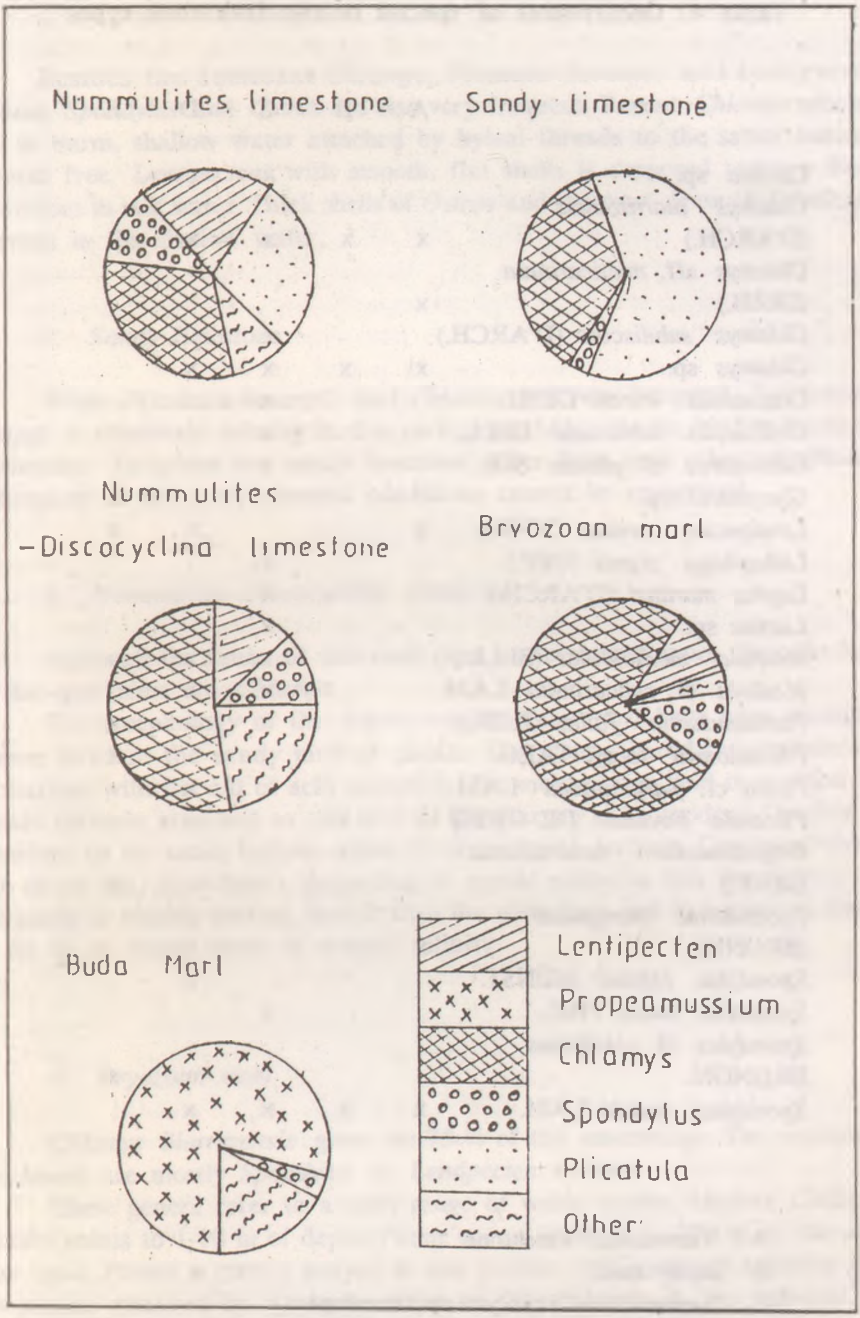

Fig. 5. Distribution of 6 bivalve genera in 5 types of rock.

Table 4. Occurrences of species in the five rock types

	A	B	C	D	E
Cardita sp.			x		
Chlamys biarritzensis (D'ARCH.)	x	x	x	x	
Chlamys aff. *multicarinata* (DESH.)	x				
Chlamys subdiscors (D'ARCH.)			x		
Chlamys sp.	x	x	x	x	
Crassatella curate DESH.			x		
Crassatella subtumida BELL.			x		
Cubitostrea cf. *plicata* SOL.			x		
Glycymeris sp.					x
Lentipecten corneus (SOW.)	x			x	x
Lithophaga zignoi (OPP.)			x		
Lopha martinsi (D'ARCH.)			x		
Lucina sp.			x		
Modiola modioloides (BELL.)				x	
Modiola cf. *subcarinata* LAM.			x	x	
Parvamussium fallax (KOR.)					x
Pholadomya loczyi TAEG.					x
Pinna cf. *margaritacea* LAM.				x	
Plicatula bovensis DE GREG.	x	x			
Propeamussium semiradiatus (MAY.)					x
Pycnodonta brongniarti (BRONN)	x			x	
Spondylus bifrons MÜNST.				x	
Spondylus buchi PHIL.			x		
Spondylus cf. *cisalpinus* BRONGN.					x
Spondylus radula LAM.	x	x	x	x	

A *Nummulites* limestone
B Sandy marl
C *Nummulites-Discocyclina* limestone
D Bryozoan marl
E Buda Marl

1. *Nummulites limestone*

Besides the dominant *Chlamys, Picatula bovensis* and *Lentipecten corneus, Spondylus* and *Ostrea* are also very frequent. Recent *Chlamys* species live in warm, shallow water attached by byssal threads to the sandy bottom or swin free. *Lentipectens* with smooth, flat shells is supposed to have lived in crevices in still water. Thick shells of *Ostrea* and spines of *Spondylus* indicate currents in the shallow water.

2. *Sandy limestone*

While *Plicatula bovensis* and *Chlamys* are very frequent, *Lentipecten corneus* is absolutely missing in this rock type. Although the bivalve fauna of *Nummulites* limestone and sandy limestone differ from each other, significant differences in the environmental conditions cannot be recognized.

3. *Nummulites-Discocyclina limestone*

Although the fauna of this rock type is the richest, more than the half of the specimens are *Chlamys.*

The morphology of the depositional surface must have been variable. *Lucina* lived in the sandy mud of shoals. *Lithophaga* bored into calcareous formations with the aid of acid secretion. The mollusc was held in position by byssal threads attached to the side of the burrow. The modern *Cardita* is abundant on the sandy bottom, above 50 m, in strong currents. Cemented forms also occur (eg.: *Spondylus*). According to recent examples this fauna lived on the sandy or muddy bottom, deeper than the wave base, but in maximum depth of 60 m, in warm water of normal salinity.

4. *Bryozoan marl*

Chlamys biarritzensis gives the 75 % of this assemblage. The remaining specimens are mostly *Spondylus* or *Lentipecten corneus.*

These genera refer to a wide range of water depths. Modern *Chlamys* species points to 1-90 m of depth. *Pinna* occurs from 30 to 300 m, in the soft, fine sand. *Pinna* is partly buried in sea bottom with pointed anterior end lowermost, attached by byssus to rocks or other objects in the sediment.

Spondylus appear even beneath 200 m, while *Modiola* lives between littoral and pelagic zones.

Interpreting this palaeocommunity we can suppose that Bryozoan Marl was deposited in approximately 100 m of warm, normal salinity water.

5. *Buda Marl*

The fauna gathered from Buda Marl indicates the deepest environment. *Amussium*, preferring deep, still water substitutes *Chlamys*, which dominates the previous rocktype. The attending *Glycymeris* and *Pholadomya* refer to deep water, too. In addition the lack of spines and ribs on shells points to deep, still water. Buda Marl may have been deposited in few hundred metres of depth.

In this sequence the bivalve assemblage indicate the deepening sea. The bottom sediments become finer from sand to mud.

Acknowledgements

This work was my graduate thesis. I am grateful to M. MONOSTORI and A. KECSKEMÉTI-KÖRMENDI for supervising this study. I thank all of the members of the Palaeontological Department of Hungarian Geological Institute and at the Department of Palaeontology of Eötvös Unviersity for their support and guidance.

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AN UPPER PANNONIAN (PONTIAN, NEOGENE) MOLLUSC FAUNA FROM THE WESTERN MECSEK HILLS, HUNGARY

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(Received: 10th April, 1989)

Abstract

A new Upper Pannonian (Pontian, Neogene) locality was found in the western part of Mecsek Hills. A 4 m thick fine sand to silt sequence contains two limoniete-cemented fossil-rich beds with casts and moulds of the bivalves *Lymnocardium cristagalli, L. majeri, L. pelzelni, L. schmidti, L. szaboi, Prosodacna vutskitsi, Congeria croatica, C. triangularis, Dreissenomya schröckingeri*, and a gastropod *Viviparus sadleri*. The beds were deposited in a nearshore, less agitated, well oxygenated environment below wave base. Palaeobiogeographical relations exist mostly with regions south of Mecsek.

Recognition of the locality increases the known extension of the Upper Pannonian nearshore sediments.

Introduction

A new fossiliferous locality of Upper Pannonian age (Pontian, Neogene) was found during a summer field work by students L. BUJTOR, T. FEHÉR and A. MOLNÁR. The small exposure lies in the western Mecsek Hills, 2,5 km northeast of the village Nyugotszenterzsébet *(Fig. 1)*. It is located 700 m north of the well in Fekete-erdő-dülő, 20 W of the field road. The outcrop is 12 m long, 4 m high, produced by slumping.

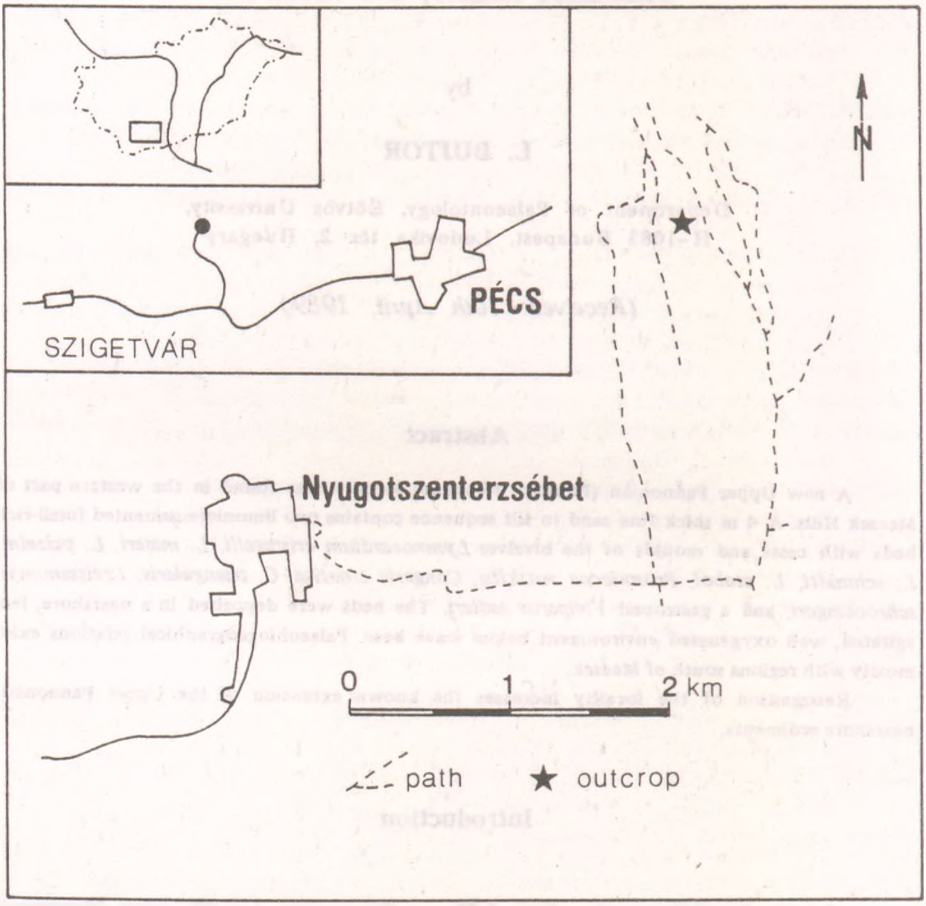

Fig. 1. Location of the Pannonian outcrop in Mecsek Hills

The sequence is the following:

Bed 1 : 1,3 m fine-grained, micaceous sand. Rare, unrecognizable mollusc moulds.
Bed 2: fine sand, less mica. Granite pebbles and detrital fedspar.
Bed 3: mica-less grey fine sand. Much detrital felspar. Rare unrecognizable gastropod steinkerns.
Bed 4: reddish brown, strongly oxidized, limonitic, fine sand-silt. Rich in fossils.
Bed 5: yellow, fine sand, with rare mica flakes. The upper 5 cm is rich in fossils. Same lithology as of Bed 4, but more fossils.
Bed 6: argillaceous sand.
Beds 7, 8: greenish grey argillaceous marl, changing into cryoturbated slope debris, covered by soil *(Fig. 2)*.

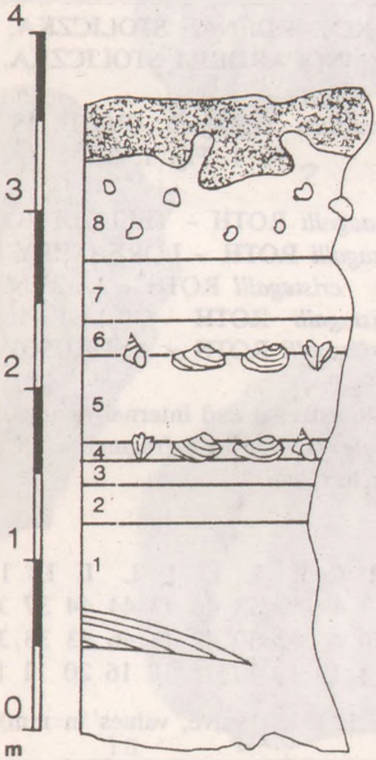

Fig.2. Sequence of the Pannonian outcrop:
1. fine-grained, yellow-grey micaceous sand, cross-bedded, 2. yellow-brown sand, 3. grey, micaceous, fine sand, 4. limonite-cemented fine sand-silt, fossil-rich, 5. yellow, fine sand-silt; upper 5 cm fossil-rich, 6. argillaceous silt, 7. green-grey argillaceous marl, 8. slope debris, cryoturbated, with calcareous concretions; soil

The fossil-rich beds are cemented by limonite; this feature is characteristic for the Mecsek Pannonian (BÖCKH, 1876). The fine limonite film helped to preserve even the minute details of the fossils. Although the molluscs have been dissolved, no subsequent compression occurred, and the moulds and casts can be recognized easily.

Ten species of five genera (including 9 bivalves and a gastropod) were determined.

Systematic palaeontology

BIVALVIA LINNÉ 1758 class
HETERODONTA NEUMAYR, 1884 subclass
VENEROIDA ADAMS et ADAMS, 1856 order
CARDIACEA LAMARCK, 1809 superfamily
LYMNOCARDIIDAE STOLICZKA, 1870 family
LYMNOCARDIINAE STOLICZKA, 1870 subfamily
LYMNOCARDIUM STOLICZKA, 1870 genus

Lymnocardium cristagalli (ROTH, 1878)

Pl. 1. Fig. 1, 2.

1878 *Cardium cristagalli* ROTH – TELEGDI-ROTH Pl. 4. Fig. 1, 2.
1890 *Adacna cristagalli* ROTH – LŐRENTHEY Pl. 1. Fig. 1.
1893 *Limnocardium cristagalli* ROTH – LŐRENTHEY Pl. 5. Fig. 4.
1943 *Budmania cristagalli* ROTH – GILLET Pl. 6. Fig. 9.
1964 *Budmania cristagalli* ROTH – ANDRUSOV Tab. 7. Fig. 11, 12.

Material: Of 43 available external and internal moulds, one bivalved, 22 intact and 9 broken single valves and 8 fragments. Of 35 single valves 15 are right and 20 are left one.

Measurements:

	R	R	R	L	R	L	L	L	L	L	L	L
Length:	49	53	37	48	49	53	48	47	44	44	37	31
Height:	51	55	40	46	42	50	42	48	46	43	38	33
Width:	21	24	18	19	19	17	15	18	16	20	11	13

(R = right valve; L = left valve; values in mm)

Description: Oval, tapering slightly anteriorly. Umbo slightly twisted in anterior direction. Posterior margin vertically truncated. Most of the internal moulds bear 6 ribs, but some giant specimens a seventh one can be observed. The total number of ribs are not preserved on the external moulds, as none of them are intact.

Plate 1


1b


2


1c


1a

Plate 1. (All figures are in natural size)
Fig. 1. *Lymnocardium cristagalli* (ROTH, 1878) Fig. 2. *Lymnocardium cristagalli* (ROTH, 1878) external mould

Rarely two more ribs can be seen, like on the type (6-8 ribs). Width and height of ribs increase posteriorly. The sixth rib is poorly developed, and is followed by the widely gaping posterior margin. Ribs on internal moulds are broader than intervals. Thickness of ribs gradually increases towards the margin and before it they slightly broaden out. Ribs are of wavy surface, continuing into thin keels. Keels are very thin considering the size of valves, but high. Their measurable height (6-9 mm) differs from the type on which keels are 20 mm high. Width of intervals on external moulds are approx. half of those of ribs. This feautre is characteristic for the type also.

Remarks: The types are preserved with complete shell and are, probably due to their shell, somewhat larger (6-7 cm long) than the specimens described here.

On external moulds of adult specimens commarginal rugae, as records of interruptions in secretion of the shell or of changes in the rate of secretion, are recognizable. Except imprints of 2-2 strong lateral teeth, hinge is not observable. Pallial line and muscle scars are not visible. Recontstruction of cross-section of the shell is shown in *(Fig. 3).*

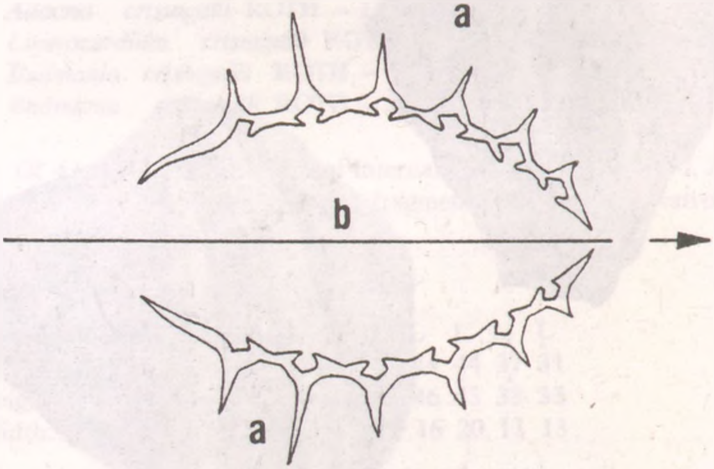

Fig. 3. Cross-section of the shell of *Lymnocardium cristagalli* based on the steinkern and the mould (natural size; c = plane of symmetry)

Occurrence: *L. cristagalli* (s. str.) is known only from the Mecsek Mts. and its surroundings. Forms related to *L. cristagalli (L.hungaricum, L. histiophora, L. semseyi)* occur in a wider area: in the Mecsek Mts. and south of it.

Lymnocardium sp. aff. *majeri* (HÖRNES, 1856)

Pl. 2. Fig. 1.

1856	*Cardium Majeri* HÖRNES – HÖRNES Taf. 28. Fig. 5.
1886	*Cardium (Adacna) Majeri* HÖRNES – HÖRNES – HALAVÁTS Pl. 25. Fig. 7.
1890	*Adacna Majeri* HÖRNES – LŐRENTHEY p. 43.
1893	*Cardium (Adacna) Majeri* HÖRNES – HALAVÁTS p. 29.
1942a	*Limnocardium majeri* HÖRNES – STRAUSZ Tab. 1. Fig.7, 12, 15.
1943	*Limnocardium mayeri* HÖRNES – GILLET Pl. 4. Fig. 6.
1951	*Limnocardium (Arpadicardium) mayeri* HÖRNES – STEVANOVIC Taf. 6. Abb. 10, 11.
1956	*Limnocardium (Arpadicardium) mayeri* HÖRNES – STEVANOVIC Taf. 1. Fig. 6.
1961	*Limnocardium majeri* HÖRNES – STEVANOVIC Taf. 5. Abb. 15, 18.
1971	*Limnocardium mayeri* HÖRNES – BARTHA Pl. 30. Fig. 6.
1971	*Limnocardium majeri* HÖRNES – SZÉLES Pl. 1. Fig. 7.

Material: 1 bivalved specimen and 5 small internal moulds. Double valves are slightly moved on one another.

Measurements:

	L	R	R	L
Length:	19	19	16	20
Height:	11	11	12	17
Width:	16	16	5	5

Description: Nearly equilateral and equivalve but variable in outline: elongated elliptic or oval. Valves with narrow posterior gape. Number of ribs (13-19) differs from the type which shows 12-13 ribs. Ribs are narrow, unevenly spaced and well observable as far as the beak where they are represented by thin treads. The type of *L. majeri* is less inflated and gaping than specimens found recently.

Remarks: Umbo is small, hinge, muscle scars and pallial line are not visible. it is worthy to note that this form is relatively small.

Occurrence: A widespread species in the Pannonian basin.

Plate 2


2


1


3


4


6


5

Plate 2. (All figures are in natural size)

Fig. 1. *Lymnocardium* sp. aff. *majeri* (HÖRNES, 1856) internal mould, Fig. 2. *Lymnocardium pelzelni* (BRUSINA, 1884) internal mould, Fig. 3. *Lymnocardium schmidti* (HÖRNES, 1856), internal mould Fig. 4. *Lymnocardium schmidti* (HÖRNES, 1856), internal mould Fig. 5. *Lymnocardium* cf. *szaboi* LÖRENTHEY 1893 internal mould of a bivalved specimen, Fig. 6. *Prosodacna vutskitsi* (BRUSINA, 1902) internal mould

Lymnocardium pelzelni (BRUSINA, 1884)
Pl. 2. Fig. 2.

1884 *Adacna Pelzelni* BRUSINA - BRUSINA Taf. 28. Fig. 37.
1893 *Cardium (Adacna) Pelzelni* BRUSINA - HALAVÁTS p. 29.
1893 *Limnocardium Pelzelni* BRUSINA - LŐRENTHEY Pl. 4. Fig. 1, 2.
1943 *Limnocardium pelzelni* BRUSINA - GILLET p. 53.
1973 *Limnocardium Pelzelni* BRUSINA - MARINESCU Pl. 3. Fig. 4.

Material : Internal moulds of an intact right valve and of two fragments.

Measurements:

	R
Length:	29
Height:	25
Width:	7

Description: Oval, nearly equivalve shell with median, slightly prosogirous beak. The unbroken internal mould is ornamented with 6 ribs. Intervals are slightly than ribs except at margin where ribs widen out. Well developed protrusions corresponding to spines of the shell, are visible on third, fourth and fifth ribs. Ribs are curved, increasing in width gradually from beak, but always narrower than intervals.

Remarks: Muscle scars are not visible. Growth lines and imprints of two elongated lateral teeth are recognizable.

Occurrence: This realtively rare species is known from the Mecsek Mts. and south of it. There are only a few indications to its occurrence north of the Mecsek.

Lymnocardium schmidti (HÖRNES, 1856)
Pl. 2. Fig. 3, 4.

1856 *Cardium Schmidti* HÖRNES - HÖRNES Taf. 28. Fig. 1.
1884 *Adacna Schmidti* HÖRNES - BRUSINA p. 144.
1890 *Adacna Schmidti* HÖRNES - LŐRENTHEY p. 44.
1893 *Cardium (Adacna) Schmidti* HÖRNES - HALAVÁTS p. 27.
1893 *Limnocardium Schmidti* HÖRNES - LŐRENTHEY Pl. 3.
1943 *Limnocardium schmidti* HÖRNES - GILLET p. 65.
1964 *Limnocardium schmidti* HÖRNES - ANDRUSOV Tab. 4. Fig. 6, 7.

1971 *Limnocardium schmidti* HÖRNES – BARTHA Pl. 30. Fig. 1, 3.
1971 *Limnocardium schmidti* HÖRNES – SZÉLES Pl. 1. Fig. 5, 6.
1973 *Limnocardium schmidti* HÖRNES – KLEB Fig. 29/2.
1973 *Limnocardium (Pannonicardium) schmidti* HÖRNES – MARINESCU Pl. 4. Fig. 1, 3.

Material: 5 internal and 1 external moulds. A fragmentary internal mould and an external mould belong together. Of 3 intact internal moulds 2 are adult specimens and 1 juvenile exemplar. Three right valves and 2 left ones have been collected. No bivalved specimen has been found.

Measurements:

	R	L
Length:	41	27
Height:	36	24
Width:	16	11

Description: Inequilateral shell with large, slightly anteriorly placed, protruding umbo and with 16-18 ribs. Ribs on internal moulds are thin, well visible from beak to margin where they are broadening out. On the external mould are broad and obtuse, crossed by fine growth lines. Intervals are narrow and not observable on internal moulds.

Remarks: Ribbed part of the shell is bordered posteriorly by a protruding keel. The gaping posterior margin is covered by growth rugae. Hinge is not observed.

Occurrence: A widespread species in the Pannonian basin.

Lymnocardium cf. *szaboi* LŐRENTHEY, 1893

Pl. 2. Fig. 5.

1893 *Limnocardium Szabói* LŐRENTHEY – LŐRENTHEY Pl. 3. Fig. 2, 3, 8. Pl. 4. Fig. 4.
1911 *Limnocardium Szabói* LŐRENTHEY – LŐRENTHEY p. 79.
1964 *Limnocardium szaboi* LŐRENTHEY – ANDRUSOV p. 489, Text-fig. 5.

Material: 35 more or less unbroken internal moulds have been collected. Except one bivalved specimen, all are single valves. Of 35 valves 17 are left valves and 18 are right ones.

Measurements:

	L	L	R	L	L	L	L	R	R	L	L	R	R	L
Length:	27	28	32	30	28	31	26	27	25	31	33	33	29	27
Height:	24	25	29	29	26	28	26	23	23	29	30	30	25	26
Width:	10	8	10	11	10	10	9	8	9	11	11	11	10	9

Distribution of length values is plotted in *Fig. 4.*

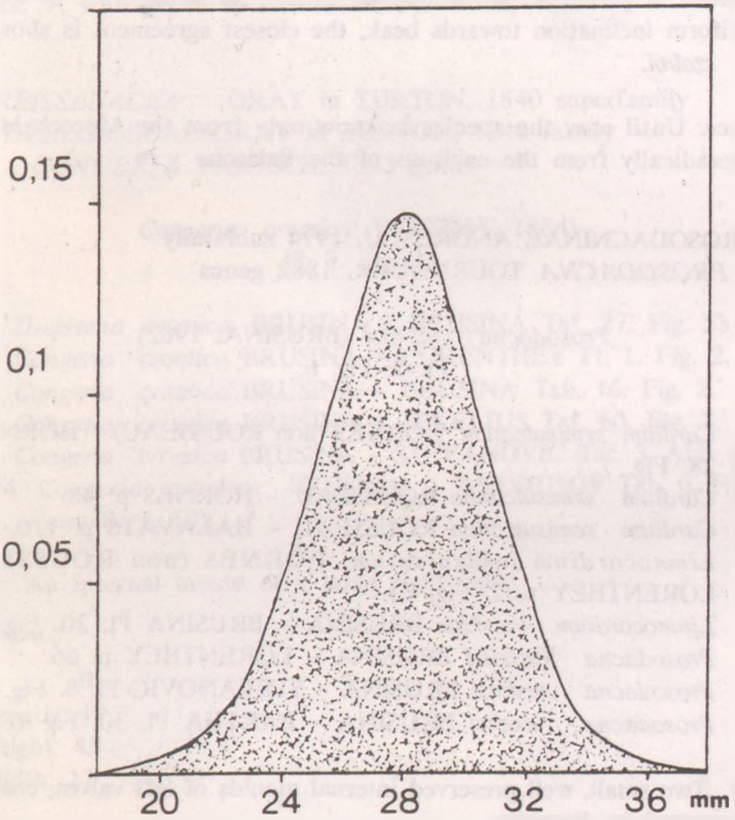

Fig. 4. Length distribution of *Lymnocardium szaboi*. (Approximated by a density function of standard normal distribution, m = 28 mm expected value and σ = 2,7 mm standard deviation)

Description: Strongly inequilateral somewhat inflated shell with slightly prosogirous beak. Anterior margin rounded, posterior one straight. The difference between numbers of ribs observed on the type (10-12) and the recently collected specimens (9-10) is probably attributable to the lack of imprints of first, weak ribs on internal moulds. Ribs are narrower than intervals and gradually increasing in width from beak towards margin where they broaden out.

Remarks: Growth lines are not observable on the internal moulds, posterior margin is smooth. The trapezoidal shape and the broadly rounded anterior margin, described by LŐRENTHEY (1893), can be probably due to the nature of preservation, not recognizable. Although ribs do not show uniform inclination towards beak, the closest agreement is shown with *L. szaboi.*

Occurrence: Until now the species is know only from the Mecsek Mts. and sporadically from the environs of the Balaton.

PROSODACNINAE ANDRESCU, 1974 subfamily
PROSODACNA TOURNOUER, 1882 genus

Prosodacna vutskitsi (BRUSINA, 1902)
Pl. 2. Fig. 6.

1856	*Cardium semisulcatum* HÖRNES (non ROUSSEAU) - HÖRNES Taf. 28. Fig. 7.
1874	*Cardium semisulcatum* ROUSSEAU - HÖRNES p. 48.
1888	*Cardium semisulcatum* ROUSSEAU - HALAVÁTS p. 170.
1893	*Limnocardium semisulcatum* HÖRNES (non ROUSSEAU) - LŐRENTHEY p. 2. Fig. 11.
1902	*Limnocardium Vutskitsi* BRUSINA - BRUSINA Pl. 30. Fig. 36-38.
1911	*Prosodacna Vutskitsi* BRUSINA - LŐRENTHEY p. 66.
1951	*Prosodacna vutskitsi* BRUSINA - STEVANOVIC Pl. 8. Fig. 11, 12.
1971	*Prosodacna vutskitsi* BRUSINA - BARTHA Pl. 30. Fig. 6.

Material: Two small, well preserved internal moulds of left valves, coated and cemented by limonite.

Measurements:

	L	L
Length:	18	17
Heigth:	16	16
Width:	6	11

Description: Elongated elliptical, very inflated shell with anteriorly placed, relatively large umbo. Internal moulds are ornamented by 21-22 very thin ribs, which are sharply protruding between margin and pallial line and thin gradually towards beak.

Remarks: Hinge is hardly observable except a strong large anterior lateral tooth. The two muscle scars are very large, elliptical, and well developed. Pallial line is integripalliate. Distance between pallial line and margin is approx. 3 mm.

It seems to be probable, however, that specimens figured by ROUSSEAU (1842) and HÖRNES (1856) do not belong to the same species.

Occurrence: A widespread species in the Pannonian basin.

DREISSENACEA GRAY in TURTON, 1840 superfamily
DREISSENIDAE GRAY in TURTON, 1840 family
CONGERIA PARTSCH, 1835 genus

Congeria croatica (BRUSINA, 1884)
Pl. 3. Fig. 1.

1884 *Dreissena croatica* BRUSINA – BRUSINA Taf. 27. Fig. 53, 54.
1893 *Congeria croatica* BRUSINA – LŐRENTHEY Pl. 1. Fig. 2, 3.
1897 *Congeria croatica* BRUSINA – BRUSINA Tab. 16. Fig. 2.
1944 *Congeria croatica* BRUSINA – JEKELIUS Taf. 60. Fig. 3.
1951 *Congeria croatica* BRUSINA – STEVANOVIC Taf. 3. Abb. 2, 3, 4.
pars 1964 *Congeria croatica* BRUSINA – ANDRUSOV Tab. 6. Fig. 4, 5. (non 8, 9, 10)

Material: An internal mould of a large right valve.

Measurements:

	R
Length:	49
Height:	45
Width:	17

Description: Amost regularly triangular from with large wing.

Remarks: The specimen agrees with the type in showing very strong sinuous growth rugae. A well developed keel is visible running from beak to ventral margin.

Plate 3

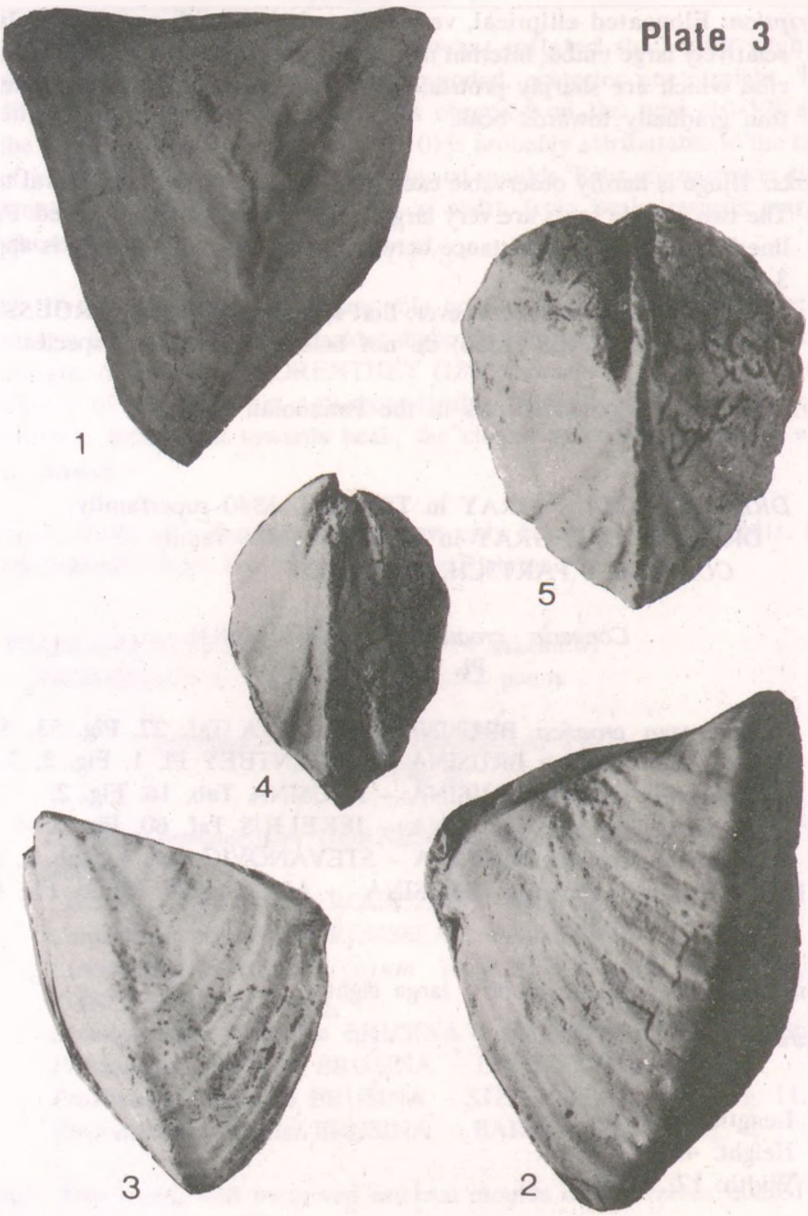

Plate 3. (All figures are in natural size)
Fig. 1. *Congeria croatica* (BRUSINA, 1884) internal mould, Fig. 2. *Congeria triangularis* PARTSCH, 1835 internal mould, Fig. 3. *Congeria triangularis* PARTSCH, 1835 internal mould of a bivalved specimen, Fig. 4. *Congeria trinagularis* PARTSCH, 1835 internal mould, Fig. 5. *Congeria trinagularis* PARTSCH, 1835 internal mould of a bivalved specimen

Occurrence: A very frequent species south of the Mecsek Mts., mainly in Slavonia, Croatia and Serbia. While *C. croatica* is rather common in the Mecsek, north of the mountains only rare occurrences are known.

Congeria triangularis PARTSCH, 1835
Pl. 3. Fig. 2 - 5.

1856 *Congeria triangularis* PARTSCH – HÖRNES Taf. 48. Fig. 1, 2, 3.
1870b *Congeria triangularis* PARTSCH – FUCHS Taf. 16. Fig. 1, 2, 3.
1893 *Congeria triangularis* PARTSCH – HALAVÁTS p. 30.
1902 *Congeria triangularis* PARTSCH – BRUSINA Tab. 18. Fig. 16, 17, 20, 22, 24.
1951 *Congeria triangularis* PARTSCH – STEVANOVIC Taf. 2. Abb. 3.
1964 *Congeria triangularis* PARTSCH – ANDRUSOV Tab. 5. Fig. 15, 16, 17.
1971 *Congeria triangularis* PARTSCH – BARTHA Pl. 26. Fig. 2, 3, 6. Pl. 27. Fig. 3, 4.

Material: 20 double-valved specimens and 26 single valves of which 13 are right and 13 are left valves. Average size of the recently collected specimens (4,1 cm) is characteristically larger than that of the type *(Fig. 5)*. Available data are not sufficient to explain this feature.

Measurements:

	L	R	L	R	R	R	L	L	L	R	R	R	L	L
Length:	37	35	40	44	41	41	50	44	27	29	50	41	36	57
Height:	29	29	31	31	32	34	33	32	20	19	40	31	21	41
Width:	12	13	16	17	19	19	18	17	10	12	22	19	14	19

Description: Triangular form, agreeing with the type. Outline of double valves from anterior view is variable from elliptical to circular.

Remarks: While the keel on internal moulds is well developed, imprint of first rib is not always visible. Thickness of the shell does not reach 1 mm even on the largest specimens. On intenal moulds growth lines are represented by coarse rugae.

The specific determination is based only on observations carried out on internal moudls. Valves of some bivalved specimens are removed on one another. *C. triangularis* is the single recently found species whose specimens are dominatly bivalved.

Occurrence: A widespread, very frequent species in the Pannonian basin.

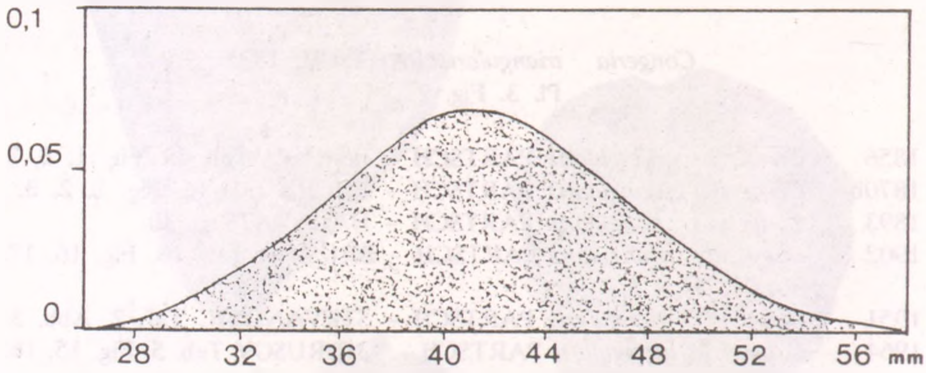

Fig. 5. Height distribution of *Congeria trinagularis* approximated by a denstiy function of standard normal distribution, m = 41 mm expected value and s = 5,7 mm standard deviation.

DREISSENA BENEDEN, 1835 genus
DREISSENOMYA FUCHS, 1870 subgenus

Dreissenomya schröckingeri (FUCHS, 1870)
Fig. 4. Fig. 1 - 5.

1870a *Congeria Schröckingeri* FUCHS - FUCHS Taf. 16. Fig. 10, 11.
1893 *Dreissenomya Schröckingeri* FUCHS - LŐRENTHEY p. 78.
1960 *Dreissenomya schröckingeri* FUCHS - BARTHA Pl. 2. Fig. 2.
1964 *Dreissenomya schröckingeri* FUCHS - ANDRUSOV Tab. 19. Fig. 9 - 11.
1971 *Dreissenomya schröckingeri* FUCHS - BARTHA Pl. 23. Fig. 6, 7.
1977 *Dreissenomya schröckingeri* FUCHS - MARINESCU Pl. 4. Fig. 8, 9.

Material: 20 available bivalved internal moulds, many are fragmentary, and some of them slightly removed on one another. 10 external moulds of single valves are also available.

Measurements:

Length:	74	43	51	43	52	48	38	79	65	43	83	80	45
Height:	28	24	24	22	27	23	21	33	28	20	40	35	23
Width:	16	12	16	12	16	12	14	19	10	-	-	-	-

H/W ratios against length values are plotted in *Fig. 6.*

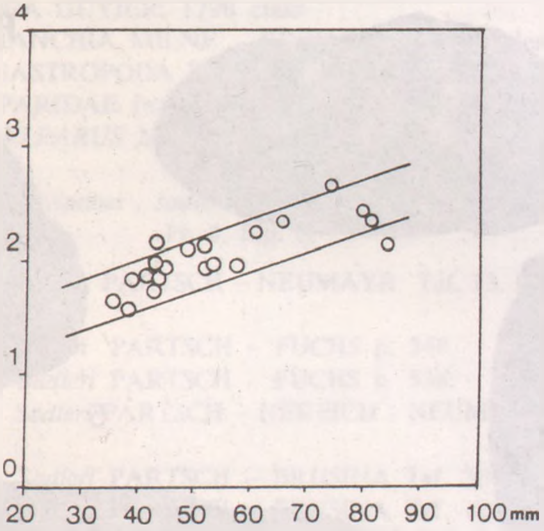

Fig. 6. Growth of *Dreissenomya schröckingeri* during ontogeny. (Length compared to length/width ratio)

Description: Slightly oblong-shaped elliptial shells. The terminal beak is small. Shell is flattened with umbo below beak. Valves are strongly gaping anteriorly, becoming closed below beak and again gaping from the strong inflexion of the posterior margin. The two radial ribs ending back of the beak are well visible on the external mould.

Remarks: Shell is ornamented by dense, usually thin, somewhere stronger growth lines. Thickness of shell approx. 0,5 mm. Pallial line sinupalliate with well observable very deep sinus occupying approx. 1/3 of the internal valve surface. The elliptical muscle scars are well visible.

On a left valve internal mould a damage is observable (Pl. 4. Fig. 5). The animal survived the proably mechanical effect and grew a "halft pearl" (for a similar case, se BACHMAYER – BINDER 1967).

Occurrence: A widespread species in the Pannonian basin.

Plate 4

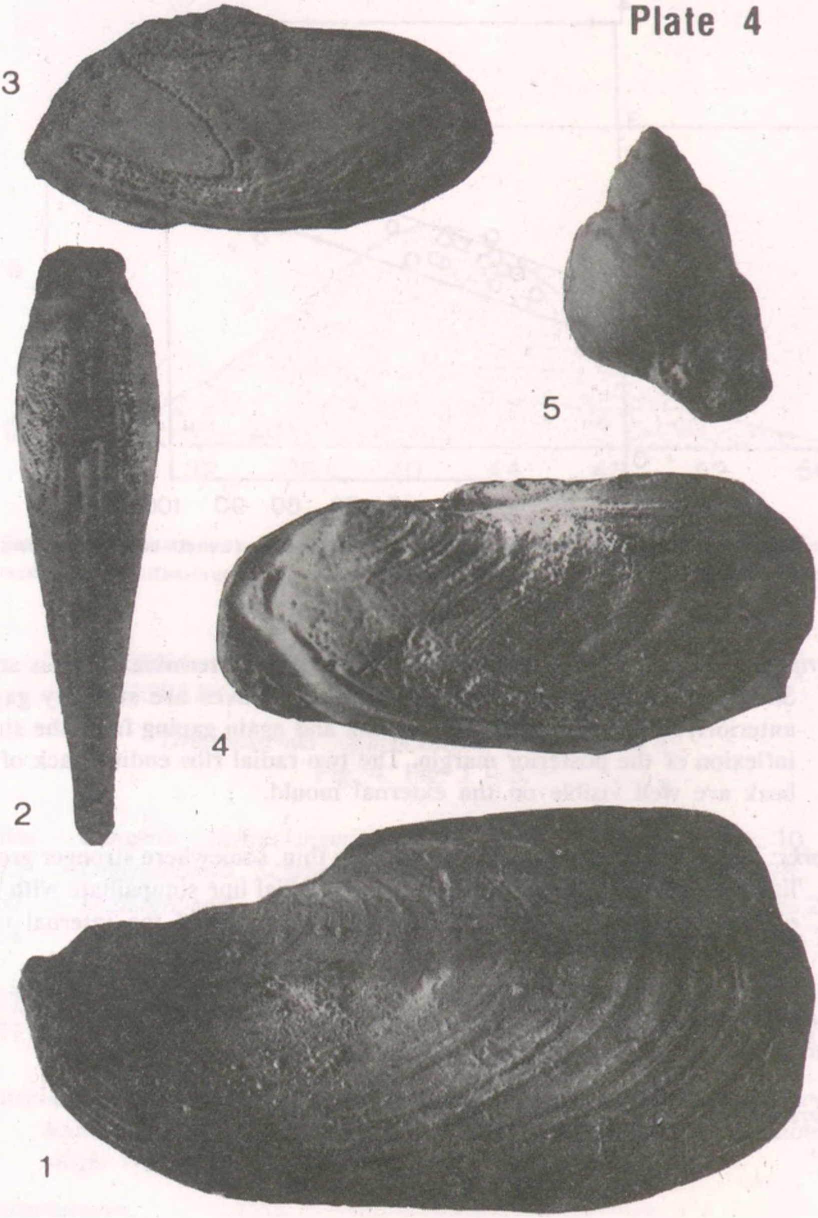

Plate 4. (All figures are in natural size)
Fig. 1. *Dreissenomya scröckingeri* (FUCHS, 1870) external mould, Fig. 2. *Dreissenomya schröckingeri* (FUCHS, 1870) internal mould of a bivalved specimen, Fig. 3. *Dreissenomya schröckingeri* (FUCHS, 1870) internal mould of a bivalved specimen, Fig. 4. *Dreissenomya schröckingeri* (FUCHS, 1870) mould of a "semi-pearl" in internal mould, Fig. 5. *Viviparus sadleri* (PARTSCH, 1835) rubber cast

GASTROPODA GUYIER, 1798 class
PROSOBRANCHIA MILNE – EDWARDS, 1848 order
MESOGASTROPODA WENZ, 1938 suborder
VIVIPARIDAE family
VIVIPARUS MONTFORT, 1810 genus

Viviparus sadleri (PARTSCH, 1835)
Pl. 4. Fig. 6.

1869 *Vivipara Sadleri* PARTSCH – NEUMAYR Taf. 13. Fig. 17. Taf. 14. Fig. 2, 3.
1870a *Vivipara Sadleri* PARTSCH – FUCHS p. 348.
1870b *Vivipara Sadleri* PARTSCH – FUCHS p. 534.
1875 *Vivipara Sadleri* PARTSCH – HERBICH - NEUMAYR Taf. 16. Fig. 1, 4.
1884 *Vivipara Sadleri* PARTSCH – BRUSINA Taf. 30. Fig. 12.
1897 *Vivipara Sadleri* PARTSCH – BRUSINA Taf. 12. Fig. 31, 33.
1942b *Viviparus Sadleri* PARTSCH – STRAUSZ Taf. 1. Fig. 8, 24.
1971 *Viviparus sadleri* PARTSCH – BARTHA Pl. 7. Fig. 1, 6.

Material: 11 internal moulds and 6 imprints. Imprints were determined by means of rubber casts. Internal moulds probably also belong to this species.

Measurements:

Height:	25	23	29
Width:	17	17	20

Description: Variable form with thin shell. First three whorls are convex, involute, then whorls become higher. Last whorl flat or slightly concave. Penultimate whorl of larger specimens can be also flat. Aperture elliptical, without shell thickening. Orthocline growth lines are the only sculpture.

Remarks: Because shell is rather thin (less than 1 mm) internal moulds well reflect the external morphology.

Occurrence: A widespread species in the Pannonian basin.

Environmental interpretations

Analysing relations between litho- and biofacies it must be taken into consideration that recently collected species were previously recorded from different rock types in the environs of the Mecsek Mts. (TELEGDI-ROTH 1878, LŐRENTHEY 1894a, BÖCKH 1876) so the biofacies probably is not closely related to the lithofacies.

Biofacies: High amount of fragmentary specimens, especially characteristic to the thin-shelled, large *Dreissenomya* indicates an environment of agitated water. The presence of large *Dreissenomya* unbroken and *L. cristagalli* specimens with intact thin keels, however, points that water energy could be moderate.

The investigated fauna could occupy a nearshore shallow-water environment. Based on data obtained on recent Dreissenidae, water depth did not exceed some 10 metres (DAVITASVILI 1966). The bottom could be characterized by moderate water energy below wave base (KORPÁS-HÓDI 1983) and good aeration.

The total lack of remains of juvenile specimens is a striking feature of the fauna. Their shell thickness (less than 0,5 mm) probably could be comparable with the grain size of the host rock and the dissolution of shells during diagenesis could eliminate juveniles.

208 adult specimens representing a thanatocoenose have been collected. Generic composition of the fauna is shown if *Fig. 7a.* Distribution of Lymnocardiid species is shown in *Fig. 7b.* Specimens of *Dreissenomya* of them fragmented are usually embedded with commissure plain parallel with the bedding. All other faunal elements are randomly oriented. The dominance of single valves, the frequent fragmentary preservation and the random orientation may indicate some reworking, but no direction of transport has been recognized.

The investigated molluscs belong to groups of different life habits:

Lymnocardium species were shallow burrowers. *Dreissenomya* the most successful deeper burrower (GRAY 1988) represents a deeper inbenthonic life habit. Species of *Congeria* are sessile epibenthonic forms.

Among these bivalves the vagile epibenthohic *Viviparus* is unexpected. According to KORPÁS-HÓDI (1983) *Viviparus* indicates an environment different of those presumed for the bivalves. These gastropods and the *Prosodacna* specimens were transported by currents from shallower water facies into the deeper water thanatocoenose. The lack of fossils preserved in life position still among the deeper burrower *Dreissenomya* also points to currents influencing the thanatocoenose. The absence of abraded shells, however, indicates a short distance transport and rapid burial.

Considering extremely large size of the investigated molluscs in comparision with other brackish-water forms, they could live in very favourable conditions.

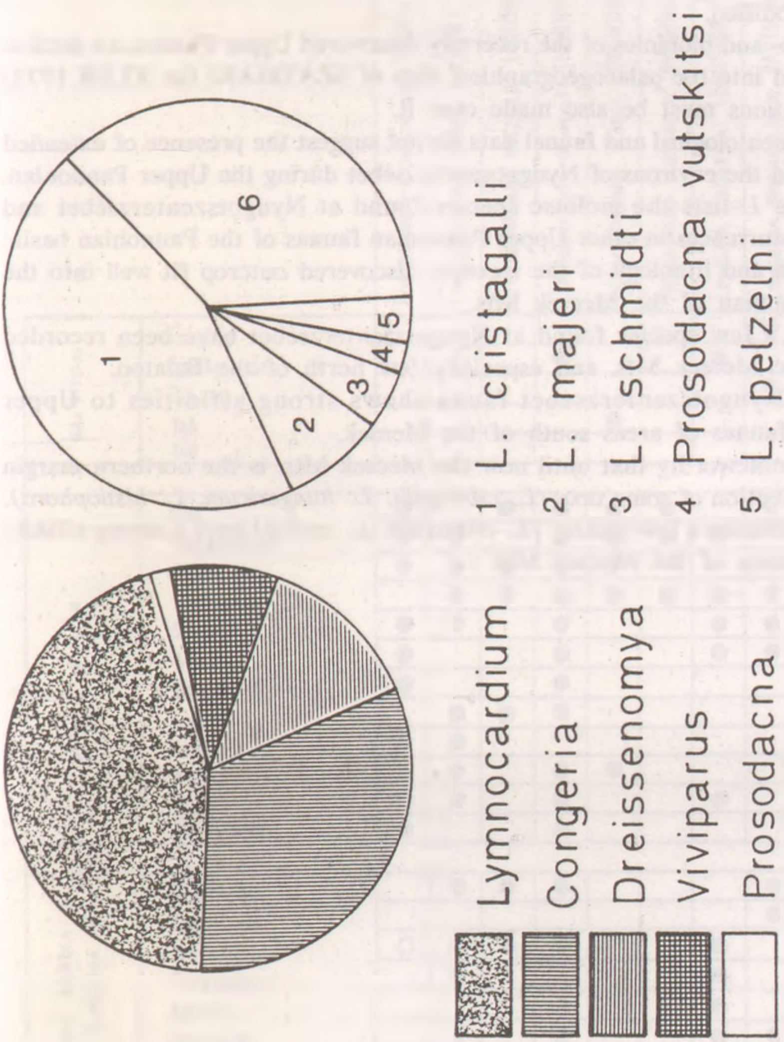

Fig. 7. Composition of the mollusc fauna and the species distribuion of the genus *Lymnocardium*

Conclusions

Following the discovery of Upper Pannonian rocks and fauna at Nyugotszenterzsébet the palaeogeographical map published by BARTHA (1971) must be modified.

Litho- and biofacies of the recerntly discovered Upper Pannonian section can be fitted into the palaeogeographical map of SZATMÁRI (in: KLEB 1973) some alterations must be also made over it.

Sedimentological and faunal data do not suggest the presence of extended land areas in the environs of Nyugotszenterzsébet during the Upper Pannonian.

Table 1. lists the mollusc species found at Nyugotszenterzsébet and indicates occurrences in other Upper Pannonian faunas of the Pannonian basin.

Fauna and lithology of the recently discovered outcrop fit well into the Upper Pannonian of the Mecsek Mts.

Only a few species found at Nyugotszenterzsébet have been recorded north of the Mecsek Mts. and especially few north of the Balaton.

The Nyugotszenterzsébet fauna shows strong affinities to Upper Pannonian faunas of areas south of the Mecsek.

It is noteworthy that until now the Mecsek Mts. is the northern margin of the distribution of some taxa *(L. cristagalli, L. hungaricum, L. histiophora).*

Distribution a few species *(L. cristagalli, L. szaboi)* have a strong affinity to the outcrops of the Mecsek Mts.

		Lymnocardium cristagalli (Roth, 1878)	Lymnocardium majeri (Hörnes, 1856)	Lymnocardium pelzelni (Brusina, 1884)	Lymnocardium schmidti (Hörnes, 1856)	Lymnocardium szaboi Lőrenthey, 1893	Prosodacna vutskitsi (Brusina, 1902)	Congeria croatica (Brusina, 1884)	Congeria triangularis Partsch, 1835	Dreissenomya schröckingeri (Fuchs, 1870)	Viviparus sadleri (Partsch, 1835)
BALATON	Fonyód								●	●	●
	Balatonarács				●			●			
	Tihany								●	●	●
	Tab					●				●	
	Kúp									●	
MECSEK	Kurd	●		●	●	●	●		●	●	
	Nagymányok	●	●		●	●	●	●			
	Hidas	●	●	●	●	●			●	●	●
	Szekszárd		●	●	●	●	●	●	●		●
	Sormás	●	●		●			●	●	●	
	Bükkösd	●			●			●	●	●	
	Magyar-Soros	●			●						
	Liptód		●	●	●						
	Bakócza	●	●								
	Árpád		●		●	●				●	
	Ibafa	○	●		●			●		●	
	Németürög	●			●						
BANAT, SERBIA SLAVONIA	Királykegye		●	●	●				●	●	
	Radmanest								●	●	●
	Okrugljak	○	●	●	●			●			●
	Černomerec		●					●			
	Remete				●			●			
	Mislodjin		●		●			●	●		
	Brestovik	○	●		●			●	●	●	
	Zagreb	○	●	●	●			●			●

Table 1. Distribution of the investigated species in some selected localities. The comparison based on the following data: Brusina 1884, Fuchs 1870a, Halaváts 1893, Hörnes 1856, Lőrenthey 1893, 1894a, 1894b, 1911, Stevanovic 1951, Sümeghy 1939, Telegdi-Roth 1878. O morphotypes of *L. cristagalli*

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METHODICAL PROBLEMS OF THE BIOPOLYMER ORGANIZATION OF PARTIALLY DEGRADED ECTEXINE

by

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(Received: 22nd February, 1989)

Abstract

A new type of the Markham rotation was introduced for the study of the regular pentagonal biopolymer units of the partially degraded ectexine of *Pinus griffithii* McCLELL. In contrast to the previous methods the centrum of the rotation was not the middle point of an effective biopolymer unit (primary rotation) or a new point of symmetry, which appeared after a primary rotation (secondary rotation), but a new point of symmetry which was indicated as follows: The scheme of a basis PENROSE-unit (a central polygon surrounded with five other pentagonal polygons) was taken for a basis which appeared in consequence of a secondary rotation. The same scheme was re-joint to the first basis PENROSE equivalent modell, and from these new points of symmetry were chosen one for the centrum of the new type of rotation, named as tertiary rotation. Based on our first work, several types (at least three) of tertiary rotation may be distinguished according to the manner of the re-joint, or the orientation of the rotations axis. This new method was suitable to prove biopolymer organization from living plant cell wall built from the basic PENROSE-units.

Introduction.

During the transmission electron microscopical investigations of the partially degraded pollen wall it was established that the basic biopolymer unit is a regular pentagonal polygon. These units are organized into a quasi-crystalloid biopolymer skeleton (KEDVES, 1988a, KEDVES et al. 1988). The MARKHAM rotation method outside to justify the symmetry of the biopolymer unit guaranteed further opportunities. The basic paper for the rotation method applied to the basic biopolymer units and its organization of the plant cell wall was published in 1989 (KEDVES). Naturally the further development of this method seemed necessary "in statu nascendi".

Previously we succeeded in demonstrating a biopolymer system from living plant cell wall a regular pentagonal polygon unit, joint with further five pentagonal polygons with secondary rotation for the first time. This is the basis PENROSE-unti (1979, p. 32, *Fig. 1*). The further problem was evident. Is it a way to demonstrate the "second stage" of PENROSE-system (1979, p. 32, *Fig. 2*) or at least space-equivalent organization from the biopolymer system of the plant cell wall? This paper summarizes our first attempt and results in this subject.

Material

Although the recent experiment of the partial degradation of the plant cell wall mostly on sporomorphs, several regular pentagonal polygon biopolymer units were observed, it seemed to be the best to solve the methodical problems on our so-called standard biopolymer unit. The first documentation, including the first rotation picture from the biopolymer units of the sporopollenin is under publication (KEDVES, 1988b).

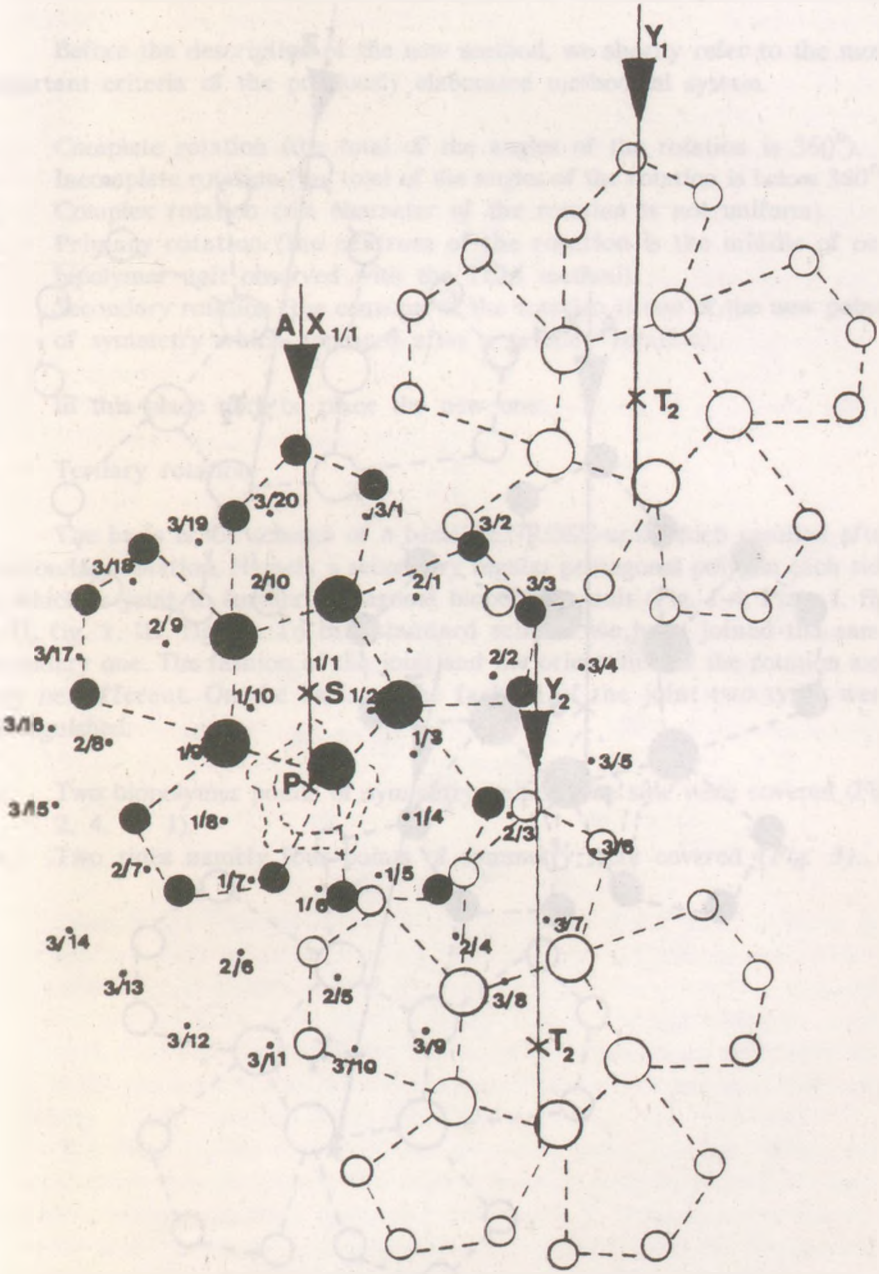

Fig. 1. Scheme of the basic PENROSE-unit, and joint on two point of symmetry after parallelization of the axis of rotation. The basic biopolymer unit is drawn with broken-line, and around the points of symmetry resulted by the rotation C.P.5.A.5.10.

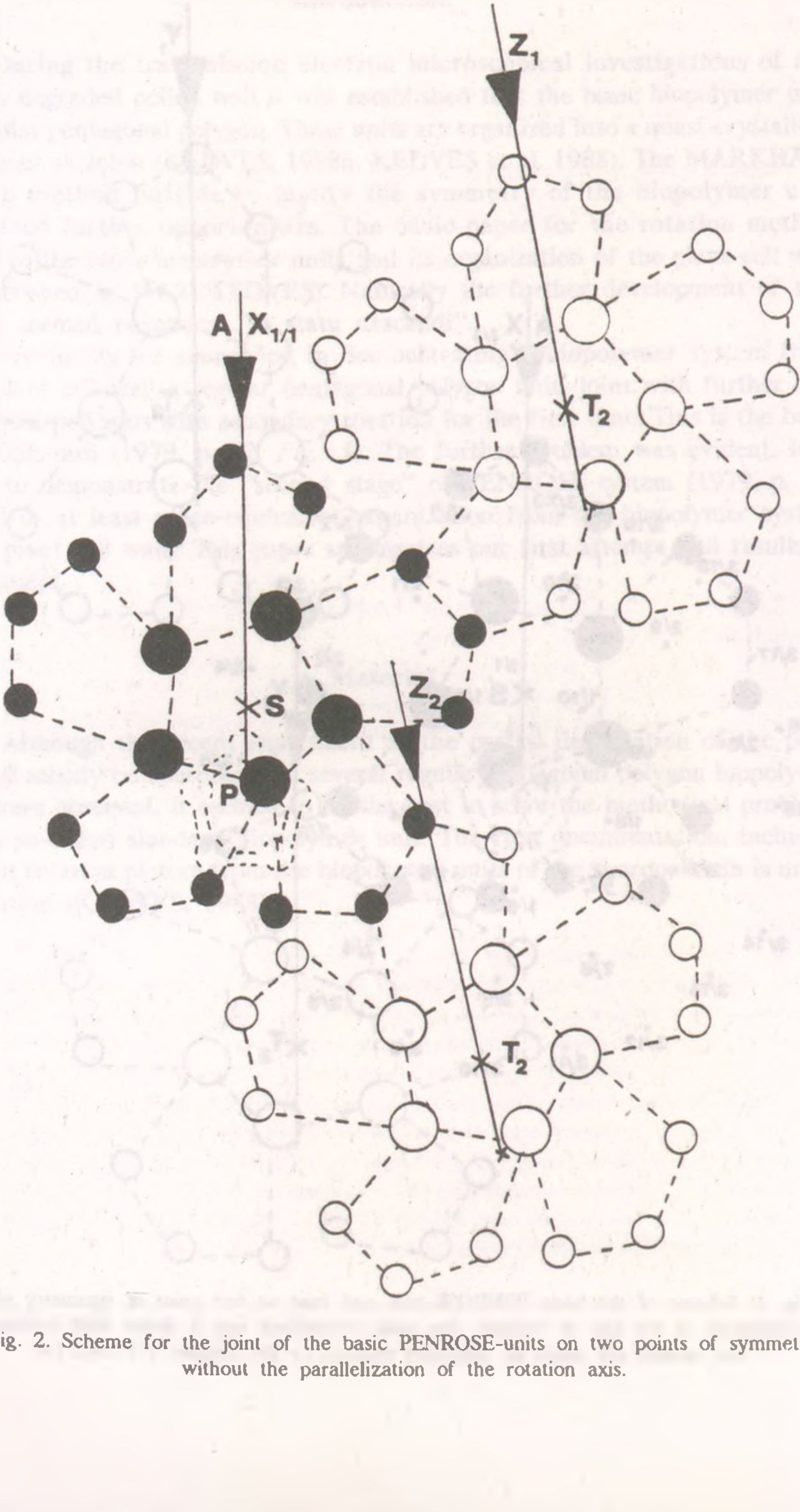

Fig. 2. Scheme for the joint of the basic PENROSE-units on two points of symmetry without the parallelization of the rotation axis.

Basis of the new method and its first results

Before the description of the new method, we shortly refer to the most important criteria of the previously elaborated methodical system.

C. - Complete rotation (the total of the angles of the rotation is 360°).
I. - Incomplete rotation (the total of the angles of the rotation is below 360°).
H. - Complex rotation (the character of the rotation is not uniform).
P. - Primary rotation (the centrum of the rotation is the middle of one bipolymer unit observed with the TEM method).
S. - Secondary rotation (the centrum of the rotation is one of the new points of symmetry which appeared after a primary rotation).

In this place may be place the new one:

T. - Tertiary rotation

The basis is the scheme of a basic PENROSE-unit which resulted after a secondary rotation. Namely a secondary regular pentagonal polygon each side of which is joint to further pentagonal biopolymer unit (Fig. 1-4; Plate I, fig. 1, II, fig. 1. III. fig. 1). To this standard scheme we have joined the same secondary one. The fashion of the joint and the orientation of the rotation axis may be different. On the basis of the fashion of the joint two types were distinguished:

T_2. - Two biopolymer points of symmetry namely one side were covered (Fig. 2, 4, cf. 1).
T_4. - Two sides namely four points of symmetry were covered *(Fig. 3).*

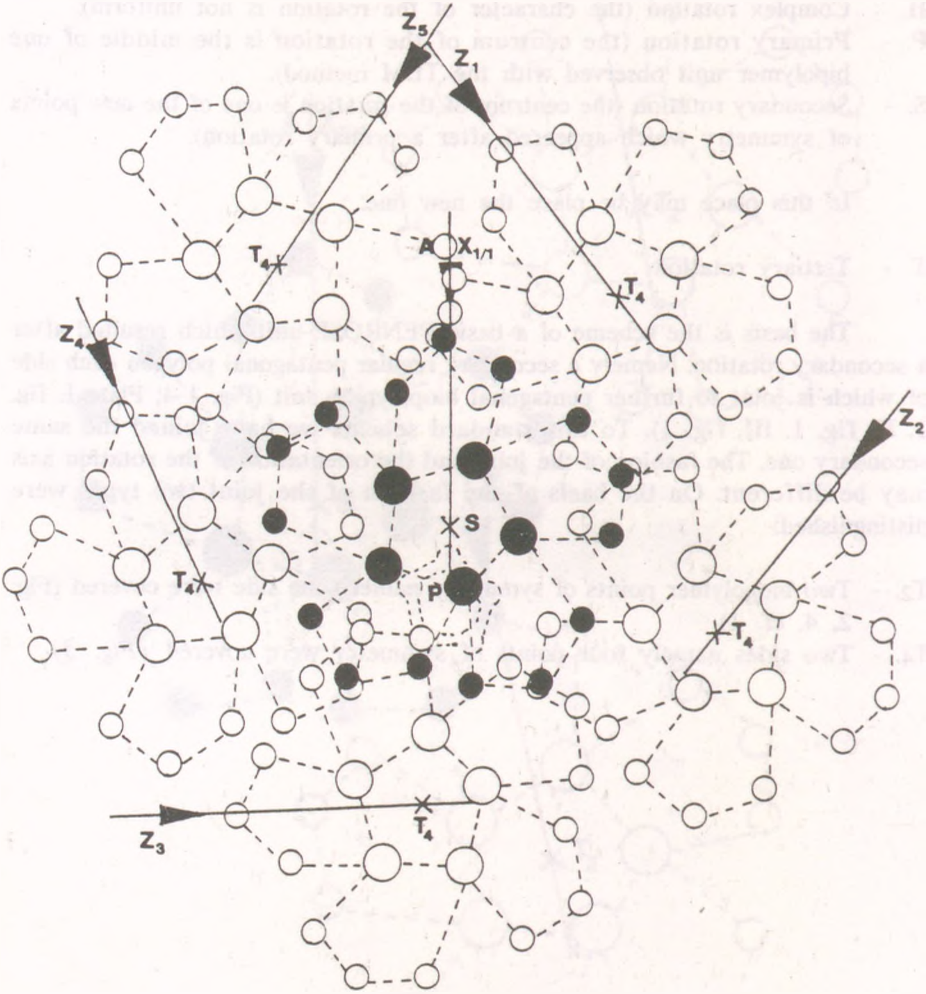

Fig. 3. Scheme of the quasi-crystalloid modell, after the joint of one side (four points of symmetry) of the basic PENROSE-unit.

The designation of the symmetry of the investigated biopolymer unit corresponds to the previous ones (5, 4, 3).

Taking into consideration the axis of the rotation the following were distinguished:

A. - The straight between the centrum of the effective biopolymer and one apex of the biopolymer polygon.
B. - The straight between the centrum of the veritable biopolymer and the bisecting point of two biopolymer polygons.
X. - The straight between the centrum of the veritable biopolymer and a non-primary point of symmetry.
Y. - Parallel with the P. A. axis, and crosses one non-primary point of symmetry.
Z. - The straight which crosses one non-primary point of symmetry, and its direction has a deviation angle.

The designation of the symmetry of the rotation (5, 4, 3 etc.) and the number of the expositions (5, 10, 4, 8, 3, 6 etc.) follows the previous ones.

For the tertiary rotation at the first attempt the scheme of the basic PENROSE-modell was taken for basis. This resulted in a secondary rotation. Centrum of the rotation: S$_{Y1}$, basic picture C.P.5.A.5.10., secondary rotation: C.S.5.X$_{Y1}$.5.5. At the tertiary rotations three manners were used with the two points of symmetry for each kind of rotation. The detail of the method, and the first results are summarized as follows:

1.1. C.T$_2$.5.Y$_1$.5.5. (Fig. 1, Plate I, fig. 2).

Namely the rotation is complete (C), tertiary (T), 2 index indicate that there are two joint biopolymer points of symmetry, 5. = the symmetry of the bipolymer unit. Y designate, that the axis of the tertiary rotation is parallel with the original P. A. axis. Index 1 refers that in relation to the P. A. axis right handed the rotation centrum is the centre of the first basic PENROSE-unit. This is the centrum of the so-called central pentagonal polygon. 5.5. = the symmetry of the rotation, respectively the number of the exposition.

Results. - At the corner of the picture appeared one part of the basis picture, which may be joint to the original (marked with an arrow). We belive, that this phenomenon has a particular importance. It is worth mentioning that when we have completely joined the corner of the fig. 2, with the corresponding part to the picture 1, the rotation axes were not parallel. The tertiary rotation resulted several well definable dark (positive) spherical units. The inner pentagonal polygon is approximatively the same in dimension as the basic biopolymer unit of the primary rotation. This polygon is surrounded by further two pentagonal polygons, bordered with spherical bipolymer units (Plate I, fig. 2). For this biological or molecular orderliness from the "non-biological" papers as analogies we refer to the following: MACKAY (1976), p. 407, "Figure 4 The hierarchic packing of pentagons". PENROSE (1979), p. 34, fig. 8. SACHDEV and NELSON (1985), p. 32, "Fig. 7. (a) Sites of the vertex icosahedral crystal and the Penrose rhombohedra projected along planes perpendicular to a fivefold symmetry axis". AUDIER and GUYOT (1986), fig. 2. "(d) high-resolution TEM micrographs along the five-fold axis (GUYOT and AUDIER 1985)". NELSON (1986), p. 46 "Icosahedral cluster of atoms..." fig. 1-4. SCHNEER (1988), p. 395, "Fig. 5. Inside of the pentagol pyramidal cap of an ISP$_3$ showing six spheres of the cap of the included IS$_2$"

1.2. C.T$_2$5.Y$_2$5.5. (Fig. 1, Plate I, fig. 3)

The centrum of the tertiary rotation was the centre of the second basic PENROSE-unit right handed to the P. A. axis. As this point on the original picture taken from the ultra-thin section is near the edge of the degraded ectexine. The result completely differs from the above discussed one (Plate IV). The appearance of one part at the edge of this tertiary rotations picture is more much express (marked with two arrows). Around the centrum of the rotation in all probability therefore the TEM negative doesn't contain really biopolymer structures, so the method of rotation in consequence of the not sufficient presence of the arrangeable matter resulted only one "fantastic picture" of the basic PENROSE-unit. This may be taken as a control.

2.1. C.T$_2$5.Z$_1$.5.5. (Fig. 2, Plate II, fig. 2)

It is interesting that this tertiary rotation resulted the negative picture of the original pentagonal polygon unit of the same size. The shade of the pin which fixed the centrum of the photographic paper is in the middle of two white globular biopolymer unit. The diameter of this negative pentagonal polygon is approximatively the same as that of the positive biopolymer unit, figured on the plate I, fig. 2. The second greater pentagonal polygon which is bordered with positive granular biopolymer units are identical with the previous ones (Plate I, fig. 2). But the contrast of the globular biopolymer units of the next polygon is not expressed. It is worth mentioning that the connection of the tertiary rotation picture with the basic photo (Plate II, fig. 1) is not so evident.

2.2. $C.T_{2}5.Z_{2}5.5.$ *(Fig. 2, Plate II, fig. 3)*

In this case the centrum of the rotation is also on the dissolving part of the partially degraded ectexine. In this way there is a certain similarity to the previous one (Plate I, fig. 3). This method resulted positive and negative globular biopolymer units, which are arranged into regular pentagonal polygons.

Around a dark circle, which has approximatively the same diameter as the pentagonal polygon biopolymer unit figured on plate II, fig. 1, there are five units which resemble the basic PENROSE-unit. Between the last mentioned units (probably pentagonal polygons) there are frustrations. This tertiary rotation picture may be extremely well joined to the basic picture (marked with two arrows). Probably this is the best first evidence that from living systems – at this moment from the pollen wall – but we managed to demonstrate two connected pentagonal biopolymer organizations consisting of a central pentagonal polygon, which is surrounded by five further also pentagonal polygons. In this way not only the basic PENROSE-unit is present in the biopolymer skeleton of the ectexine. It is worth mentioning too that the demonstrated two basic PENROSE-units are not on the same organization level. This is self-understanding taking into consideration the space arrangement of the regular pentagonal polygon systems.

3.1. $C.T_{4}5.Z_{1}.5.5.$ *(Fig. 3, Plate III, fig. 2)*

This kind of tertiary rotation as it is well shown on the fig. 3. corresponds the best with the PENROSE-modell so this has a particular importance from another point of view. The fig. 2. on the plate III, on the one hand, may be well joined to the basic picture (Plate III, fig. 1), on the other hand, a new evidence for the not single PENROSE biopolymer organization in the ectexine. The white globular units forming a pentagonal polygon in the centrum are essentially identical with the fig. 1. on the plate III polygon, which is surrounded by five dark globular biopolymer units. The further so-called large polygon forming globular biopolymer units are not separated so well from the surrounding part. But the next white globular units of the pentagonal polygon is characteristic, and is roughly in the centrum of the five polygons which surround the central polygons. These units are also in the position of the positive biopolymer units.

3.2. $C.T_{4}Z_{2}5.5.$ *(Fig. 3, Plate III, fig. 3)*

The white globular polygon units at the apices of the central pentagonal polygon correspond with the previously discussed (Plate III, fig. 2). But the further points of symmetry so these of the five polygons surrounding the central polygon are not so characteristic. This may be explained with the position of the centrum of the rotation, which is in this case also outside of the partially degraded ectexine. At this place on the ultra-thin sections there are only fragments of the biopolymer structures. But it must be emphasized that the joint of this tertiary rotation picture to the basic picture (Plate III, fig. 1), similarly to the previous also tertiary rotation picture (Plate III, fig. 2) is perfect. This latter connection is marked with three arrows.

Plate IV, represents a review of the real position of the rotation pictures. On a 1,250.000 magnified picture of the TEM structure of the partially degraded ectexine the centrum and the axes of the rotation are indicated. The results of the rotation are oriented in the direction of the corresponding axes. Magnification of these pictrues is 500.000. Well shown are the axes out of the T_2 centrum with different angles (T_2Z_1. 9°; T_2Z_2 11°), and the axes T_4Z_1 respectively T_4Z_2, which represent in principle two sides on one large pentagonal polygon *(Fig. 3.)* The distortion originates from the not so perfect symmetry and position of the biopolymers.

Finally, in connection with the *Fig. 4.* which represents the scheme of the PENROSE-units joint on two points of symmetry. On the basis of our up-to-date knowledge the five basic PENROSE-units surrounding the central unit may form only one more or less regular pentagonal polygon in the way that the manner of the joints are not consistent and are of different value. But the T_2Z_1., and the T_2Z_2 rotation resulted interesting results, and it seems to conclude that later we need to return to this problem thereupon, because at this moment we cannot give a sufficient explication.

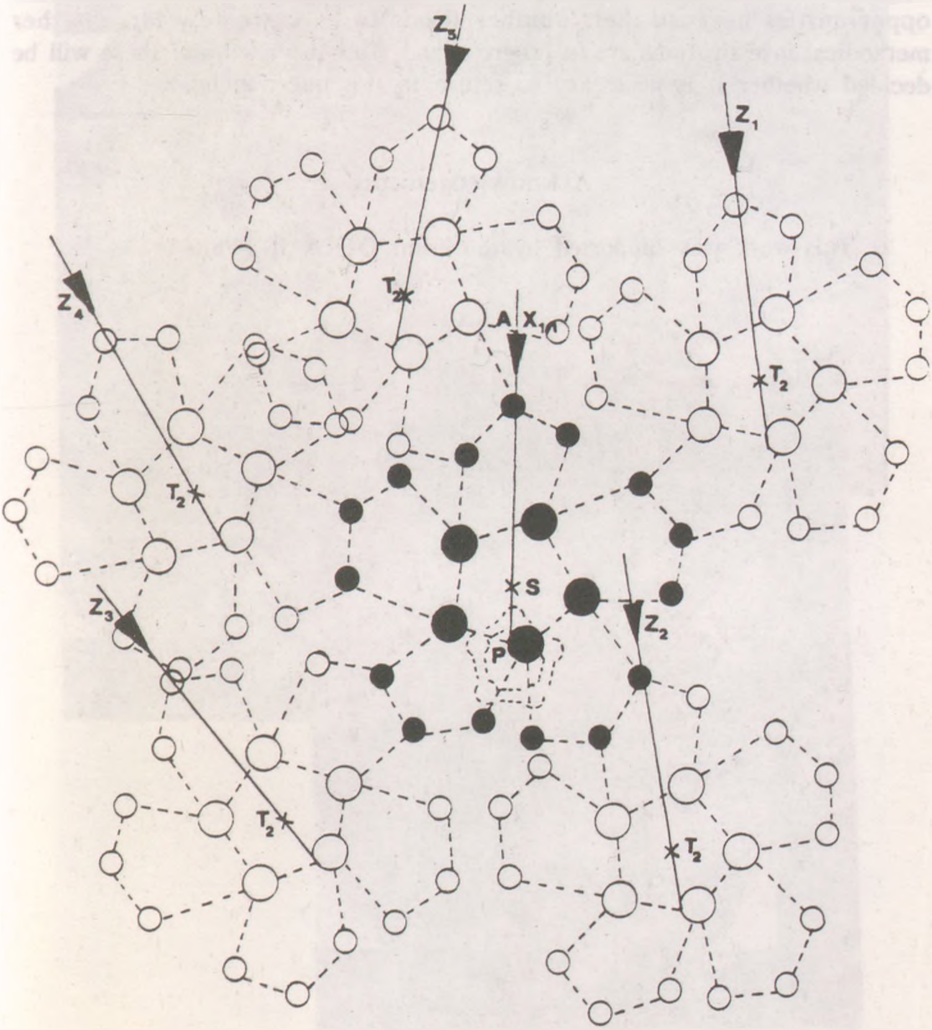

Fig. 4. Scheme of the joint of two points of symmetry. Well shown are that it was not possible to join in every case all the PENROSE-units, and the frustrations between the different units are not the same, and there are overlaps also between the pentagonal polygons. This scheme is published here with the intention of elevating this problem.

Final conclusions

In this paper the bases of the tertiary rotation method elaborated for the study of the organization of the biopolymer structures of the partially degraded exines. Naturally we have not dealt with all the theoretical opportunities because their number seems to be extremely large. Other methodical investigations are in progress, and after the results of these will be decided whether it is necessary to return to this question later.

Acknowledgements

This work was supported by the grant OTKA II-24/88.

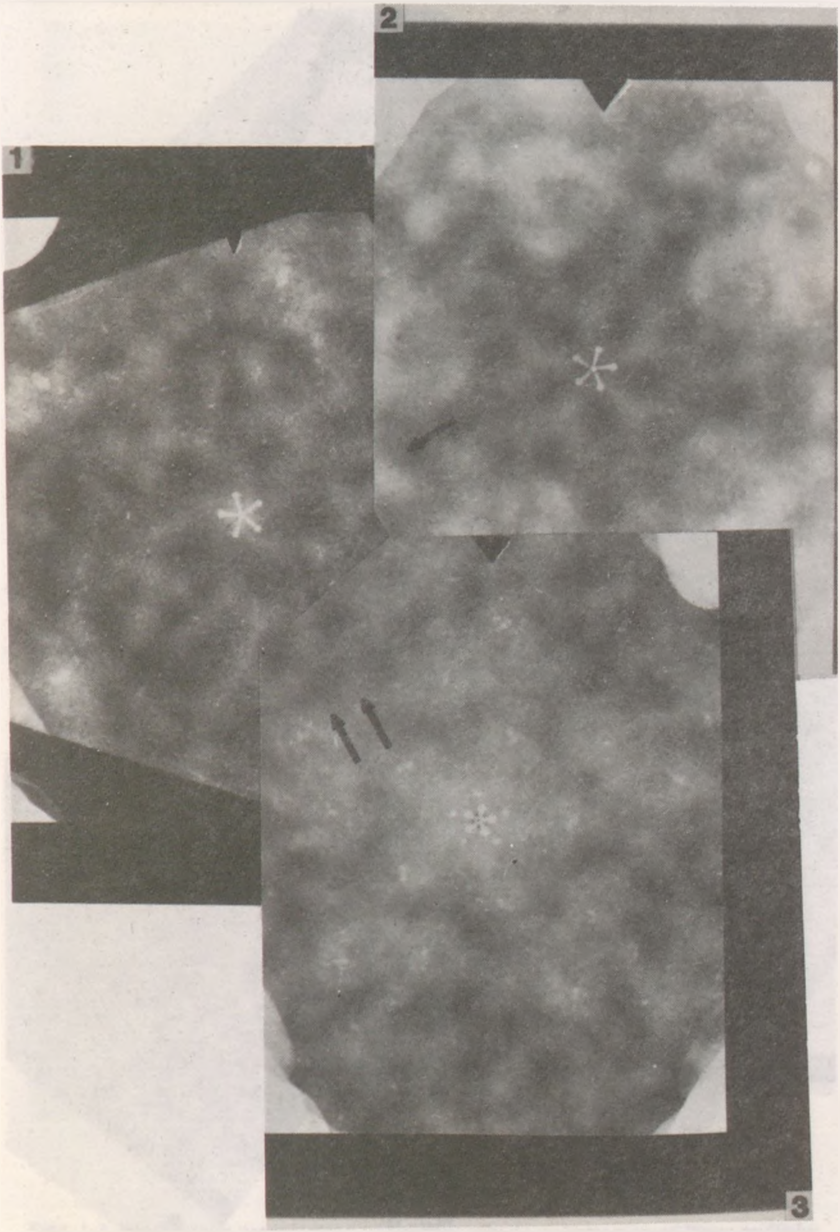

Plate I.

Figs. 1-3. Biopolymer organization of the partially degraded exine of *Pinus griffithii* McCLELL. Fig. 1. The basic secondary rotation picture; C.P. 5. A.5.10., C.S.5.$X_1/_1$.5.5., Figs. 2,3. Tertiary rotation pictures. Fig. 2. C.T_2Y_1.5.5. the joint of the tertiary and secondary rotation pictures is marked with an arrow. Fig. 3. C.T_2.5.Y_2.5.5. the joint of the tertiary and secondary rotation picture is marked with two arrows. N : 1 million.

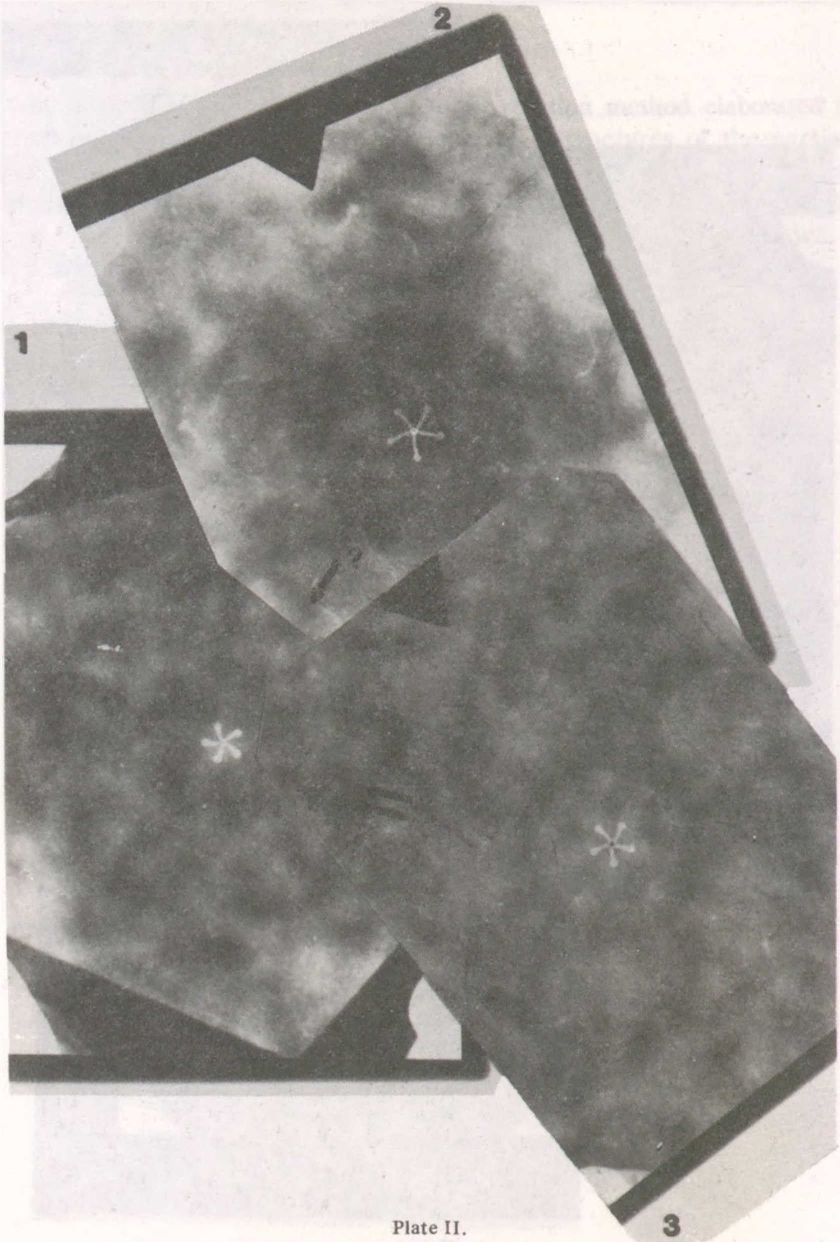

Plate II.

Figs. 1-3. Biopolymer organization of the partially degraded exine of *Pinus griffithii* McCLELL. Fig. 1. The basic secondary rotation picutre; C.P.5.A.5.10., C.S.5.$X_{1/3}$.5.5. Figs. 2,3. Tertiary rotation pictures. Fig. 2. C.$T_2$5.Z_1.5.5. the connection of the tertiary and secondary rotation picture is not so clear, because it is a note of interrogation after the arrow. Fig. 3. C.T_2.5.$Z_2$5.5. the joint of the tertiary and secondary rotation picture is characteristic, marked with two arrows. N : 1 million.

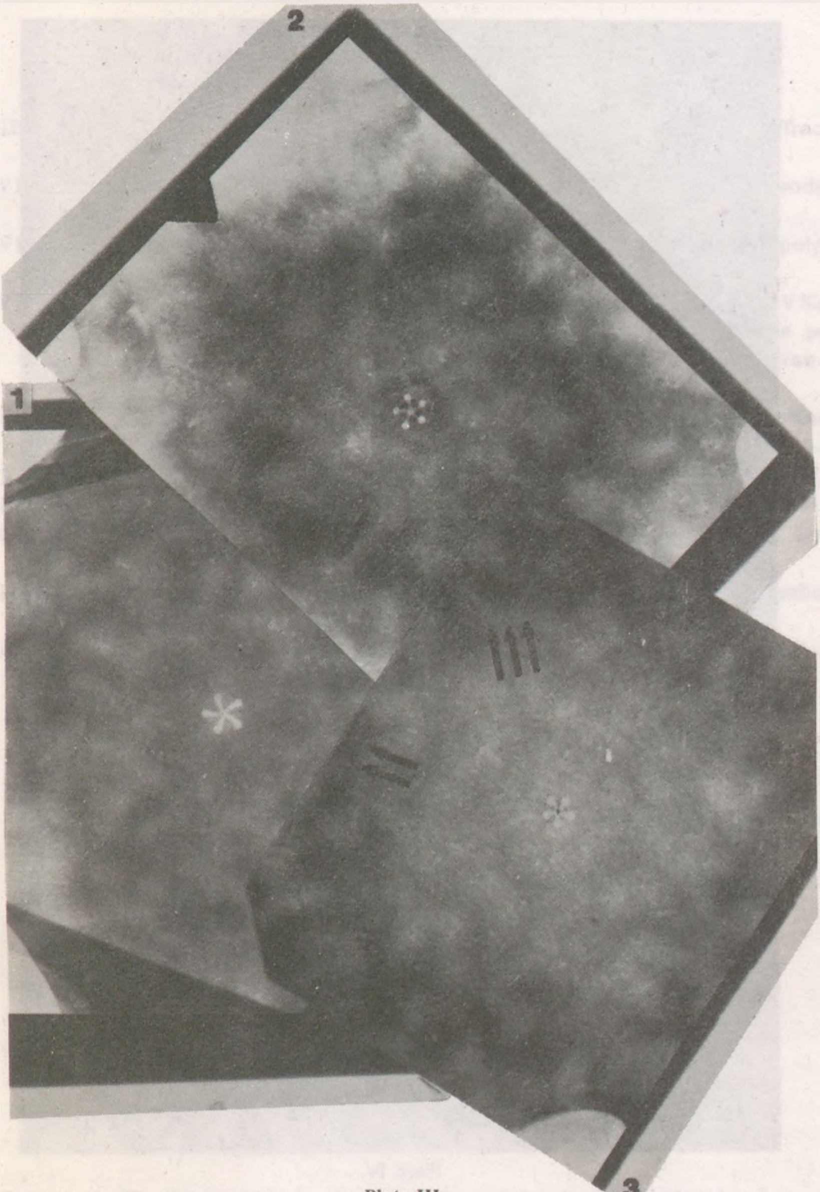

Plate III.

Figs. 1-3. Biopolymer organization of the partially degraded exine of *Pinus griffithii* McCLELL. Fig. 1. The basic secondary rotation picture; C.P.5.A.5.10., C.S.5.X$_{1/1}$.5.5. Figs. 2,3. Tertiary rotation pictures. Fig. 2. C.T$_4$.5.Z$_1$.5.5. the joint of the tertiary and secondary rotation pictures is characteristic, marked with an arrow. Fig. 3. C.T$_4$Z$_2$.5.5. the secondary and the tertiary rotation pictures joint well, marked with two arrows, moreover the connection of the two tertiary rotation pictures is characteristic, marked with three arrows. N : 1 million.

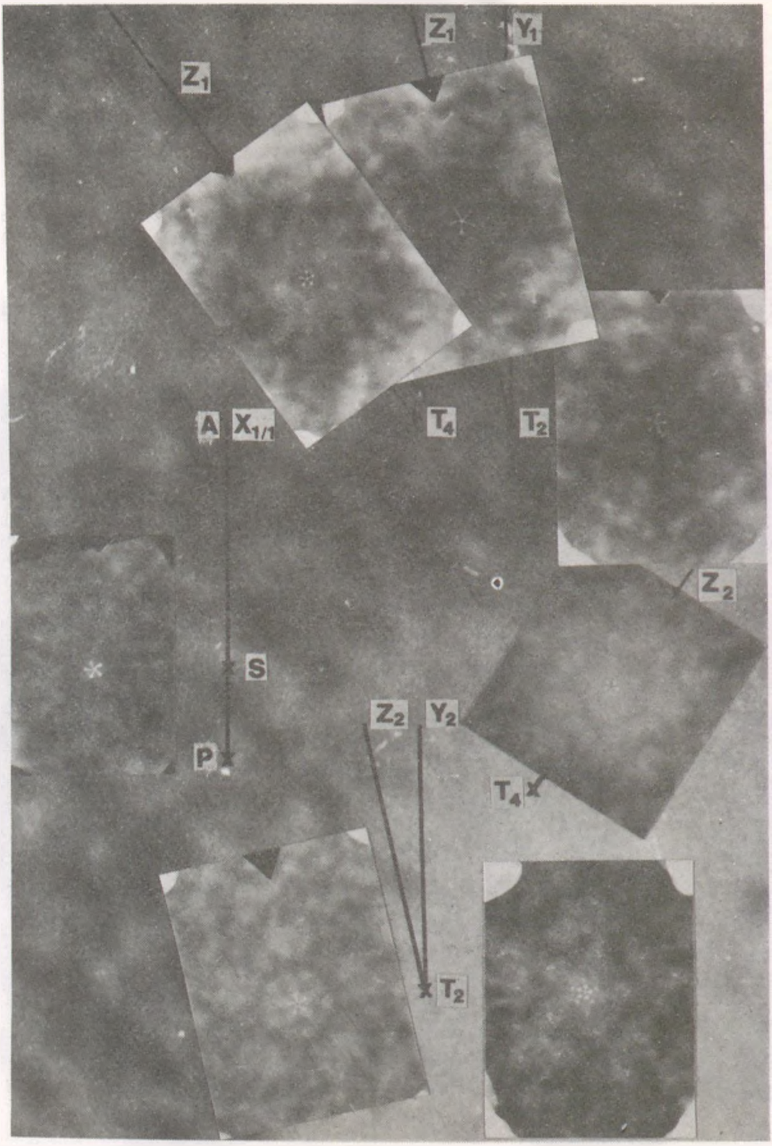

Plate IV.

Comprehensive photo plate about the up-to-date tertiary rotation results. The basis is a TEM picture from the partially degraded ectexine of *Pinus griffithii* McCLELL magnified 1,250.000 P = the centrum of the standard biopolymer unit, P. A. = the basic primary rotation axis, S = the centrum of the basic secondary rotation. S.$X_{1/1}$. = the axis of the secondary rotation, which in this case corresponds to the P. A. axis. T_2, T_4 = tertiary rotation centrum, Y and Z with indexes marks the second points of the tertiary rotation axis. The basic secondary rotation picture and the tertiary rotation pictures are fixed on the basic picture. The magnification of these pictures for the easy to survey is 500.000.

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QUASI-CRYSTALLOID BIOPOLYMER STRUCTURES FROM THE EXPLOSIVE DANGEROUS COAL PULVER FROM HUNGARY

by

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(Received: 10th March, 1989)

Samples from explosion dangerous coal mines from the Mecsek region were the subject of our investigations. The coal pulver was prepared with the solvent and oxidizing method used at recent sporomorphs. The ultra-thin section was investigated with a Tesla BS-500 transmission electron microscope, with a resolution of 6 Å. Among the first results, by the TEM method on the highly magnified pictures granular fossil biopolymer units were observed, some arranged into regular pentagonal polygons, fig. 1,2. To study the quasi-crystalloid lattice of the biopolymer structure of the sporoderm, similarly to the partially degraded wall of the recent sporomorphs, the modified Markham rotation (cf. HORNE and MARKHAM, 1972, KEDVES, 1989.) method was used. The rotation method resulted in the following: The C.P.5.A.5.5. type rotation verified the regularity of the fossil basic pentagonal polygon biopolymer unit; fig. 3. In particular the C.P.5.A.5.10. rotation resulted in new points of symmetry, fig. 4. The secondary rotation, C.S.5.X$_{1/1}$.5.5., fig. 5,7, and C.S.5.X$_{1/1}$.5.5., fig. 6,8, resulted in a deformed form for the first time the PENROSE-unit organized fossil biopolymer structure. Taking into consideration the new results, the reason of the coal pulver explosion may be as follows: As it was established earlier (SZIRTES, 1969) the porosity, e. g. the occurrence of the gas-channels in the coal (fig. 1,2) is important. The explosion of the gas in the channels may be initiated by a flake of fire. The energy of the gas explosion starts the explosion of the quasi-lattice structure of the coal pulver.

The quasi-crystalloid biopolymer structure of the coal pulver is explosive only in dry condition, in this way vaporisation of the mines may diminish the danger. Alkalis may destroy the biopolymer structures, this fact can also be taken into consideration to diminish or eliminate the explosion danger in the mines.

This work was supported by the grant OTKA-2, 24/88.

Plate I.

Figs. 1-8. TEM pictures from the coal pulver, Komló-148 sample, after experiment, No 160; 20 mg coal pulver + 1 ml 2-aminoethanol, temperature 30 C^{o}, length of time 24^{h}, washing, HF dil. for 24^{h}, washing, embedding in Araldite, ultra-thin sectioning, TEM investigation.

Fig. 1. Negative No 7547, well shown are the gas channels in the coal pulver, and the globular biopolymer units, between them regular pentagonal polygon units also occur, marked with an arrow. Magnification: x200.000.

Fig. 2. Negative No 7548, similarly well shown are the gas channels and the biopolymer units. Magnification: x200.000.

Figs. 3-8. Rotation pictures. Magnification: x500.000.

Fig. 3. C.P.5.A.5.5. rotation picture from the pentagonal polygon biopolymer unit marked in fig. 1 with arrow, negative No 7547.

Fig. 4. C.P.5.A.5.10. rotation picture, negative No 7547.

Fig. 5. C.S.5.X1/1.5.5. secondary rotation picture, negative No 7547.

Fig. 6. C.S.5.X2/1.5.5. secondary rotation picture, negative No 7547.

Fig. 7. C.S.5.X1/1.5.5. secondary rotation picture, negative No 7548.

Fig. 8. C.S.5.X2/1.5.5. secondary rotation picture, negative No 7548.

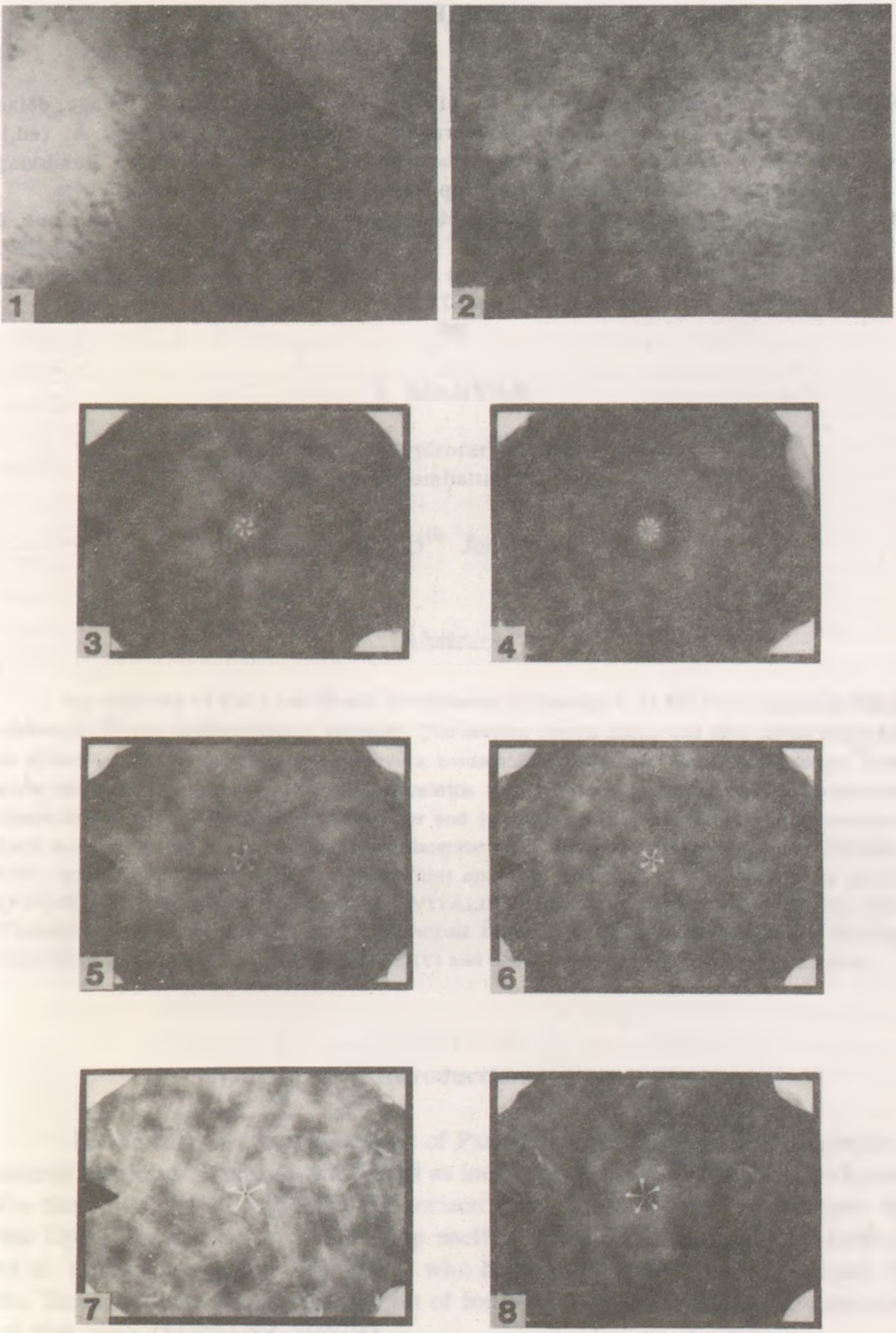

Plate 1.

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AN UPPER PANNONIAN s. l. (MIOCENE) MOLLUSC FAUNA FROM FEHÉRVÁRCSURGÓ (HUNGARY)

by

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(Received: 25th January, 1989)

Abstract

An exposure of Kálla and Somló Formations (Pannonian s. l.) has been studied in Fehérvárcsurgó, NW of Székesfehérvár, Hungary. The section reveals sandy and silty layers deposited in offshore-bars and open lake environments, containing a mollusc fauna belonging to the "Congeria ungulacaprae horizon" and dark, huminitic layers formed in back-lagoon environments, characterized with dominance of freshwater and terrestrial fossils. Remarks on some characteristic mollusc species, such as *Congeria ungulacaprae* (MÜNSTER), *Dreissena auricularis* (FUCHS) *Unio mihanovici* (BRUSINA), *Lymnocardium apertum* (MÜNSTER), *Lymnocardium penslii* (FUCHS), *Lymnocardium variocostatum* (VITÁLIS), *Theodoxus intracarpaticus* (JEKELIUS), *Theodoxus* aff. *soceni* (JEKELIUS), *Melanopsis kupensis* (FUCHS), *Melanopsis* aff. *impressa* KRAUSS), *Valvata* aff. *varians* (LŐRENTHEY) and *Gyraulus inornatus* (BRUSINA) are given.

Introduction

At the early stage of the study of Pannonian and Pontian biostratigraphy, mainly species of *Congeria* were used as index fossils. LŐRENTHEY introduced the term "*Congeria ungulacaprae* horizon" as a biozone in the lowest part of the Upper Pannonian s. 1. The Kúp section (FUCHS 1870) can be regarded as its classical exposure. STRAUSZ, who had mapped the western foreland of the Transdanubian Range, listed a lot of localities and the characteristic species of this zone (STRAUSZ 1942/a).

In fact, *Congeria ungulacaprae* has a wider stratigraphic range than the zone named after it. It first appears in the Pannonian s. str. with species like *Congeria czjzeki, Congeria partschi, Congeria subglobosa, Lymnocardium soproniense.* On the other hand, it may also occur in the much younger *Congeria balatonica* beds (e. g. in Tihany). In principle, the intermediate "*Congeria ungulacaprae* horizon" ought to be marked with species that seem to be confined to this zone, such as *Lymnocardium variocostatum, "Lymnocardium" priscae, Melanopsis* aff. *impressa* or *Melanopsis kupensis.* However, shells of *Congeria ungulacaprae* are much more common than those of the above species, due to its mass appearance and the good preservation potential of its often thick umbo. Thus, from a practical point of view, it seems best to insist on the traditional nomenclature until we better understand the stratigraphic conditions of the Pannonian s. l.

KORPÁS-HÓDI (1983) described the *Melanopsis pygmaea-Lymnoardium penslii* palaeoassociation (or, rather, thanatocoenosis) from the northern foreland of the Transdanubian Range. The Fehérvárcsurgó fauna can be well assigned to both these stratigraphic and ecological units. Its great similarity to the faunas of Kúp (FUCHS 1870), Kocs (VITÁLIS 1934), Dáka, Pápa, Tüskevár, Tapolca (STRAUSZ 1942/a), Tataros (= Brusturi, Rumania; STRAUSZ 1942/b) and Lázi (STRAUSZ 1942/a, BARTHA 1963) must indicate that all of them are about of the same age. According to K-Ar ages from Tihany (MÜLLER et SZÓNOKY 1988), their estimated age is between 8 and 9 Ma.

Geologic setting

The Fehérvárcsurgó quartz sand pit is situated in the northeastern foreland of the Bakony Mts., 13 km NW of Székesfehérvár. The sandy formations of the Pannonian s. l., which follow the edge of the mountains, outline an embayment here, extending 3 km northeastward (BIHARI, pers. comm.).

The white quartz sand (Kálla Formation) rests partly on Upper Triassic dolomite; where the Traissic is situated deeper, the underlying rocks are Cretaceous bauxite and bauxitic clay, Eocene marl and limestone, Oligocene-Miocene clay and older Pannonian clay (VECSERNYÉS 1966). The overlying silt and sandy silt beds (Somló Formation) contain a mollusc fauna belonging to the "*Congeria ungulacaprae* horizon". As the layers gently dip southeastward, the presence of the *Congeria balatonica* beds (Tihany Formation) can be assumed on the top of the Somló Formation in the southeast (see faunal list by VECSERNYÉS 1966). In the studied exposure Somló Formation is overlain by Pleistocene or Holocene sand and gravel.

Sedimentology and ecology

The Kálla Formation and the overlying Somló Formation seem to belong to one depositional unit. Both contain black, huminitic layers that were formed in marshy back-lagoons separated from the open lake by well-sorted sand bars. Due to horizontal shifting of the different environments, huminitic layers appear both in the white sand and the overlying beds of coarse silt and fine sand. The latter ones, containing pebbles, carbonates and mica were deposited shoreward of the central white sand zone (BIHARI 1985).

The section reveals the following layers *(Fig. 1):*

Layer 1 consists of very well-sorted, fine-grained quartz sand with brown, limonitic stripes and pisiform concretions. It represents the central part of the offshore bars, indicating intensive wave action. Layer 2 with limonitic, poorly sorted, sandy coarse silt and mica may represent the shoreward side of the bars.

Layer 4 consists of finely laminated, sometimes crossbedded, dark huminitic silt with a great amount of small shell fragments. Its lower part (Layer 3) is red, probably due to subsequent oxidation. They suggest a shallow water, backlagoon environment overgrown by water-plants. Plant remains, such as *Stratiotes* sp. are common. Freshwater and terrestrial molluscs (*Lymnaea* sp., *Radix* sp., Limacidae sp., *Planorbarius* cf. *corneus*, *Cepaea* sp., Helicidae sp.) are prevailing. *Congeria* cf. *neumayri*, *Theodoxus* aff. *soceni*, *Melanopsis sturii* and opercula of *Bithynia* are also common. Only a few shells of ostracods were found.

In Layer 5, the increasing ratio of bivalves to gastropods and the presence of species of *Melanopsis* with large body size argue for the deepening of the water and a well-aerated environment. The grey, poorly sorted silt contains sandy lenses. Characteristic molluscs are *Melanopsis pygmaea*, *Melanopsis* aff. *impressa*, *Melanopsis kupensis*, *Melanopsis sturii*, *Unio mihanovici*, *Lymnocardium penslii*, *Lymnocardium variocostatum*, *Gyraulus inornatus*, *Valvata* aff. *varians* and juvenile forms of *Dreissena.* As for ostracods, species of genera *Amplocypris*, *Cyprideis* and *Hemicytheria* are common. The finds of Helicidae sp. indicate near-shore deposition.

Layer 6 consists of well-sorted coarse silt with carbonate nodules. A few fragments of shells and one specimen of *Unio mihanovici* were found in it. A protected lagoon environment can be assumed for Layer 7. In the base of the dark, huminitic layer eroded shells of *Congeria ungulacaprae* can be found. They were washed in from a high-energy environment. The autochthonous molluscs were species of Planorbidae.

Layer 8 consists of grey, poorly sorted, coarse silt, containing thin, well-sorted, very fine-grained sand beds. Byssus-anchored bivalves are prevailing in the fauna. The mass appearance of *Congeria ungulacaprae* in the lowermost sandy bed (Layer 8/a) indicates well-aerated, strongly agitated water. As a low-energy environment was re-established, *Congeria ungulacaprae* retreated from this area. The bottom became covered with shells of *Dreissena auricularis.* The increasing current velocity offered favourable circumstances again for *Congeria ungulacaprae*, but it failed to return probably in the absence of free substratum. *Melanopsis pygmaea, Lymnocardium penslii, Lymnocardium*

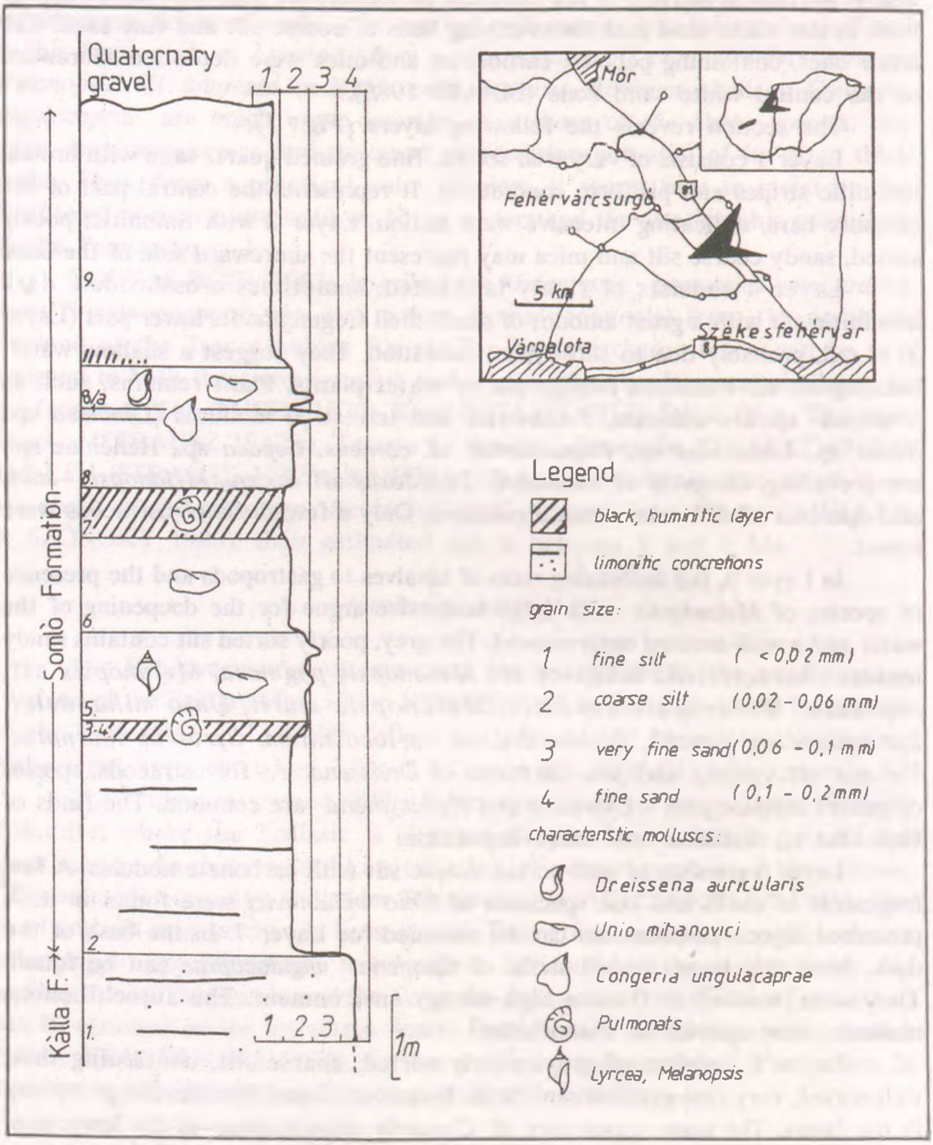

Fig. 1.

apertum, *Unio mihanovici* and ostracods, such as *Amplocypris*, *Candona*, *Bacunella*, *Leptocythere*, *Hemicytheria*, *Loxoconcha* and *Cyprideis* are common in Layer 8. Low number of gastropods indicate deeper water environment.

Layer 9 consists of clayey fine silt with sandy beds containing extremely poorly preserved shells. On the top of the Pannonian s. l. sequence, Pleistocene or Holocene layers of gravel and sand rest with erosional unconformity.

Molluscs

The following forms were determined from the section:

	layer					
Bivalvia	3-4	5	6	7	8	8/a
Congeria ungulacaprae (MÜNSTER)				(x)		x
Congeria cf. *neumayri* ANDRUSOV	x	x				
Dreissena auricularis (FUCHS)		x			x	
Unio mihanovici BRUSINA	x	x	x		x	
Lymnocardium apertum (MÜNSTER)		x				x
Lymnocardium cf. *trifkovici* BRUSINA		x				
Lymnocardium penslii (FUCHS)		x			x	
Lymnocardium variocostatum VITÁLIS		x				
Protoplagiodacna cf. *chyzeri* (BRUSINA)		x				
Gastropoda						
Theodoxus intracarpaticus JEKELIUS		x				
Theodoxus aff. *soceni* JEKELIUS	x					
Valvata aff. *varians* LŐRENTHEY		x				
Valvata kupensis FUCHS		x				
Valvata cf. *minima* FUCHS	x					
Valvata sp.	x					
Bithynica cf. *jurinaci* BRUSINA	x					
Prososthenia sp.		x				
Micromelania sp.		x				
Pyrgula sp.		x				
Melanopsis pygmaea PARTSCH		x			x	x
Melanopsis struii FUCHS	x	x				
Melanopsis aff. *impressa* KRAUSS		x				
Melanopsis kupensis FUCHS		x				
Gyraulus inornatus (BRUSINA)		x				
Gyraulus sp.	x					
Radix sp.	x					
Lymnaea sp.	x					

	layer					
	3-4	5	6	7	8	8/a
Planorbarius cf. *corneus* (LINNÉ)	x					
Planorbidae sp.				x		
?*Anisus confusus* SOÓS	x					
Cepaea sp.	x					
Helicidae sp.	x	x				
Limacidae sp.	x					

Without full description, I give remarks on several forms, the majority of which is characteristic for the "*Congeria ungulacaprae* horizon".

Congeria ungulacaprae (MÜNSTER, 1839)
(Pl. 1, fig. 1-4)

1835 *Congeria triangularis* n. sp. - PARTSCH, pl. XII, fig. 1-4

1870 *Congeria triangularis* PARTSCH - M. HÖRNES, pl. 48, fig. 1,3.

1870 *Congeria Balatonica* PARTSCH var. *crassitesta* - FUCHS, pl. XXII, fig. 15, 16.

1875 *Congeria balatonica* PARTSCH var. *crassitesta* FUCHS - R. HÖRNES, pl. II, fig. 1,2.

1886 *Congeria ungula caprae* MÜNSTER - HALAVÁTS, text-fig. 2, pl. XXVI, fig. 4.

1897 *Congeria ungula caprae* (non MÜNSTER) - ANDRUSOV, Pl. V, Fig. 18-22.

1897 *Congeria hörnesi* BRUSINA - ANDRUSOV, pl. VI, fig. 1-3, 6-7

?1902 *Congeria ungula caprae* (MÜNSTER) - BRUSINA, pl. XVIII, fig. 32-38

1902 *Congeria ungula-caprae* MÜNSTER - LŐRENTHEY, pl. XIX, fig. 1-5, pl. XX, fig. 1-3

1903 *Congeria ungula caprae* MÜNSTER - HALAVÁTS, text-fig. 7.

1910 *Congeria ungula caprae* MÜNSTER - VITÁLIS, text-fig. 1, 3, 4, 7 pl. I, pl. II, fig. 1-3.

1953 *Congeria hoernesi* BRUSINA - PAPP, pl. 15, fig. 6,7

?1953 *Congeria ungula caprae* MÜNSTER - PAPP, pl. 15, fig. 8,9

1971 *Congeria ungulacaprae* MÜNSTER - BARTHA, pl. XXVII, fig. 1, 2

1971 *Congeria hörnesi* BRUSINA - BARTHA, pl. XXIV, fig. 1.

Plate I.
Fig. 1-4. *Congeria ungulacaprae* (MÜNSTER 1839) (fig. 2-3: 0.75 x)

It is a well-known and often referred species, the long history of recognition and distinction of which was described by VITÁLIS (1910) in detail. In the synonymy above I have tried to collect only the figures of the species that had been published since the description of genus Congeria (PARTSCH 1835).

Attempts to separate new species or subspecies of this form, based on the outline of the shell, on the sharpness of the anteroventral edge, on the thickness of the umbo or on any other feature (BRUSINA 1892, LŐRENTHEY 1902, VITÁLIS 1910) resulted in confusion. For example, specimens of *Congeria ungulacaprae* from Sopron are called *Congeria hoernesi,* in spite of the fact that they show no diagnostic difference with specimens from other localities.

Congeria ungulacaprae is a very variable species indeed. While the outline of the shell displays great variety in a given layer, partly because it lived in crowded colonies, the thickness of the umbonal region, however, does not. It must have ecological reasons. The young individual, in a given growth stage, closed its byssal notch in order to change for a recliner mode of life (SEILACHER, 1984). It continued the deposition of shell material in the umbonal region until it was able to stabilize the shell by its weight on the substratum. This might explain why the thickness of the shell vary from place to place. I measured the ratio of the shell cavity to the whole shell volume in order to express the relative shell thickness. It was 0,65 in a Fehérvárcsurgó specimen and 0,28 in a Somló-hegy specimen. However, taking into account other localities, we find continuous series of transition between these two extreme forms.

Shells of *Congeria ungulacaprae,* often in life position, can be foound in Layer 8/a of the Fehérvárcsurgó section.

Dreissena auricularis (FUCHS 1870)
(Pl. 2, fig. 1-3)

1870 *Congeria auricularis* FUCHS - FUCHS, p. 547, pl. XXII, fig. 26-28.
1897 *Dreissena auricularis* FUCHS f. *typica* - ANDRUSOV, p.2 43, pl. XIII, fig. 1-5.
1951 *Dreissena auricularis* FUCHS f. *typica* - STEVANOVIC, p. 215 pl. III, fig. 7.
1959 *Dreissena auricularis* FUCHS - BARTHA, pl. XII, fig. 5,6.
1963 *Dreissena auricularis* FUCHS - BARTHA, pl. III, fig. 3, pl. IV, fig. 3.
1971 *Dreissena auricularis* FUCHS - TÓTH, pl. II, fig. 6,7, pl. IV, fig. 1.

The type locality of the species is Kúp. Though the Fehérvárcsurgó specimens are variable concerning the outline of the shell, the pointedness of the beak and the sharpness of the edge running from the beak ventralward, they can be taken as typical forms.

Adult specimens can be found in Layer 8. They covered the bottom in such a mass that prevented other molluscs from settling down.

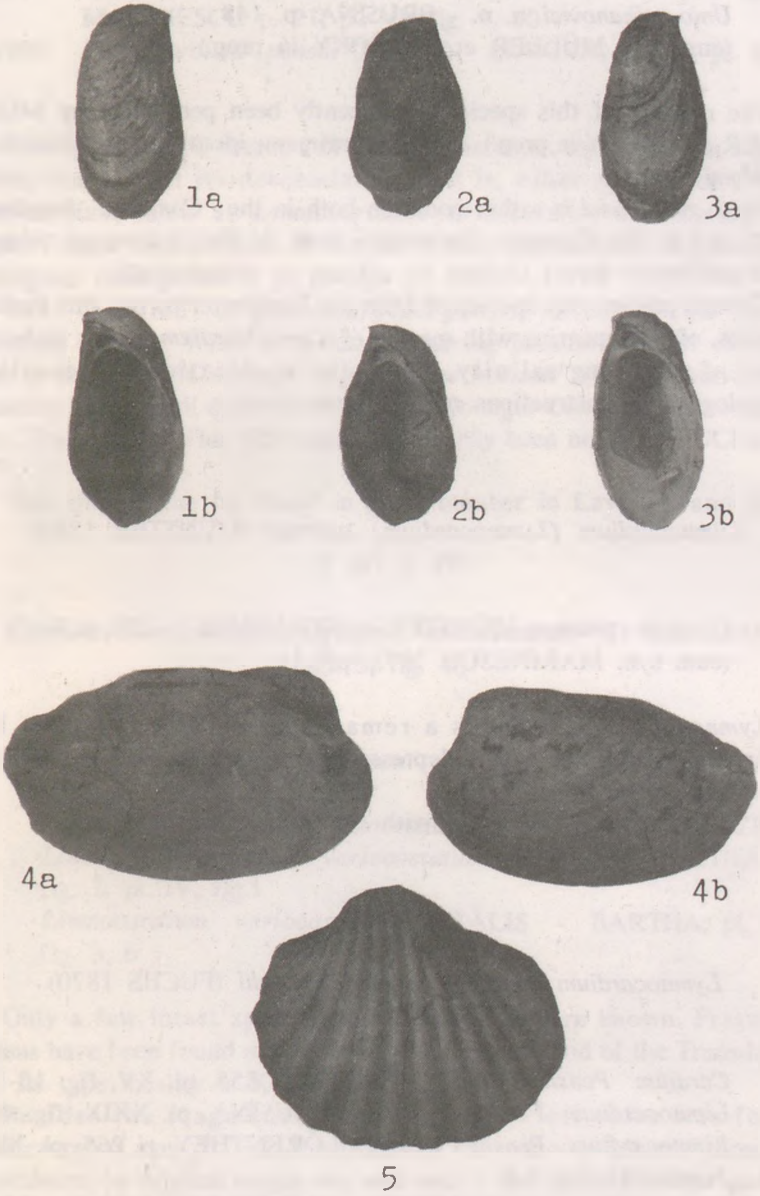

Plate II.
Fig. 1-3. *Dreissena auricularis* (FUCHS 1870). 1.5x Fig. 4. *Unio mihanovici* BRUSINA 1896,
Fig. 5. *Lymnocardium apertum* (MÜNSTER 1839) 1.5 x

Unio mihanovici BRUSINA 1896
(Pl. 2, fig. 4)

1896 *Unio mihanovici* n. n. - BRUSINA, p. 148
(cum syn. MÜLLER et SZÓNOKY in prep.)

The revision of this species has recently been performed by MÜLLER (MÜLLER-SZÓNOKY in prep.). A lot of specimens, identified as "*Unio atavus*", must belong here.

Unio mihanovici is rather common both in the "*Congeria ungulacaprae* horizon" and in the *Congeria balatonica* beds. In Fehérvárcsurgó, almost all of the fossiliferous layers contain its opened or closed shells.

Though present-day species of *Unio* are freshwater forms, this Pannonian s. l. species, often appearing with masses of *Lymnocardium*, seems to be rather tolerant of changing salinity. Thus, the application of actualism in palaeoecological reconstructions require great caution.

Lymnocardium (Lymnocardium) apertum (MÜNSTER 1839)
(Pl. 2, fig. 5)

1839 *Cardium apertum* MÜNSTER in GOLDFUSS, p. 223, pl.1 35, fig. 8.
(cum syn. MARINESCU 1973, p. 11)

Lymnocardium apertum is a remarkably variable species. In the Fehérvárcsurgó section, a rather depressed, posteriorly elongated variant with sharp ribs is prevailing.

It is common in Layer 8/a with *Congeria ungulacapreae.*

Lymnocardium (Pannonicardium) penslii (FUCHS 1870)
(Pl. 3, fig. 1-3)

1870 *Cardium Penslii* FUCHS - FUCHS, p. 355, pl. XV, fig. 15-17
1902 *Limnocardium Penslii* (FUCH) - BRUSINA, pl. XXIX, fig. 46, 47
1902 *Limnocardium Penslii* FUCHS - LŐRENTHEY, p. 265, pl. XIX, fig. 7, pl. XXI, fig. 4,5
1903 *Limnocardium penslii* FUCHS - ANDRUSOV, pl. V, fig. 7,8
1951 *Pannonicardium penslii* FUCHS - STEVANOVIC, p. 239, pl. IV, fig. 1-3.

1963 *Limnocardium penslii* FUCHS - BARTHA, pl. III, fig. 5, pl. IV, fig. 2.
1971 *Limnocardium (Pannonicardium) penslii* (FUCHS) GILLET et MARINESCU p. 21, pl. VI, fig. 9, 10
? 1980 *Limnocardium penslii* (FUCHS) - LUEGER, p. 112, pl. 4, fig. 5

This species has a rather well defined character, its distinction has raised problems only from its descendants, that is, other species of subgenus *Pannonicardium*, such as *Lymnocardium variocostatum* and *Lymnocardium schmidti*. I think that, in most of the cases, they can be easily separated using their original description.

The "variation" of *Lymnocardium penslii* rather seems to be an evolutionary pattern: While it is smaller, having broader ribs set closely side by side in the older "*Congeria ungulacaprae* horizon" (Kúp, Fehérvárcsurgó), it is usually larger with narrower ribs is the younger *Congeria balatonica* beds (Tihany, Radmanest). This difference has already been noted by FUCHS (1870, p. 547).

This species can be found in great number in Layers 5 and 8.

Lymnocardium (Pannonicardium) variocostatum VITÁLIS 1934

(Pl. 3, fig. 4.)

1934 *Limnocardium vario-costatum* n. sp. - VITÁLIS, p. 696, pl. VI, fig. 1-4
1942 *Limnocardium Penslii variocostatum* VITÁLIS - STRAUSZ, p. 68
1963 *Limnocardium penslii variocostatum* (VITÁLIS) - BARTHA, pl. II, fig. 1, pl. IV, fig.1
1971 *Limnocardium variocostatum* VITÁLIS - BARTHA, pl. XXXII, fig. 3, 6

Only a few intact specimens of this species are known. Fragmentary specimens have been found mainly in the western foreland of the Transdanubian Range. Its type locality is Kocs.

Besides the fragments, a nearly intact left valve was found is Fehérvárcsurgó (Layer 5). The dimensions of the oval valve exceed those of the type specimen; its original length was well over 7 cm. As the anterior and dorsal margins are set at a right angle, the anterodorsal auricle, which was considered to be a specific character by VITÁLIS, is missing here. In addition, the edge of the anterior ribs is less marked than in the type specimen.

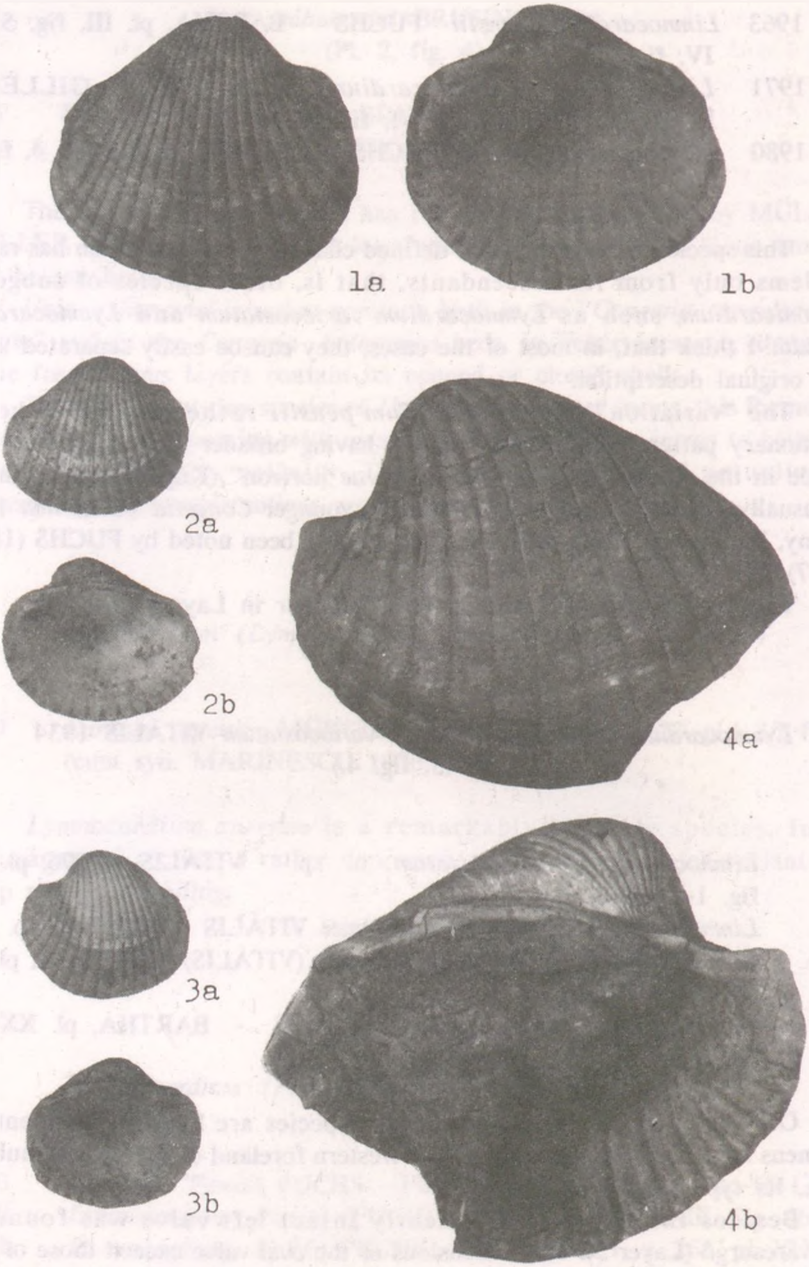

Plate III.

Fig. 1-3. *Lymnocardium penslii* (FUCHS 1870) Fig. 1 : 1.5x

Fig. 4. *Lymnocardium variocostatum* VITÁLIS 1934.

Theodoxus intracarpaticus JEKELIUS 1944
(Pl. 4, fig. 1-3)

1944 *Theodoxus intracarpaticus* n. sp. - JEKELIUS, p. 112, pl. 41, fig. 1-24
1953 *Theodoxus (Theodoxus) intracarpaticus* JEKELIUS - PAPP, p. 97, pl. 2, fig. 4-11

The small specimens are slim, subtriangular in outline, the larger ones are wide and oval. The labial area is usually strongly convex; its outer margin is arched, the inner one is straight or slightly, adaxially curved in the middle; it is dentate only in few specimens. However, once it is dentate, the denticles are rather well developed.

Colour ornamentation of smaller specimens agrees fairly well with that of the form figured by PAPP (1953, pl. 2, fig. 9 and 10). The white ground is covered with square, light brown spots and, in 4 spiral zones, with smaller, dark brown spots. The ornamentation of the larger specimens is different: it is fine, dark brown network on brown ground. They wear strong varices near the aperture.

A form with similar ornamentation was described by LŐRENTHEY (1902) from Budapest as *Theodoxus pilari* BRUSINA. However, our form differs from it in being much larger and thicker-shelled and having a more convex labial area with usually smooth margin.

In Fehérvárcsurgó, it is rather rare in Layer 5.

Theodoxus aff. *soceni* JEKELIUS, 1944
(Pl. 4, fig. 4-6)

The shell is small but thick. Juvenile specimens are slim, higher than broad, narrowing below. The adults are wider, elongated oval in outline. Maximum width of the labial area is always at its lower half. Its outer margin is irregular, the inner one is usually finely dentate.

Colour ornamentation was preserved in all of the specimens. The white or light brown ground is covered with dark brown, usually elongated triangular spots pointed towards the aperture. If they are arranged densely, we see abaperturally pointed, white triangles on dark ground. The dark spots are sometimes arranged into axial zones.

This form is very common in Layers 3 and 4.

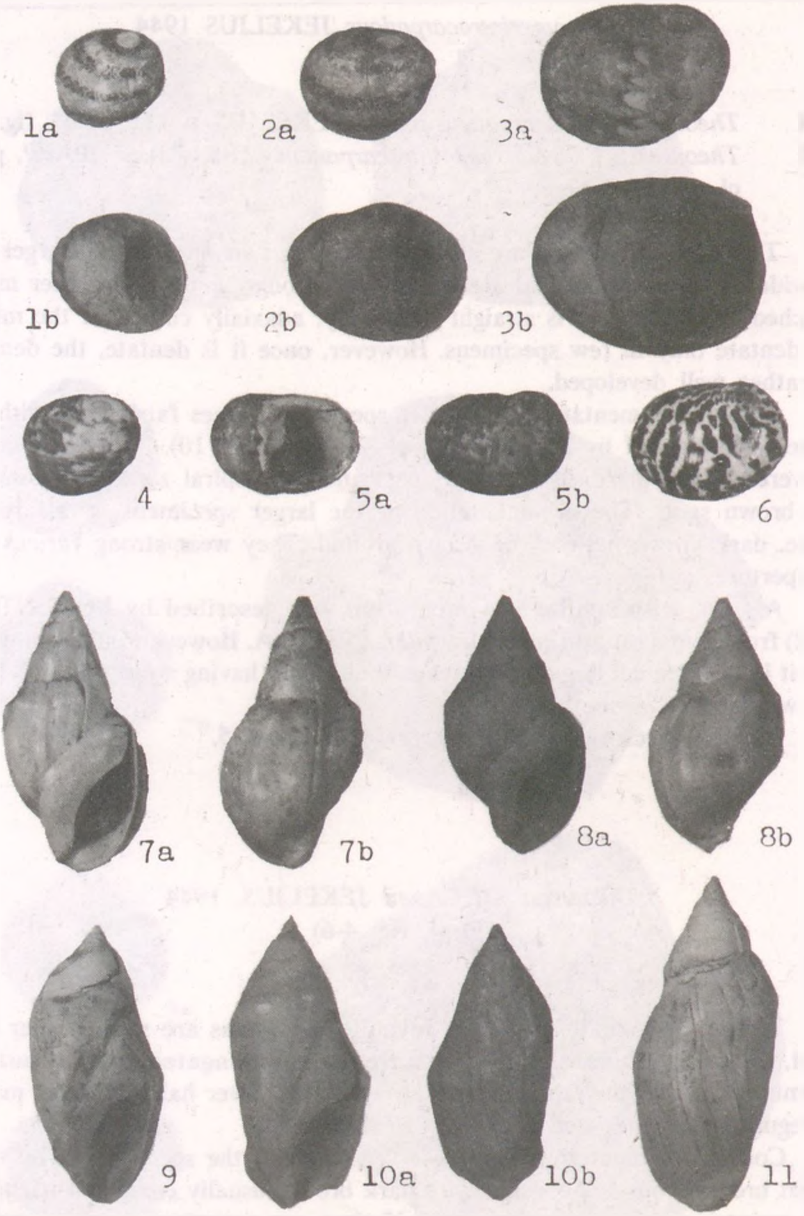

Plate IV.
Fig. 1-3. *Theodoxus intracarpaticus* JEKELIUS 1944. (Fig. 1a, 2a, 3a: 2.5x; fig. 1b, 2b, 3b: 3x)
Fig. 4-6. *Theodoxus* aff. *soceni* JEKELIUS 1944. 4x
Fig. 7-8. *Melanopsis kupensis* FUCHS 1870. 1.5x
Fig. 9-11. *Melanopsis* aff. *impressa* KRAUSS 1852

Valvata aff. *varians* LŐRENTHEY 1902
(Fig. 2)

Valvata varians was described by LŐRENTHEY from Budapest. The Fehérvárcsurgó material markedly differs from it in some features, though the Budapest form is very variable itself. Our specimens are definetely larger and wear not only a spiral angulation but a well-developed carina along the abaxial-adapical part of the last whorl. It also differs from *Valvata subgradata* LŐRENTHEY in having a much shallower umbilicus and lacking abaxial carinae.

This form is very common in Layer 5.

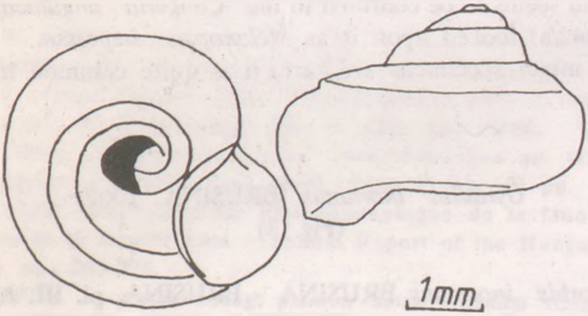

Fig. 2. *Valvata* aff. *varians* LŐRENTHEY 1902

Melanopsis kupensis FUCHS 1870
(Pl. 4, fig. 7,8)

1870	*Melanopsis Kupensis* - FUCHS, p. 544, pl. XXII, fig. 3, 4
1942	*Melanopsis kupensis* FUCHS - STRAUSZ, p. 87, pl. V, fig. 11-13
1963	*Melanopsis kupensis* FUCHS - BARTHA, pl. I, fig. 4.

The type locality of the species is Kúp. It has been found only in the foreland of the Transdanubian Range so far.

The Fehérvárcsurgó specimens are smaller and slimmer than the type. Height of adults is 23.0 to 26.7 mm, their width is 12.2 to 14.7 mm. On the adapical part of the strongly widening last whorl the pustules become more and more elongated, forming costae near the aperture. They are abrupt in the upper and gently sloping in the lower part. In some spcimens, the colour ornamentation can be seen: small, irregular orange spots.

This form can be found in Layer 5; quite rare.

Melanopsis aff. *impressa* KRAUSS, 1852
(Pl. 4, fig. 9-11)

1963 *Melanopsis bonelli bonelli* MANZ. - BARTHA, pl.III, fig. 1.
1963 *Melanopsis impressa* KRAUSS - BARTHA, pl. III, fig. 2

The spire is high, pointed, not gradate. In the adapical third of the last whorl a well-marked spiral angulation can be sen, along which the shell reaches its maximum width.

This form seems to be confined to the "*Congeria ungulacaprae* horizon". STRAUSZ (1942/a) looked upon it as *Melanopsis impressa.*

Though intact specimens are rare, it is quite common in Layer 5.

Gyraulus inornatus (BRUSINA, 1902)
(Fig. 3)

1902 *Planorbis inornatus* BRUSINA - BRUSINA, pl. III, fig. 49-51
1959 *Gyraulus (G.) inornatus* (BRUSINA , 1902) - BARTHA, p. 77, pl. X, fig. 3-5.
1971 *Gyraulus (Gyraulus) inornatus* (BRUSINA, 1902) - GILLET et MARINESCU, p. 59, pl. XXV, fig. 1-9.

A strongly depressed form with a flattened base. Width of the shell is 2 to 4 mm, its height is always less than 0.5 mm. The cornet-shaped apex is surrounded by convex whorls with strong, prosocline growth lines. The umbilicus is wide and shallow. The bases of the whorls are flattened, sloping towards the umbilicus. The growth lines are orthocline here.

This form is common in Layer 5.

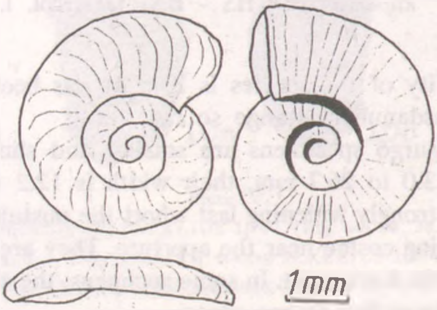

Fig. 3. *Gyraulus inornatus* (BRUSINA 1902)

Acknowledgements

I thank dr. PÁL MÜLLER for loaning specimens from his collection and dr. ENDRE KROLOPP for the determination of some freshwater and terrestrial fossils.

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COMPARISON OF ALPINE AND GERMANO-TYPE MIDDLE TRIASSIC BRACHIOPOD FAUNAS FROM HUNGARY, WITH REMARKS ON COENOTHYRIS VULGARIS (SCHLOTHEIM 1820).

by

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(Recived: 10th January, 1989)

Abstract

Two well-known Middle Triassic areas, Balaton Highland (Alpine) and Mecsek Mts (Germano-type) were investigated. The attention was concentrated on the faunistical and sedimentological characters of the fossiliferous Pelsonian (Upper Anisian) limestone. The intense collections yielded a very rich, high diversity brachiopod fauna (35 species) from the Balaton Highland and an impoverished one (7 species) from the Mecsek. Based on internal morphology the so-called *Coenothyris vulgaris* from those territories seems to be not conspecific. Sedimentological data give evidence of a shallow marine normal sedimentation which was interrupted by storms (storm-generated coquinas) in Mecsek. Various paleoenvironments of a disrupted bottom relief provided advantageous conditions for brachiopods in Balaton Highland. By the comparative faunistical analysis paleobiogeographic considerations were deducted, as the present geographic position of Balaton Highland and Mecsek is inverse to that of Triassic period.

Introduction

The Balaton Highland and the Mecsek Mts are two regions of Hungary with extended and well-known Triassic sequences *(Fig. 1/a)*. The authors contemporaneous studies on Middle Triassic formations and their fauna – primarily brachiopods – provided new data for comparison and conclusions.

Brachiopods from the Balaton Highland have been known since the middle of the 19th century. BÖCKH (1873) surveyed the region and set an outstanding stratigraphic division for its Triassic formations and provided a faunal list with 14 brachiopod species. LÓCZY (1916) compiled a geological map and a comprehensive volume about the geology of the Balaton Highland. BITTNER (1900) and FRECH (1912) were also involved in the study of fossils collected during this work. After a long time DETRE (1970) contributed to the knowledge of the Triassic brachiopods of the region. Recently one of the present authors has engaged in the revision of this fauna (PÁLFY, 1986 and 1988).

Even the earliest studies about the Mecsek Mts mentioned the peculiar Middle Traissic limestones (BEUDANT, 1822) and referred to their characteristic fossil "*Terebratula vulgaris*" (HAIDINGER, 1865 and LŐRENTHEY, 1891). The latter emphasized the low diversity of the fauna. VADÁSZ (1935) gave a faunal list in the first monograph on the geology of the Mecsek Mts. He was succeeded by NAGY E. (1968). Recently DETRE (1973), and DETRE et al. (1986) dealt with this subject.

In the first descriptions (BÖCKH, 1881; KLEIDORFER, 1898) Alpine-type names and synonyms like Recoaro and Guttesntein limestone could be found. VADÁSZ (1935) referred to Anisian Alpine analogies, but he considered the Upper Triassic of Mecsek as Middle European Keuper. Concerning the paleogeographic position NAGY (1968) placed the Mecsek in transitional position between Alpine and Germano-type areas. Most recently it is widely considered that Mecsek has rather German than Alpine affinity (KÁZMÉR, 1986).

Description of localities

The two investigated areas have different tectonical and geographical position. Balaton Highland is a part of the Transdanubian Central Range, while Mecsek Mts is situated south of the Zagreb-Zemplén tectonic line in the Mecsek Zone, Tisza Unit *(Fig. 1/a)*. Their stratigraphy reflects this dissimilarity. *(Fig. 2)*.

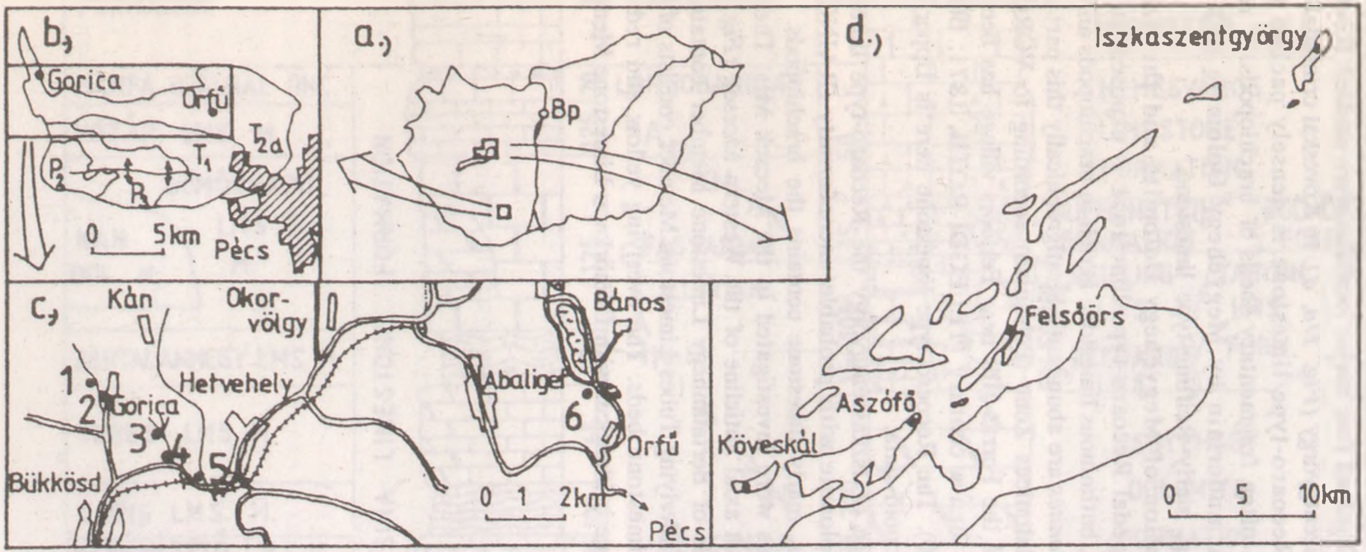

Fig. 1. a; Location of Balaton Highland and Mecsek Mts in Hungary. b; Distribution of Middle (P_2), Upper (P_3) Permian and Lower (T_1), Middle (T_2) Triassic in the Western Mecsek anticline. c; Map of the investigated area in Western Mecsek. Localities of exposures; 1, Gorica Valley, 2, Gorica, road cout, 3. Valley fork near Gorica, 4, Path to Gorica, 5, Hetvehely, roadside slope, 6, Orfű, Sárkánykút, d; Surface distribution of Anisian rocks in the Balaton Highland and the four investigated localities.

In Balaton Highland four major localities were studied: Köveskál, Aszófő, Felsőörs and Iszkaszentgyörgy *(Fig. 1/a, d)*. In Köveskál crinoidal-brachiopodal lumashella-like Recoaro-type limestone is densely packed with usually disarticulated and often fragmentary shells of brachiopods. It represents the Lower Pelsonian, underlain by Megyehegy Dolomite and overlain by *Balatonites*- bearing, marly Reifling-type limestone.

The succession of Megyehegy Dolomite and the overlying thin crinoidal-brachiopodal Recoaro-type limestone is exposed at Aszófő. The well-bedded brown, butiminous limestone is rich in brachiopods and cephalopods (particularly *Balatonites* are abundant). Stratigraphically this part of the section belongs to the Balatonicus Zone (Pelsonian) according to VÖRÖS (1987).

The slope of the Forrás Hill near Felsőörs village has been a reference section for more than a century (TELEGDI-RÓTH, 1871; BÖCKH, 1873; SZABÓ et al. 1980). The Recoaro-type limestone here is Upper Pelsonian on the basis of ammonoid data.

At the village of Iszkaszentgyörgy the Recoaro-type limestone overlies the Megyehegy Dolomite with probable unconformity (RAINCSÁK, 1980). Yellowish, siliceous, marly limestone contains the brachiopods.

Six exposures were investigated in the Mecsek Mts. The outcrops are situated in east-west axial anticline of the Western Mecsek *(Fig. 1/b, c)*. The lumashella-like beds of Bertalanhegy Limestone Member contain brachiopods and bivalves. The underlying Tubes Limestone Member consists of thick-layered (0.5-0.8 m) grey limestone beds. The overlying yellow and red spotted grey intraclastic liemstone is identical with Dömörkapu Limestone Member *(Fig. 2)*.

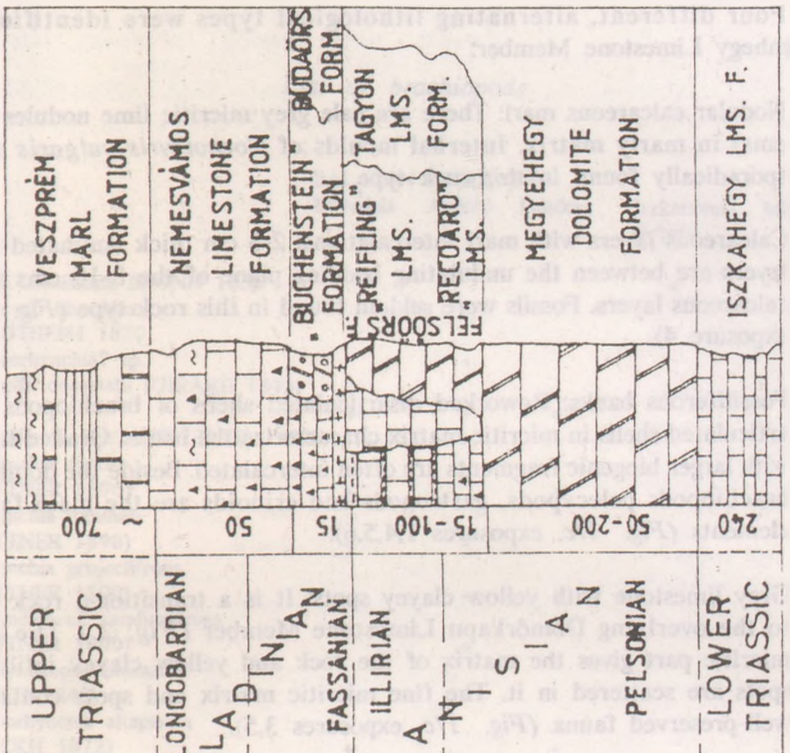

Fig. 2. Composite stratigraphical column of the Middle Triassic of Mts (left) and Balaton Highland (right).

Four different, alternating lithological types were identified in Bertalanhegy Limestone Member:

- Nodular calcareous marl: There are pale grey micritic lime nodules (3-6 cms) in marly matrix. Internal moulds of *Coenothyris vulgaris* were sporadically found in this rock type.

- Calcareous layers with marl intercalations: 2-3 cm thick laminated marl layers are between the undulating bedding plane of the 8-10 cms thick calcareous layers. Fossils were seldom found in this rock type *(Fig. 1/c,* exposure 4).

- Fossiliferous banks: Reworked disarticulated shells of brachiopods and articulated shells in micritic matrix characterize the banks. Graded layers with larger biogenic fragments are often intercalated. Beside the dominant brachiopods pelecypods, gastropods and crinoids are the main faunal elements *(Fig. 1/c,* exposures 1,4,5,6).

- Grey limestone with yellow clayey spots: It is a transitional rock type to the overlying Dömörkapu Limestone Member *(Fig. 2.).* The grey micritic part gives the matrix of the rock and yellow clayey infillings, spots are scattered in it. The fine micritic matrix and spots contain a well-preserved fauna *(Fig. 1/c,* exposures 3,5).

The composition of the fauna

The collection from both the Balaton Highland and the Mecsek was carried out by the authors and partly by the Hungarian Geological Survey (in Aszófő and Iszkaszentgyörgy localities). Brachiopods are the most characteristic faunal elements of the Anisian Recoaro-type limestone in the Balaton Highland. The relatively high diversity indicates favourable life conditions. Beside them cephalopods appear in great number and diversity, while gastropods and bivalves are also major elements in Aszófő locality. In Felsőörs and Köveskál cephalopods and bivalves also occur, but much less frequently. In Iszkaszentgyörgy brachiopods represent the only fossil group.

As far as the brachiopods are concerned up to now the presence of 35 taxa was recognized from the four localities of the Balaton Highland. Brachiopod species are listed in *Table 1.*

Table 1.

List of brachiopods

	BALATON HIGHLAND				
	Köveskál	Aszófő	Felsőörs	Iszkaszentgyörgy	MECSEK
Lingula tenuissima BRONN 1856				+	+
Discina cf. discoides SCHLOTHEIM 1820	+				
Homoeorhynchia? sp.		+			
Decurtella decurtata (GIRARD 1843)	+	+	+		+
Decurtella cf. illyrica (BITTNER 1902)		+			
Volirhynchia vivida (BITTNER 1890)	+		+		
Volirhynchia tommasi (BITTNER 1890)	+	+			
Volirhynchia projectifrons (BITTNER 1890)		+	+		
Volirhynchia cf. productifrons (BITTNER 1890)		+			
Costirhynchopsis mentzeli (BUCH 1843)	+	+			
Caucasorhynchia altaplecta (BÖCKH 1872)	+		+		
Holcorhynchella delicatula (BITTNER 1890)		+			
Piarorhynchella trinodosi (BITTNER 1890)	+	+	+		
Trigonirhynchella attilina (BITTNER 1890)		+	+		
Sinucosta pectinata (BITTNER 1890)	+				
Costispiriferina manca (BITTNER 1890)	+				
Dinarispira cf. dinarica (BITTNER 1890)	+				
Dinarispira avarica (BITTNER 1890)	+				
Punctospirella fragilis (SCHLOTHEIM 1814)	+	+			+
Mentzelia mentzeli (DUNKER 1851)	+	+	+	+	+
Mentzelia balatonica (BITTNER 1890)			+		
Koeveskallina koeveskalyensis (STUR 1865)	+	+	+		+

	BALATON HIGHLAND				
	Köveskál	Aszófő	Felsőörs	Iszkaszentgyogy	MECSEK
Koeveskallina paleotypus (LORETZ 1875)		+			
Thecocyrtella sp.	+				
Tetractinella trigonella (SCHLOTHEIM 1820)	+	+	+	+	+
Schwagerispira schwageri (BITTNER 1890)	+	+	+		
Schwagerispira mojsisovicsi (BÖCKH 1872)	+	+	+		
Athyridida gen. et sp. indet.		+			
Coenothyris vulgaris (SCHLOTHEIM 1820)	+	+	+	+	+
Coenothyris? cf. kraffti (BITTNER 1902)		+			
Coenothyris? cf. cuccensis (BITTNER 1902)		+			
Sulcatinella incrassata (BITTNER 1890)		+			
Angustothyris angustaeformis (BÖCKH 1872)	+	+	+		
Silesiathyris angusta (SCHLOTHEIM 1820)			+	+	+
Terebratulida gen. et sp. indet.		+			

In the Mecsek the fauna has much lower diversity with extreme density of *Coenothyris vulgaris*. Brachiopods make up more than 90% of fauna and within them *Coenothyris vulgaris* represents 99% with the exception of two exposures (localities No. 2 and 5).

In the first one bivalves are more frequent than brachiopods *(Fig. 3)*. Some unidentifiable gastropods and ammonoids were observed in thin sections.

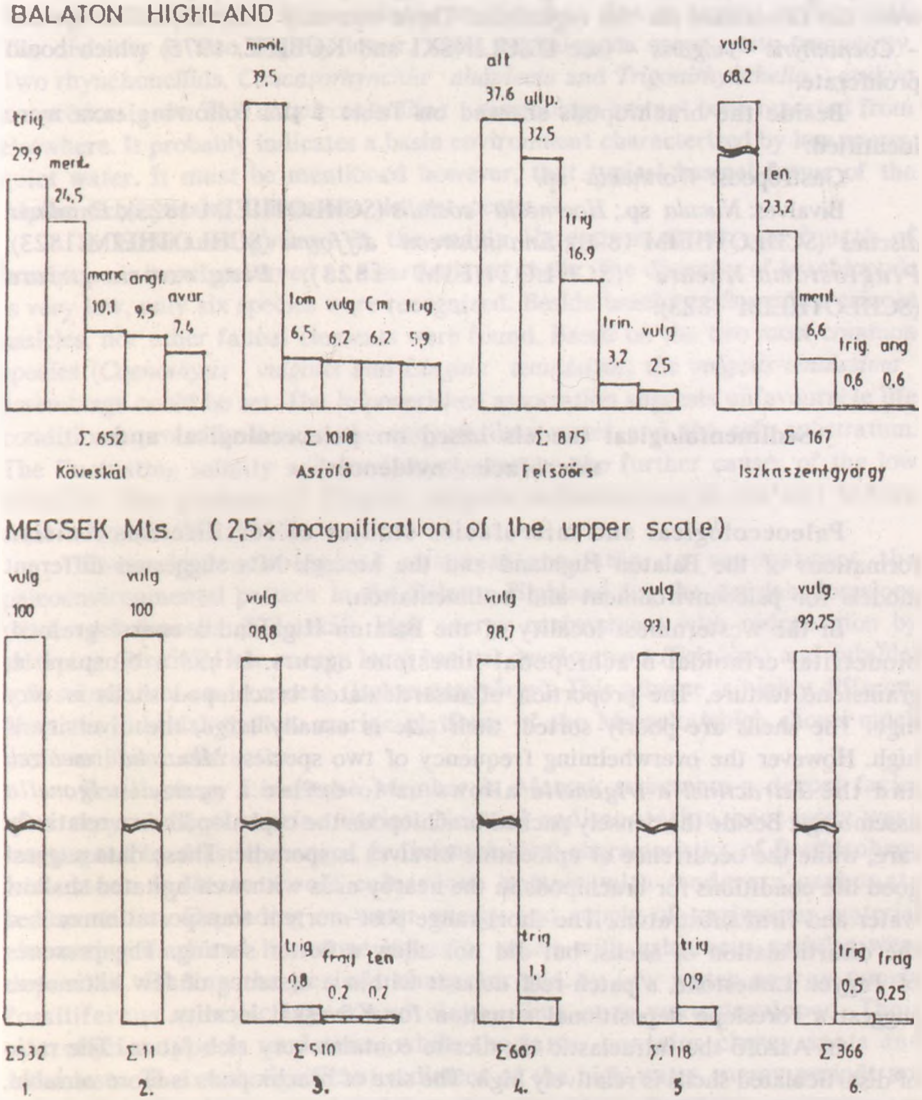

Fig. 3. Percentage of the five most frequent brachiopod species and the number of collected specimens in each localities. Explanation of abbreviations: alt. – *Caucasorhynchia altaplecta*, ang. – *Silesiathyris angusta*, angf. – *Angustothyris angustaeformis*, att. – *Trigonirhynchella attilina*, avar. – *Dinarispira avarica*, C.m. – *Costirhynchopsis mentzeli*, frag. – *Punctospirella fragilis*, manc. – *Costispiriferina manca*, ment. – *Mentzelia mentzeli*, ten. – *Lingula tenuissima*, trig. – *Tetractinella trigonella*, trin. – *Piarorhynchella trinodosi*, vulg. – *Coenothyris vulgaris*.

The low diversity can be explained by extreme environmental factors such as varying salinity and fluctuating water energy. The unstable physical conditions were not favourable for the organisms. There was only one euryecious species – *Coenothyris vulgaris* – (see DZULINSKI and KUBICZ, 1975) which could proliferate.

Beside the brachiopods showed on Table 1 the following taxa were identified:

Gastropods: *Worthenia* sp.

Bivalves: *Nucula* sp.; *Hoernesia socialis* (SCHLOTHEIM 1823); *Entolium discites* (SCHLOTHEIM 1820); *Enantiostreon difforme* (SCHLOTHEIM 1823); *Plagiostoma lineata* (SCHLOTHEIM 1823); *Plagiostoma striata* (SCHLOTHEIM 1823).

Sedimentological models based on paleoecological and microfacies evidences

Paleoecological and microfacies studies of fossiliferous Anisian formations of the Balaton Highland and the Mecsek Mts suggested different models for paleoenvironment and sedimentaiton.

In the westernmost locality of the Balaton Highland a coarse-grained, biodetrital crinoidal-brachiopodal limestone occurs. It has a biosparitic, grainstone texture. The proportion of disarticulated brachiopod shells is very high. The shells are poorly sorted, their size is usually large, the diversity is high. However the overwhelming frequency of two species, *Mentzelia mentzeli* and the *Tetractinella trigonella* allows us to define a *mentzeli-trigonella* assemblage. Beside the densely packed brachiopods the cephalopods are relatively rare, while the occurrence of epibenthic bivalves is sporadic. These data suggest good life conditions for brachipods in the nearby area with well-agitated shallow water and firm substratum. The short-range post-mortem transportation caused the disarticulation of shells, but did not allow a better sorting. The presence of Tagyon Limestone, a patch-reef deposit within a distance of few kilometers suggest a foreslope depositional situation for Köveskál locality.

In Aszófő the intraclastic biomicrite contains very rich fauna. The ratio of disarticulated shells is relatively high. The size of brachiopods is more variable, the average size of the most common species is somewhat smaller than that of Köveskál. The fauna from Aszófő has the greatest diversity and the richest mollusc assemblages among the localities. It may represent a slightly mixed assemblage of fauna, fossils from more or less different habitats got together by slumping or small-scale gravitational sliding of sediments from a shallow water, high energy environment.

In Felsőörs crinoidal-brachiopodal marly limestone (biomicrite) contains the fauna. The ratio of disarticulation among brachiopod shells is extremely low. The size of brachiopods is remarkably smaller than that in Aszófő or Köveskál. The diversity is also slightly lower, while cephalopods occur quite frequently. Two rhynchonellids, *Caucasorhynchia altaplecta* and *Trigonirhynchella attilina* are predominant. This *altaplecta-attilina* assemblage has not been reported from elsewhere. It probably indicates a basin environment characterized by low energy quiet water. It must be mentioned however, that typical basinal forms of the Alpine Schreyeralm Limestone do not occur.

In Iszkaszentgyörgy in the marly limestone about one-fourth of brachiopods were preserved as disarticulated shells. The diversity of brachiopods is very low, only six species were recognized. Beside brachiopods neither crinoid ossicles, nor other faunal elements were found. Based on the two most common species (*Coenothyris vulgaris* and *Lingula tenuissima*) the *vulgaris-tenuissima* assemblage could be set. The impoverished association suggests unfavourable life conditions, probably due to the very shallow water and the soft substratum. The fluctuating salinity and food supply can be the further causes of the low diversity. The presence of *Lingula* suggests sedimentation in the soft bottom tidal zone (EMIG, 1986).

These paleoecological observations help to reconstruct the paleoenvironmental pattern in the Balaton Highland for the Anisian: foreslope patch-reef deposits (Köveskál), high energy environment with redeposition by slumping (Aszófő), low energy local basinal development (Felsőörs) and subtidal soft substratum environment (Iszkaszentgyörgy). This scheme is highly different from the subtidal shallow marine platform of the Mecsek, which shows much more uniform character.

Bertalanhegy Limestone Member in Mecsek represents a deeper facies of a very shallow marine series. Normal sedimentation processes were interrupted by drastic changes. Sedimentological characteristics of Bertalanhegy Limestone indicate a soft calcareous bottom with moderate carbonate sedimentation. Depending on water energy and supply of terrigenous material alternating marl and limestone layers or marls with calcareous nodules were deposited. During the periods characterized by low water energy poorly fossiliferous micritic layers and clayey lime ooze were developed. Their microfacies type is mudstone, while the latter contains clayey spots and intraclasts. The most significant sediment of the high water energy periods are the shell-beds of disarticulated brachiopods. These fossiliferous lenses are underlain by graded beds, which gives the other evidence of the fast redeposition. We consider these layers as strom-generated coquinas which are similar to the German Upper Muschelkalk (AIGNER et al., 1979).

In summary, these data from the Mecsek Mts suggest that the sediments were deposited in quiet shallow water just below the wave base. The normal sedimentation was interrupted by storms which produced considerable sediment redeposition. In quiet periods laminated and nodular beds were formed, while in the periods characterized by storms graded beds and coquina tempestites were accumulated.

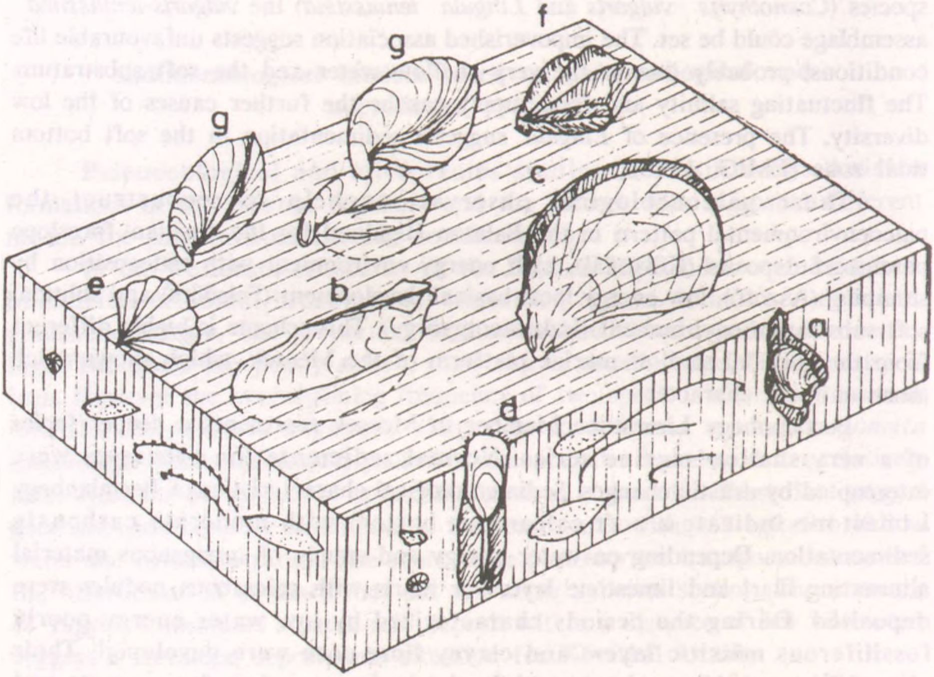

Fig. 4. Paleoecological community of the Middle Triassic Bertalanhegy Limestone (Mecsek Mts.) a. – *Nucula* sp., b. – *Hoernesia socialis*, c. – *Plagiostoma lineata*, d. – *Lingula tenuissima*, e. – *Punctospirella fragilis*, f. – *Tetractinella trigonella*, g. – *Coenothyris vulgaris*.

Comparing the data of the Balaton Highland and Mecsek it becomes clear that within the distance of some tens of kilometers the measurable and comparable features show significant differences in the Balaton Highland, while they remain practically uniform in the Mecsek Mts. These paleoecological deductions involve a paleogeographic implication: the former one was a part of a mobile shelf, while the latter belonged to a stable shelf during the Anisian.

Paleobiogeographical significance of the brachipod faunas

The Triassic paleogeography of Hungary has been the target of investigations and polemics for long time. The Alpine affinity of the Balaton Highland – both lithologically and faunistically – was first recognized in the second half of the 19th century. STUR (1865) divided the Alpine Muschelkalk into two parts – the Recoaro and the Reifling Limestones, and BÖCKH (1873) justified the presence of analogous developments in the Balaton Highland. After the careful study of brachiopods BITTNER (1890, 1900) considered its fauna as transitional between those of the Southern Alps and the Northern Calcareous Alps. ARTHABER (1903) confirmed this judgement by similarities of cephalopod faunas.

The present study and the comparison to recent and older data from different areas shows the greatest similarities between the faunas from the Balaton Highland, West Carpathians and Southern Alps. Important, but less close affinities exist to the faunas of Northern Calcareous Alps and the Dinarids *(Table 2).*

Table 2.

Comparison of Anisian brachiopod faunas of different regions, showing the number of common species having reference to the Balaton Highland fauna.

	Number of species	Number of common species
BALATON HIGHLAND	35	
NORTHERN CALCAREOUS ALPS		
Schreyeralm (BITTNER 1890)	10	7
SOUTHERN ALPS		
Alpi Orobie (CASATI et GNACCOLINI 1967)		
Val Trompia (SPECIALE 1967)		
Guidicaria (GAETANI 1969)	28	15
Monte Rite (Cadore) (DE TONI 1912)		
DINARIDS		
Ljubisnja (SUSIC-PROTIC 1962)	23	12
Seljani (BESIC 1949)	16	8
WESTERN CARPATHIANS		
Silica (SIBLÍK 1971, 1972)	24	16
Aggtelek (SCHOLZ 1972)	15	12
SILESIA		
Tarnowitz (ASSMANN 1937)	12	9
MECSEK (DETRE 1986, NAGY E. 1968)	8	8

Concerning the Mecsek VADÁSZ (1935) already mentioned the Germano-type character of its Triassic sequence. Later it was reaffirmed by NAGY (1968). Recently KÁZMÉR (1986) emphasized the Germano-type features. HAAS et al. (1986) after the comparison of Lower Triassic sequences concluded, that different developments of the Scythian of the Balaton Highland and that of the Tisza Unit (which the Mecsek belongs to) marks different paleotectonic positions. As far as the Jurassic faunas are concerned, the Mediteranean affinity of the Bakony and the European character of the Mecsek was clearly proved by GÉCZY (1973), VÖRÖS (1980, 1984) GALÁCZ (1984), TÖRÖK et al. (1987). However, recently KOZUR and MOCK (1987) studying lithologic sequences and conodont faunas seriously doubted the true German character of the Mecsek Triassic.

Regarding the Middle Traissic brachiopods the Mecsek fauna resembles that of the German Basin. The low diversity *Coenothyris vulgaris* dominated assemblages are very typical to both territories. All species found in the Mecsek have also been reported from the German Basin. By extensive collections (over 2000 specimens from the Mecsek and about 3500 specimens from the Balaton Highland) 35 species were distinguished from the Balaton Highland, while that number is only 4 in the Western Mecsek, and does not exceed 8 added the other species reported from the Eastern Mecsek by DETRE (1986). DAGYS (1974) concluded, that Alpine and Germano-type territories should not be considered as distinct faunal provinces, but the Germano-type brachiopod faunas are rather impoverished assemblages of species, which are not endemic and are also characteristic for the Alpine localities. Indeed, there is no any species in Mecsek assemblage, which would be missing from the Balaton Highland. All brachiopod species of Mecsek were also found in the certainly Germano-type localities, such as Thüringia, Silesia and so on. However, primarily not the common species, but the common features, such as the low diversity, the percentage distribution of taxa and often the overwhelming occurrence of *Coenothyris vulgaris* are distinctive.

It should be mentioned, that these features were observed in the assemblage found in Iszkaszentgyörgy locality, at the edge of Balaton Highland. This fact gives evidence that Germano-type brachiopod assemblages are not indicators of an independent faunal province, but compose rather environmentally and ecologically controlled associations. The slightly fluctuating salinity would have been one of the factors determining the species distrubiton, resulting in dominance of the most adaptive forms, like *Coenothyris vulgaris, Mentzelia mentzeli, Tetractinella trigonella.* Due to the lateral facies changes on a disrupted mobile shelf (Balaton Highland during the Anisian) within a distance of few tens of kilometers in Iszkaszentgyörgy similar conditions appeared which usually characterized the widespread European epicontinental seas.

In the Mecsek these characteristics are typical for each localities, so this uniform appearance allows to assume the belonging to a Germano-type sedimentary basin.

Remarks on Coenothyris vulgaris

Comparing Middle Triassic Brachiopod faunas from different localities one of the most striking facts is the almost overall presence of *Coenothyris vulgaris*, the most common species of that period. The interpretation of its extremely wide geographic distribution, somewhat controversial stratigraphic range (Anisian to Lanidinian, as most widely accepted), and occurrence in strongly different assemblages, which suggests the toleration of different habitats and life conditions is an important issue. The species has very simple external morphology, medium-sized, smooth, biconvex shell with rectimarginate or slightly uniplicate anterior commissure. It is hard to imagine a more simple form for a terebratulid brachiopod. It seems to be interesting that SCHLOTHEIM (1823), the author of the species mentioned a number of earlier named forms in his original description. His unification can be justified by the supposedly great morphological variability. Later on this opinion was widely accepted. However, up to now no modern research has been carried out based on serial grinding method to expose the internal structure of *Coenothyris vulgaris* in question.

The serial grinding of several specimens of the so called *Coenothyris vulgaris* from both the Balaton Highland and the Mecsek was done by the authors. In the inner structure so sharp differences occurred, that their conspecific character became doubtful. The presence or absence of dental plates is such a feature, which would not be considered within the limits of intraspecific variability *(Fig. 5)*. Moreover *Coenothyris vulgaris* specimens from the Mecsek have rather semicircular pedicle valve section, longer dorsal median septum (about 40% of the total valve length), oval septal cavities and deeper septalium, while the Balaton Highland morphotype has rather trapezoidal pedicle valve section, slightly shorter median septum (about 30% of the valve length), trigonal septal cavities and shallower septalium.

The internal morphology of *Coenothyris vulgaris* specimens (studied by the authors) from Thüringia, a typical Germano-type locality, coincides with that of the Mecsek specimens. Since the true *Coenothyris vulgaris* was described from the German Basin, the Balaton Highland morphotype should be treated taxonomically separated.

Hitherto no effort was made to investigate so-called *Coenothyris vulgaris* specimens from other Alpine localites. It is theoretically possible, that the paleobiogeographic difference of Alpine and Germano-type areas is reflected in the difference of these species, as the majority of the "*Coenothyris vulgaris*" from Alpine areas are taxonomically distinct from those of Mecsek and other Germano-type areas.

This preliminary evaluation does not serve as a detailed redescription of the species and the possible separation of the two more or less distinct morphotypes (which is planned to publish later on by the authors), but rather to inspire further studies.

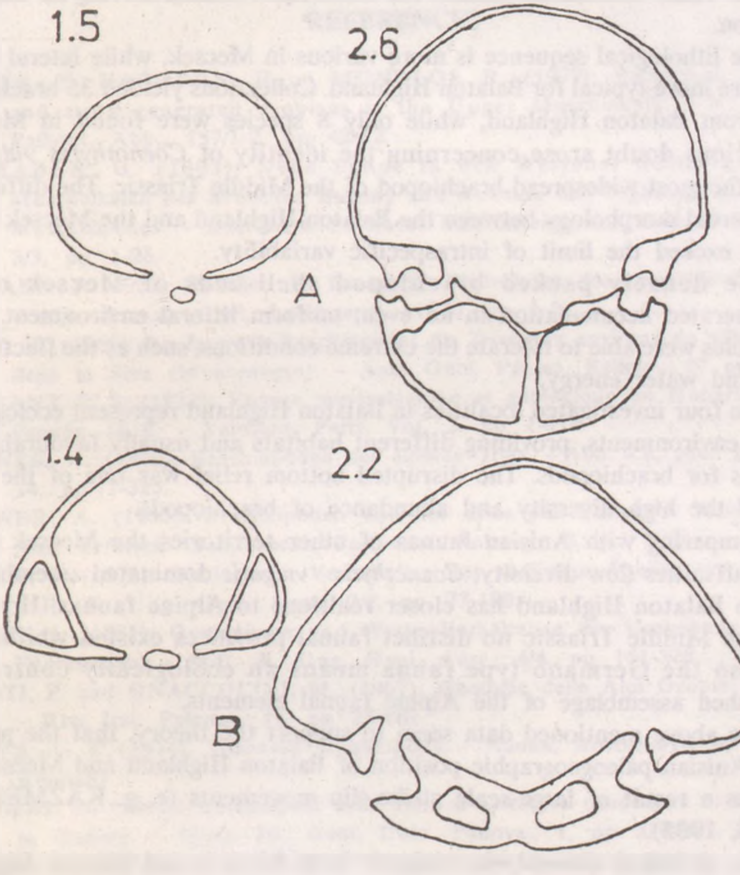

Fig. 5. Two characteristic stages of serial transverse sectioning of *"Coenothyris vulgaris"* from Mecsek and Balaton Highland. A – specimen from Mecsek (locality Gorica). Original length 17.1 mm. B – specimen from Balaton Highland (locality Aszófő) Original length 17.9 mm. The specimens were fixed in the same orientation. Distances are in mm from the pedicle umbo.

Conclusions

The Balaton Highland and the Mecsek Mts are now situated in a distance of 150 kms, on the opposite sides of the Zagreb-Zemplén tectonic lineament. The former belongs to Transdanubian Central Range, the latter to Tisza Unit.

During the Anisian time shallow water marine sediments formed in both territories. These carbonates yielded the brachiopod faunas serving as basis for comparison.

The lithological sequence is more various in Mecsek, while lateral facies changes are more typical for Balaton Highland. Collections yielded 35 brachiopod species from Balaton Highland, while only 8 species were found in Mecsek.

Serious doubt arose concerning the identity of *Coenothyris vulgaris*, which is the most widespread brachiopod of the Middle Triassic. The difference in the internal morphology between the Balaton Highland and the Mecsek forms seems to exceed the limit of intraspecific variability.

The densely packed brachiopod shell-beds of Mecsek reveal strom-generated accumulation in an even, uniform littoral environment. Only a few species were able to tolerate the extreme conditions, such as the fluctuating salinity and water energy.

The four investigated localities in Balaton Highland represent ecologically different environments, providing different habitats and usually favourable life conditions for brachiopods. The disrupted bottom relief was one of the main causes of the high diversity and abundance of brachiopods.

Comparing with Anisian faunas of other territories the Mecsek shows German affinities (low diversity, *Coenothyris vulgaris* dominated assemblages), while the Balaton Highland has closer realtions to Alpine faunas. However, during the Middle Triassic no distinct faunal provinces existed whithin the Tethys, so the Germano-type fauna means an ecologically controlled, impoverished assemblage of the Alpine faunal elements.

The above mentioned data seem to support the theory, that the present and the Anisian paleogeographic position of Balaton Highland and Mecsek are inverse, as a result of large-scale strike-slip movements (e. g. KÁZMÉR and KOVÁCS, 1985).

The so-called *Coenothyris vulgaris* from Mecsek and Balaton Highland seems to be taxonomically different by the internal morphological characters. The Mecsek forms belong to the true *Coenothyris vulgaris* while the specimens from Balaton Highland should be assigned to a new taxon which still needs a formal description.

Acknowledgement

Sincere thanks are due to A. GALÁCZ, M. KÁZMÉR and A. VÖRÖS for their help and advice during the thesis work, which formed the basis of this paper, and for the critical review of the manuscript.

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EARLY JURASSIC MOLLUSCS FROM THE MECSEK MOUNTAINS, (S. HUNGARY). A PRELIMINARY STUDY.

by

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(Received: 9 March, 1989)

Abstract

The examined Hettangian bivalves and gastropods have been collected from a coal-bearing sequence. Freshwater and marginal marine assemblages are recognized. Distribution of molluscs in the sequence as well as sedimentological data suggest that sedimentation of the Mecsek Coal Fm. was influenced by eustatic sea-level changes.The fauna shows affinity to contemporaneous faunas of West and Central Europe.

Inroduction

Lower Liassic bivalves and gastropods from the Mecsek Coal Formation have been known since the beginning of extended mining i. e. the middle of the last century. However the fauna is very poorly documented, in spite of the abundance of molluscan remains in some places.

First report on molluscs of the coal-bearing sequence including descriptions was published by PETERS (1862). Important data on the distribution of fossils and figures on the most frequent forms were given by KLEIDORFER (1898). VADÁSZ (1935) in his monograph of the Mecsek Mountains gave an extended faunal list including several new species. The descriptions, however, have remained unfortunately unpublished. Except the work of NAGY (1970) no systematic work on the fauna has been published in this century.

Opening of coal pits during the last decade has provided favourable conditions for collection. The new collections, which were made recently in the Pécsbánya coal pit, may serve as a proper starting point for studying the Early Jurassic molluscan faunas of the Mecsek Mountains.

Geological setting

The Mecsek Coal Formation occupies the whole Hettangian and parts of the Upper Triassic and the Lower Sinemurian. The coal-bearing sequence lies conformably on the Karolinavölgy Sandstone Formation. Traditionally the basal junction i.e. the lowermost coal seam was regarded as the Triassic/Jurassic boundary. Palynological studies recently suggested to draw this boundary higher in the sequence (BÓNA 1983). The top of the Mecsek Coal Fm. is dated within the Sinemurian. In the lowermost sandstone beds of the overlying Vasas Marl Fm. ammonites indicating Upper Sinemurian, Obtusum Zone age appear. (FÖLDI 1967).

Fitting the Mecsek Coal Fm. into the standard system of Jurassic zones is, due to the scarcity of index fossils, rather difficult. NAGY and NAGY (1969) divided the formation into three informal members. The lower one consisting of continental – fluvial deposits belongs to the Triassic. The base of the upper member is formed by a characteristic sequence, the so-called "Upper Seamfree Leading Beds". The oldest Jurassic ammonites of the Mecsek came mainly from this important marker horizon and indicate Lower Sinemurian, Bucklandi and Semicostatum Zones age (NAGY 1967). Therefore the middle member roughly corresponds to the Hettangian Stage.

The thicknesses of "coal-measures" show marked variation: 120 m and up to 1200 m in the northern and southern regions, respectively. This pattern suggests deposition in a tectonic half-graben. The whole sequence is more or less folded.

The locality

The Pécsbánya coal pit is exploited about 4 km NNE of the centre of the town Pécs (Fünfkirchen), in the Karolina valley. A succession belonging to the middle member of the Mecsek Coal Fm. is exposed. The beds are steeply dipping east and south-east. The succession is complicated by several faults. Deposits of the Pécsbánya sequence are highly variable laterally as well as vertically. As the coal-it is worked extensively the exposures are rapidly changing.

Therefore a general model of sedimentology, partly based on studies of BIMBÓ (1971) is presented and illustrated in *Fig. 1.*

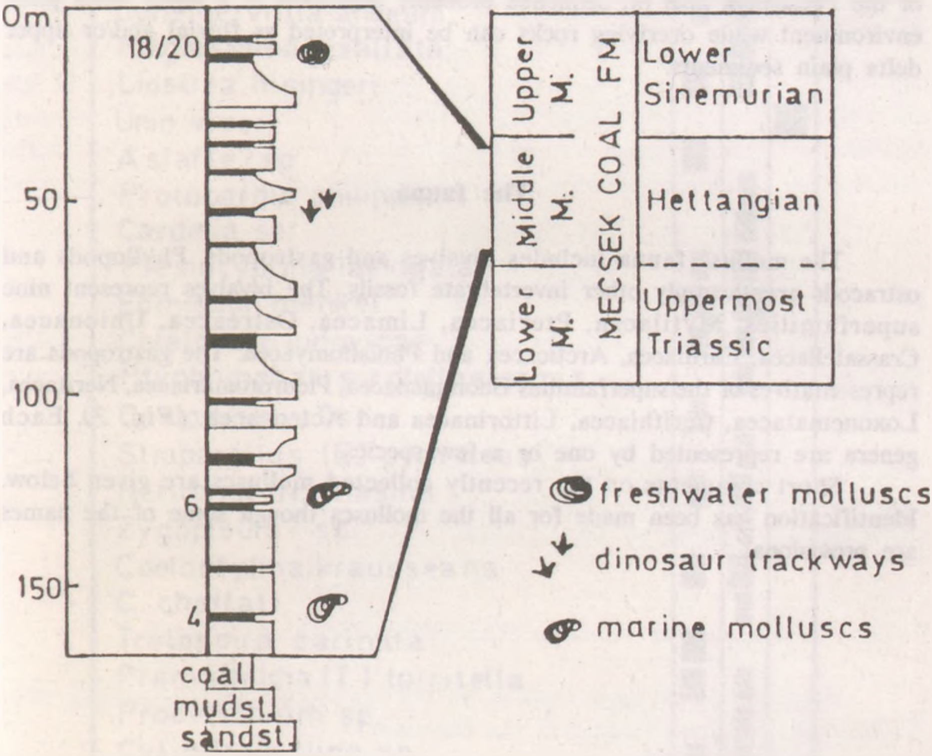

Fig. 1. Schematized section of the Pécsbánya coal pit. Numbers refer to coal seams beneath fossiliferous beds.

Lower part of the succession is dominated by argillaceous and marly siltstones and relatively thick (up to 2.4 m) coal seams. These beds overlie an unexposed sequence of fining upwards sandstone-clay-thin coal seam cycles.

Above seams Nos. 4 and 6 shell beds are frequent. These occurences and a preceding one ca. 10 m below contain the oldest known Jurassic macrofossils in the Mecsek.

Several thick (up to 12 m) sandstone beds characterize the middle part of the succession. Sandstones are often coarse-grained and rich in felspar. Upwards fine-grained sediments became dominant. Recently a rich ichnofauna consisting of dinosaur trackways and arthropod trails has been discovered.

Sedimentological and palaeontological data suggest that the lower part of the Pécsbánya coal pit sequence probably deposited in a lower delta plain environment while overlying rocks can be interpreted as fluvial and/or upper delta plain sediments.

The fauna

The mollusc fauna includes bivalves and gastropods. Phyllopods and ostracods are the only other invertebrate fossils. The bivalves represent nine superfamilies: Mytilacea, Pteriacea, Limacea, Ostreacea, Unionacea, Crassatellacea, Cardiacea, Arcticacea and Pholadomyacea. The gastropods are representatives of the superfamilies Euomphalacea, Pleurotomariacea, Neritacea, Loxonematacea, Cerithiacea, Littorinacea and Acteonacea. *(Fig. 2).* Each genera are represented by one or a few species.

Short comments on the recently collected molluscs are given below. Identification has been made for all the molluscs though some of the names are provisional.

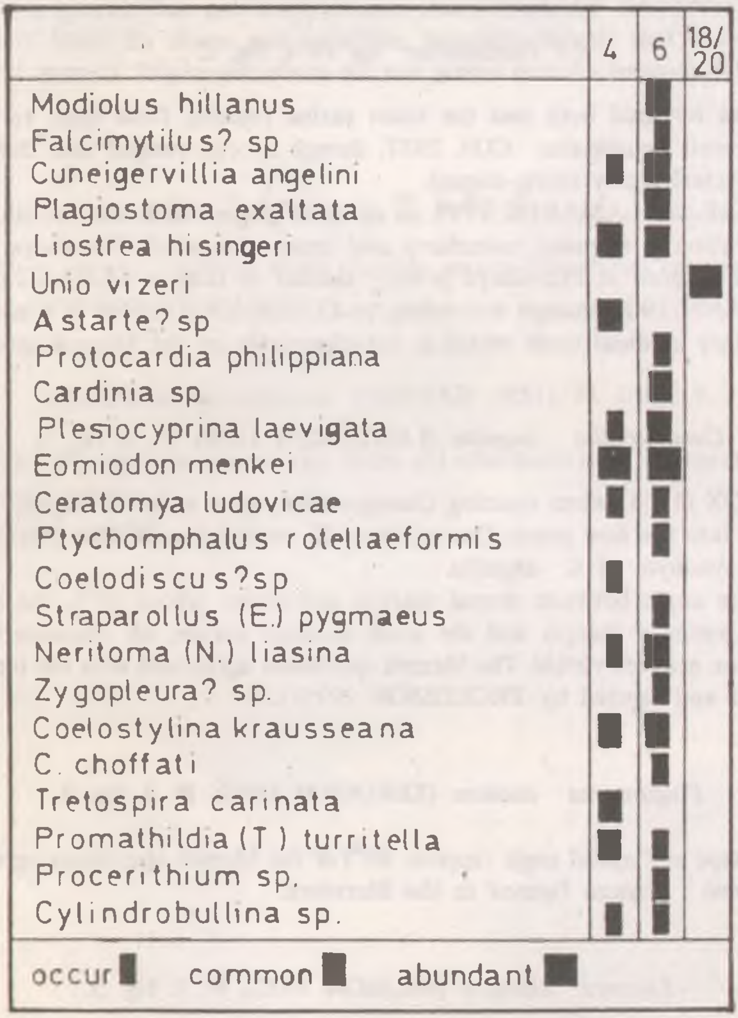

Fig. 2. Composition of the mollusc fauna from the Mecsek Coal Fm. at Pécsbánya. Numbers refer to coal seams in Fig. 1.

Modiolus hillanus SOWERBY 1818. Pl. I. fig. 1.

The shape and dimensions of the Pécsbánya specimens agree well those of the species figured in the literature. The agreement is especially good with the type.

? *Falcimytilus* sp. Pl. I. fig. 2.

The terminal beak and the blunt carina running from beak to ventral margin recall *Falcimytilus* COX 1937, though species ranged into this genus are characteristically sickle-shaped.

Modiolus LAMARCK 1799, as an other genus which may be taken into consideration is rounded anteriorly and more elongated. The shape of the specimens found at Pécsbánya is very similar to that of *Mytilus chartroni* COSSMANN 1904 though according to COSSMANN (1904) it possesses a rudimentary cardinal tooth which is not observable on the Mecsek specimens.

Cuneigervillia angelini (LUNDGREN 1878). Pl. I. fig. 3.

COX (1954) when erecting *Cuneigervillia* gave a list of Liassic species included into the new genus. One of them *C. conimbrica* (BÖHM 1901) seems to be a synonym of *C. angelini.*

The angle between dorsal margin and umbo (about 40°), the slightly concave posterior margin and the small anterior auricle, all characteristic of the species, are well visible. The Mecsek specimens agree well with the topotypes described and figured by TROEDSSON (1951).

Plagiostoma exaltata (TERQUEM 1855). Pl. I. fig. 4.

Shape and apical angle (approx. 80°) of the Mecsek specimens agree with *Plagiostoma exaltata* figured in the literature.

Liostrea hisingeri (NILSSON 1832). Pl. I. fig. 5.

Specimens of this very variable species have thick shell walls. According to STENZEL (1971) this feature is characteristic of the "southern" representatives of *L. hisingeri.*

In NW Europe the continuing Liassic transgression resulted in the replacement of *Liostrea* by the stenohaline *Gryphaea* (HUDSON and PALMER

1976). A similar situation is seen in the Mecsek succession where the Vasas Marl contains abundant *Gryphaea mcullochii* J. de C. SOWERBY.

Unio vizeri (VADÁSZ in NAGY 1970). Pl. I. fig. 6.

This species was previously ranged into *Trigonodus* SANDBERGER in ALBERTI 1864. Its shape and dentition, however, suggest that it belongs to *Unio s. l. instead Trigonodus* which did not persist into the Jurassic (HALLAM, 1981a).

? *Astarte* sp. Pl. I. fig. 7.

Very poorly preserved shells showing astarte-like strong concentric ribs. Internal characters are unknown.

Protocardia philippiana (DUNKER 1851). Pl. I. fig. 8.

The Pécsbánya specimens show all characteristic features of this widespread species.

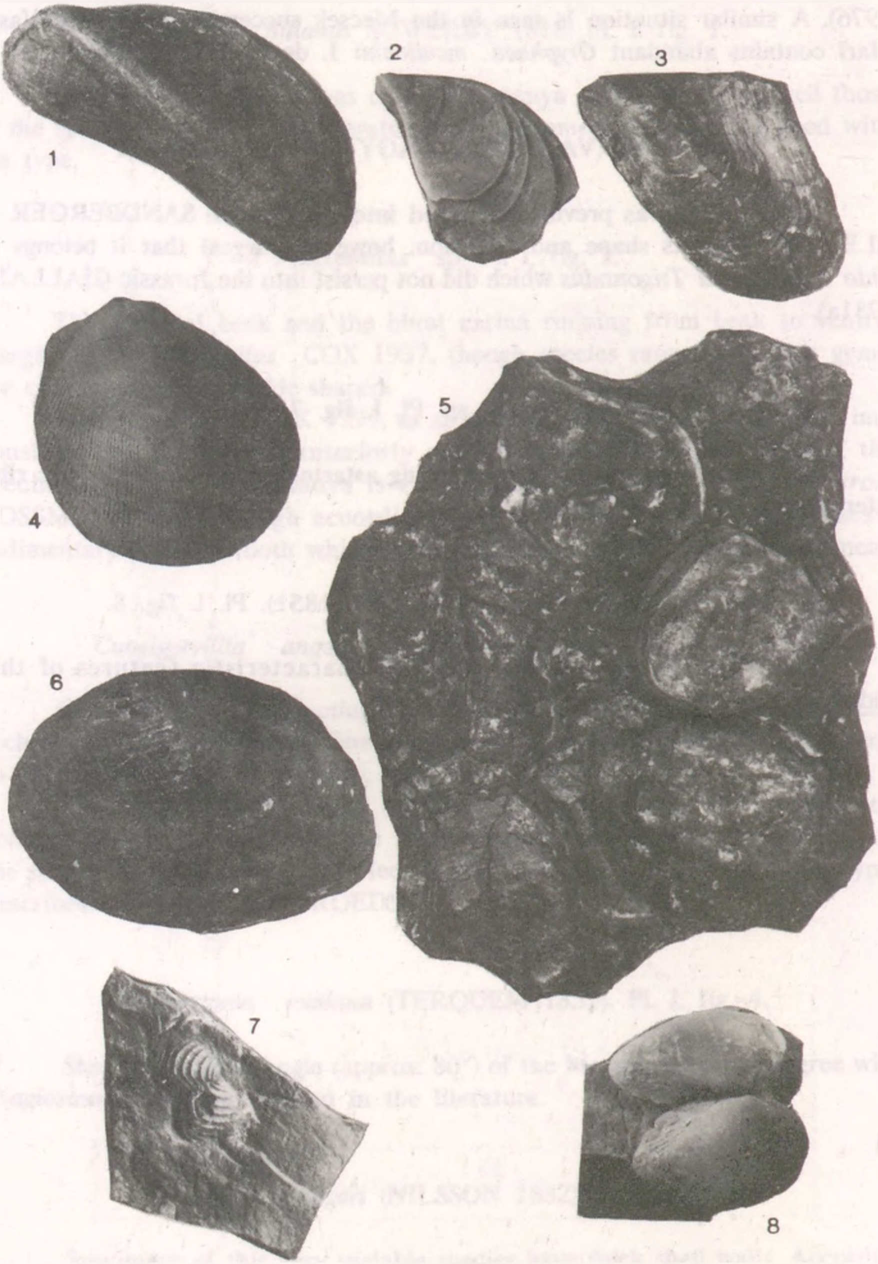

PLATE I.
Fig. 1. Modiolus hillanus SOWERBY, Fig. 2. ? Falcimytilus sp., Fig. 3. Cuneigervillia angelini (LUNDGREN), Fig. 4. Plagiostoma exaltata (TERQUEM) Fig. 5. Liostrea hisingeri (NILSSON), Fig. 6. Unio vizeri (VADÁSZ in NAGY), Fig. 7. ? Astarte sp., Fig. 8. Protocardia philippiana (DUNKER) (Figures are in natural size unless otherwise stated)

Cardinia sp. Pl. II. fig. 1.

Shells of small size for the genus. Outline is characteristically trapezoidal, dentition is of *Cardinia* -type.

Plesiocyprina laevigata (TERQUEM 1855). Pl. II. fig. 2.

Shape and dentition of the specimens collected at Pécsbánya agree well with those of specimens figured and described by COSSMANN (1904) from W France.

Eomiodon menkei (DUNKER 1851). Pl. II. figs. 3-5.

The most frequent bivalve species at Pécsbánya. The specimens show all characteristic features stated and illsutrated by HUCKRIEDE (1967). Outline and development of teeth are rather variable.

Ceratomya ludovicae (TERQUEM 1855). Pl. II. fig. 6.

Although the pallial line of available specimens is not observable, split extending back form beak on internal mold of right valve is rather short and shallow so this species can be ranged into *Ceratomya.* The specimens from the Mecsek are very similar to those described by JOLY (1907, 1936).

Ptychomphalus rotellaeformis (DUNKER 1851). Pl. II. figs. 7-8.

Two, somewhat crushed specimens were collected recently. The peripheral, subsutural selenizone, the lenticular form and the unornamented shell, all characteristic features to the species, are well visible.

? *Coelodiscus* sp. Pl. II. figs. 9-10.

The specimens of smooth, evolute shell, almost flat spiral face and wide umbilucus probably belong to the mixed group of species ranged to *Coelodiscus* BRÖSAMLEN 1909.

Straparollus (Euomphalus) pygmaeus (DUNKER 1851). Pl. II. figs. 11-13.

It is worthy to mention this small gastropod because this species is a very late representative of *Euomphalus*. A well preserved specimen came from borehole Rücker-31 and several specimens from Pécsbánya show all generic (subgeneric) characteristics summarized by YIN HONG-FU and YOCHELSON (1983): the discoidal shell with a keel on the upper face and a 2nd on base, the rounded outer face and the collabral and spiral threads. Growth lines of the Mecsek specimens are slightly opisthocline on upper whorl surface, curving to prosocline at keel, prosocline on outer whorl surface and slightly prosocline on basal surface. According to YIN HONG-FU and YOCHELSON (1983) a few of the Triassic species assigned to *Euomphalus* does really belong to this taxon. One can suppose that it persisted into the Early Jurassic.

Neritoma (Neridomus) liasina (DUNKER 1851). Pl. II. fig. 14.

A rather common species at Pécsbánya. Inner lip callous, not concave.

? *Zygopleura* sp. Pl. II. fig. 15.

A poorly preserved fragment showing axial ribs on its last whorl probably belongs to *Zygopleura* KOKEN 1892.

Coelostylina krausseana (DUNKER 1851). Pl. II. fig. 16.

A very frequent species at Pécsbánya. The specimens show some variability in shape though do not differ considerably from the lectotype and topotypes described and figured by HUCKRIEDE (1967).

Coelostylina choffati BÖHM 1901. Pl. II. fig. 17.

The Mecsek specimens show the same dimensions as the type although their apical angle may be somewhat smaller.

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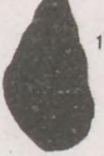

PLATE II.

Fig. 1. Cardinia sp., Fig. 2. Plesiocyprina laevigata (TERQUEM), Figs. 3-5. Eomiodon menkei (DUNKER). 3: external view, 4: internal view of left valve, 5: internal view of right valve., Fig. 6. Ceratomya ludovicae (TERQUEM), Figs. 7-8. Ptychomphalus rotellaeformis (DUNKER). 7: apical view, 8: apertural view., Figs. 9-10. ? Coelodiscus sp. (8x), Figs. 11-13. Straparollus (Euomphalus) pygmaeus (DUNKER) 11: apical view, 12: apertural view, 13: basal view. (10x) Fig. 14. Neritoma (Neridomus) liasina (DUNKER), Fig. 15. ? Zygopleura sp., Fig. 16. Coelostylina krausseana (DUNKER) (5x), Fig. 17, Coelostylina choffati (BÖHM)

Tretospira carinata (TERQUEM 1855). Pl. III. fig. 1.

Specimens collected from the Pécsbánya agree well with the strongly carinate topotype figured by COSSMANN (1913, Pl. X. fig. 16.).

Promathildia (Teretrina) turritella (DUNKER 1851). Pl. III. fig. 2.

The specimens from the Mecsek Coal Fm. at Pécsbánya shows the same shape and dimensions as the type. Growth lines are opisthocyrt.

Procerithium (Rhabdocolpus) sp. Pl. III. fig. 3.

Several fragmentary specimens are available showing slightly curved axial ribs and somewhat weaker four spiral threads. Aperture (broken in most specimen) apparently evenly rounded.

Cylindrobullina sp. Pl. III. fig. 4.

Small (up to 3mm) shells ornamented only by growth lines possessing heterostrophic embrional whorls.

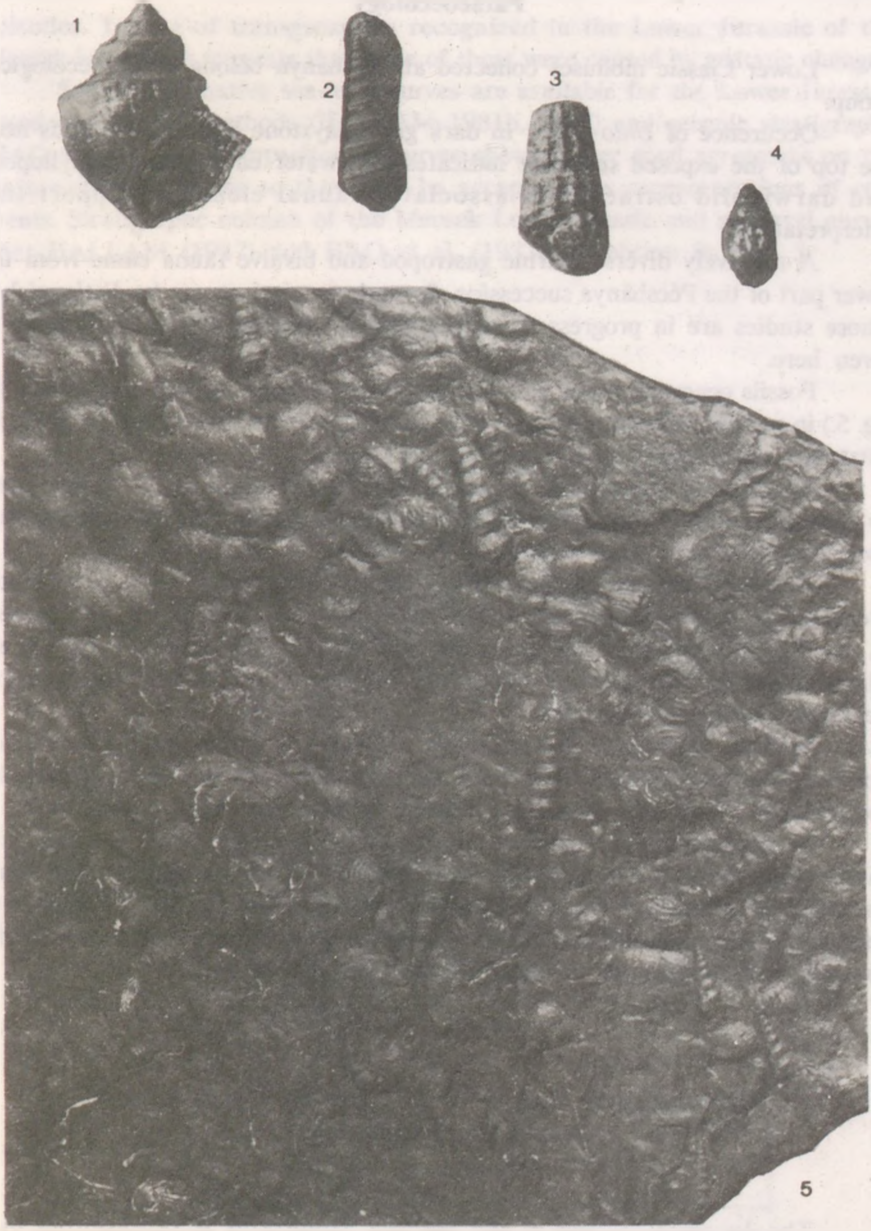

PLATE III.
Fig. 1. Tretospira carinata (TERQUEM), Fig. 2. Promathildia (Teretrina) turritella (DUNKER), Fig. 3. Procerithium (Rhabdocolpus) sp. (5x), Fig. 4. Cylindrobullina sp. (5x), Fig. 5. Bedding-plane view.

Palaeoecology

Lower Liassic molluscs collected at Pécsbánya belong to two ecological group.

Occurence of *Unio vizeri* in dark grey claystone and siderite beds near the top of the exposed sequence indicates freshwater environment. Phyllopods and darwinulid ostracods as associated faunal elements support this interpretation.

A realtively diverse marine gastropod and bivalve fauna came from the lower part of the Pécsbánya succession. Several associations can be distinguished whose studies are in progress so only a general palaeoecological evaluation is given here.

Fossils generally oscur as paucispecific shell beds and pavements (Pl. III. fig. 5.) in various sediments ranging from silty claystones to argillaceous or marly siltstones often immediately overlying coal seams.

The lack of stenohaline organisms and composition of the fauna point to lowered and/or fluctuating salinity environments in which these skeletal concentrations have been formed.

Among European Jurassic bivalve associations four main a ecological group can be distinguished (HALLAM 1976). All marine bivalve genera present in the Pécsbánya fauna are characteristic of lagoonal associations except Plagiostoma and Ceratomya which are abundant in the more stenohaline nearshore marine associations.

Jurassic gastropods are realtively neglected in palaeoecological studies. Species found at Pécsbánya have been recorded elsewhere from marginal marine sediments so they may indicate a similar environment as the bivaives.

In marginal marine environments salinity is often the dominant ecological factor. Lagoons and enclosed bays are especially characterized by short-term oscillations in salinity. Such oscillations may account for the occurence of relatively stenohaline forms such as *Ceratomya, Plagiostoma* and the eotomariid gastropod *Ptychomphalus* in association of euryhaline genera.

Environmental changes in the Lower Liassic of the Mecsek Mountains

The Jurassic System in the Mecsek Mountains is represented by a continuous sequence of marine deposits. The temporal change of depositional environments shows a general deepening tendency from the Early Jurassic fluvial – marginal marine setting to the Late Jurassic pelagic sedimentation. This trend may be considered as a succession of several minor shallowing and deepening episodes. Timing of transgressions recognized in the Lower Jurassic of the Mecsek Mountains suggests that some of them were caused by eustatic changes.

Several alternative sea-level curves are available for the Lower Jurassic, based on classical methods (HALLAM 1981b, 1987) and seismic stratigraphy (HAQ et al. 1987). Comparison of curves shows rather good agreement on the main eustatic changes so they may be acceptable as representations of real events. Stratigraphc column of the Mecsek Lower Liassic and sea-level curves after HALLAM (1987) and HAQ et al. (1987) are shown in *Fig. 3.*

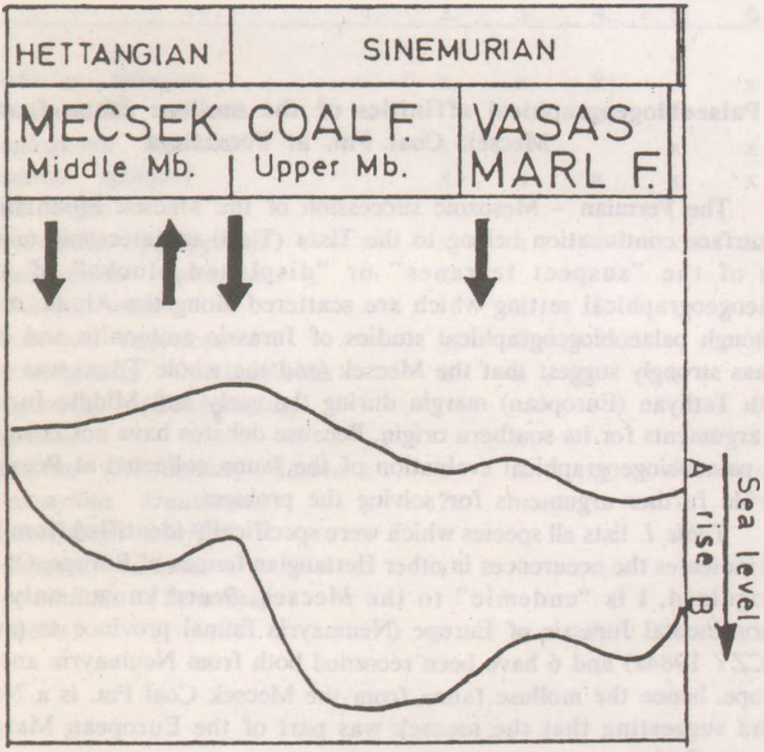

Fig. 3. Lower Liassic sequence of the Mecsek Mountains and sea-level curves. A, after HAQ et al. (1987); B, after HALLAM (1987). Arrows refer to transgressive (to the righ) and regressive (to the left) trends in the Mecsek Mountains.

Two transgressions have been observed in the Mecsek Coal Formation (NAGY and NAGY 1969). The first one resulted in the lowermost occurence of marginal marine sediments and fauna described above. Marine influences related to the second transgressive episode reached their maximum during deposition of the fully marine "Upper Seamfree Leading Beds".

Lower Sinemurian age of the latter corresponds well to a phase of sea-level rise which was one of the most important in the Jurassic (HALLAM 1981b, p. 739). Therefore the first transgression may correspond tot he Middle Hettangian rise suggested by HALLAM's curve.

Higher Sinemurian correlations seem to be not so clear as the Hettangian – Lower Sinemurian ones. The start of fully marine sedimentation in the Mecsek (Obtusum Zone) corresponds to episodic falling sea-level as suggested by both curves. Sedimentary evolution of the Mecsek basin was controlled by local tectonic activity at that time.

Palaeobiogeographical affinities of the mollusc fauna from the Mecsek Coal Fm. at Pécsbánya

The Permian – Mesozoic succession of the Mecsek Mountains and its subsurface continuation belong to the Tisza (Tisia) megatectonic unit. Tisza is one of the "suspect terranes" or "displaced blocks" of uncertain palaeogeographical setting which are scattered along the Alpine mobile belt. Although palaeobiogeographical studies of Jurassic ammonite and brachiopod faunas strongly suggest that the Mecsek (and the whole Tisza) was part of the north Tethyan (European) margin during the early and Middle Jurassic there are arguments for its southern origin. Because debates have not been concluded yet, palaeobiogeographical evaluation of the fauna collected at Pécsbánya may provide further arguments for solving the problem.

Table I. lists all species which were specifically identified from Pécsbánya and indicates the occurences in other Hettangian faunas of Europe. Of 16 species recognized, 1 is "endemic" to the Mecsek, 9 are known only from the epicontinental Jurassic of Europe (Neumayria faunal province as proposed by GÉCZY 1984a) and 6 have been recorded both from Neumayria and "Alpine" Europe. hence the mollusc fauna from the Mecsek Coal Fm. is a Neumayrian fauna suggesting that the mecsek was part of the European Margin of the Jurassic Tethys.

This agrees with results previously obtained for Liassic ammonites (GÉCZY 1973, 1984b), for Pliensbachian gastropods (SZABÓ 1988) and for Jurassic brachiopods (VÖRÖS 1984).

It is worthy to note, however, that benthonic molluscs seem to be less suitable for palaeobiogeographic analysis than other groups e.g. brachiopods.

According to HALLAM (1976) compositional differences between Jurassic bivalve faunas of NW Europe and south ("Alpine") Europe can be attributed to local environmental rather than province determining factors. The European Jurassic Bivalve Province of HALLAM (1977) involves areas both of Neumayria and the classical Mediterranean Province. According to SZABÓ (1980) Jurassic gastropods show stronger provinciality. The Souther Alps, which are regarded as part of the southern Tethyan margin, however, bear Neumayrian Hettangian gastropod faunas (SZABÓ 1980).

The relative uniformity of Hettangian betnhonic mollusc faunas indicates that bivalves and gastropods could migrate between the northern and southern shores of Tethys during the Early Jurassic.

Table 1.

	1.	2.	3.	4.	5.	6.
Modiolus hillanus	x	x	x	x		x
Cuneigervillia angelini	x			x		
Plagiostoma exaltata	?	x			x	x
Liostrea hisingeri		x	x	x	x	x
Unio vizeri						
Protocardia philippiana	x	x	x	x	x	x
Plesiocyprina laevigata		x				
Eomiodon menkei			x	?		
Ceratomya ludovicae		x	?			
Ptychomphalus rotellaeformis		x	x		x	
Straparollus (Euomphalus) pygmaeus			x			
Neritoma (Neridomus) liasina	x	x	x			
Coelostylina krausseana		?	x			
Coelostylina choffati	x					
Tretospira carinata		x				
Promathildia (Teretrina) turritella	x	x	x		x	

Table I. palaeobiogeographical comparison of the mollusc fauna from the Mecsek Coal Fm. at Pécsbánya. 1: Portugal (BÖHM 1901), 2: W and NE France (TERQUEM 1855, COSSMANN 1904), 3: Halberstadt, NW Germany (DUNKER 1851), 4: Scania (TROEDSSON 1951), 5: Southern Alps (BISTRAM 1903, GAETANI 1970), 6: NW Carpathians (KOCHANOVÁ 1961, 1967).

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ELECTROLYSIS: A NEW POSSIBILITY FOR "IN SITU" Fe-Mn ELIMINATION

by

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(Received: 23^{d} February, 1989)

Abstract

Electrolysis, one of the possible methods of "in situ" Fe-Mn elimination, is not economical under common hydrogeological conditions.

Since in Hungary the hydrogeological conditions do not allow a proper use of the oxygene input method, a detailed study of other methods had to be done to examine the possibilities of their individual and even combined use.

In this study the problem has been approached through experiments on small samples, followed by tests done under laboratory conditions but in industrial dimensions (electrode distance = 6 m) to get prepared for the frothcoming tests at industrial level.

Purpose and scope

The laws of electrolysis were laid down by Faraday in the 19th century, and they soon became widely used in galvan technology. The results of our study prove that under seepage conditions the theoretical and "in vitro" connections differ from each other.

In our experiments we followed both the direction and the efficiency of cathodic processes step by step from the water filled glass vessel to an aquifer, made of fine sand.

The examined equation and parameters are given using the formula:

$$G = A_e \times I \times t \times n$$

where

G = weight of material gained by electrodeposition
A_e = electrochemical equivalent weight
(in case of $Fe^{2+} - Fe^{0}$, this value is 1.042)
I = current intensity
t = time
n = cathodic efficiency.

The aim of "in situ" Fe-Mn elimination is to bring the dissolved $Fe(HCO_3)_2$ and $Mn(HCO_3)_2$ into solid state and, if possible, to remove them. To achieve this, there are two optional electrolytic ways, namely

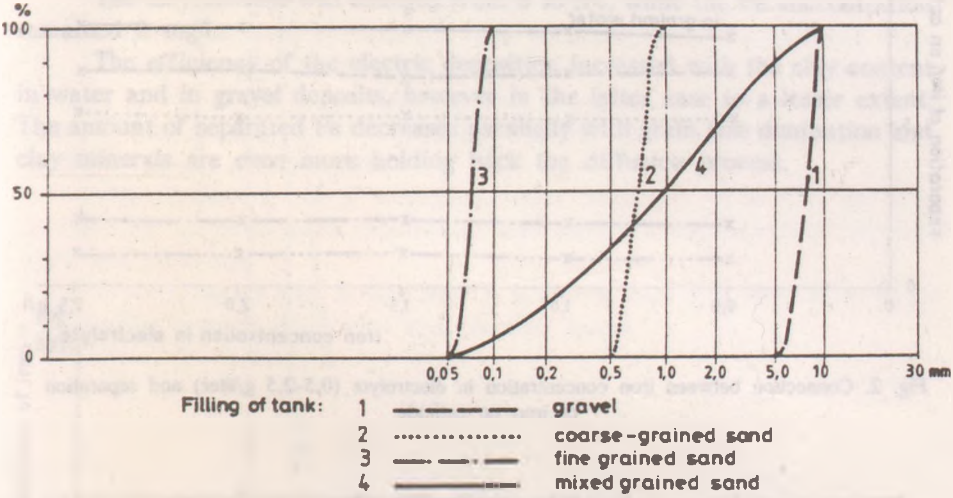
i : removal of the elementary Fe and Mn on the cathode
ii : oxidation of the Fe^{2+} to Fe^{3+} on the anode, where it hydrolyses and becomes solid.

This paper discusses the effects of different conditions on elestrodeposition of metals from a solution.

Deposition voltage : 0 – 48 volts
Current intensity : 0 – 300 ampers
Electrodes,
cathode : spectroscopically pure graphite bar
anode : graphite or iron bar
Effective electrode surface : 2×1386 mm^2
Electrolysis tank : $250 \times 250 \times 450$ mm glass vessel.

Experimental variables: voltage, current intensity, time, Fe-Mn content, media (water, gravelly-, coarse and fine sand), grain sorting, clay and humin acid content.

Experimental testing



These signs are valid for the following figures

Fig. 1. Investigated granulometric composition

Experiment A, Fig. 2.

Experimental conditions: voltage 2 V, current density 4330 A/m^2, time 6000 sec, surface of the graphite electrodes 2 x 1386 mm^2, electrolite concentration range within 0.5 – 2.5 g/l.

Theoretically, in case of 100 percent electric and cathodic efficiency, it would be separated:

$$G = 1.042 \times 0.1386 \times 43.3 \times 1.67 \times 1 = 10.44 \text{ g Fe}$$

In practice, the electro-separated amount is 25% of the counted value, due to decrease in efficiency.

In agreement with our other experiences, along with the decreasing porosity in clastic aquifers, the speed of chemical reactions also decreases rapidly.

During the given time of experiment and in case of 0.5 – 2.5 g/l iron concentration the amount of separated material does not depend on the concentration of the solution.

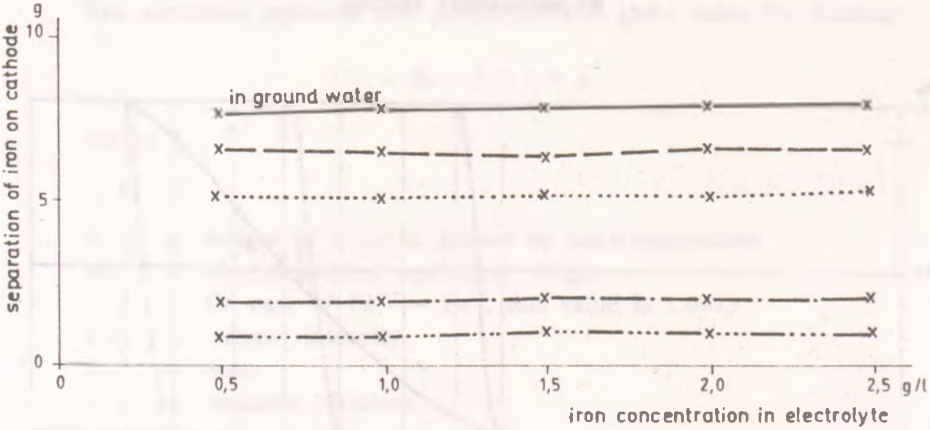


Fig. 2. Connection between iron concentration in electrolyte (0,5-2,5 g/liter) and separation of iron on cathode

Experiment B, Fig. 3.

Here the conditions are identical with those of experiment A, except for the concetration that was reduced to 0.5 - 2.5 mg/l, i.e. to values characteristic of reservoirs storing riverbankfiltered waters.

The measured results proved that the electrically deposited amount is close to the theoretical maximum, both in water or gravels and coarse sands but separation is much poorer in substances of fine or mixed grain size distribution.

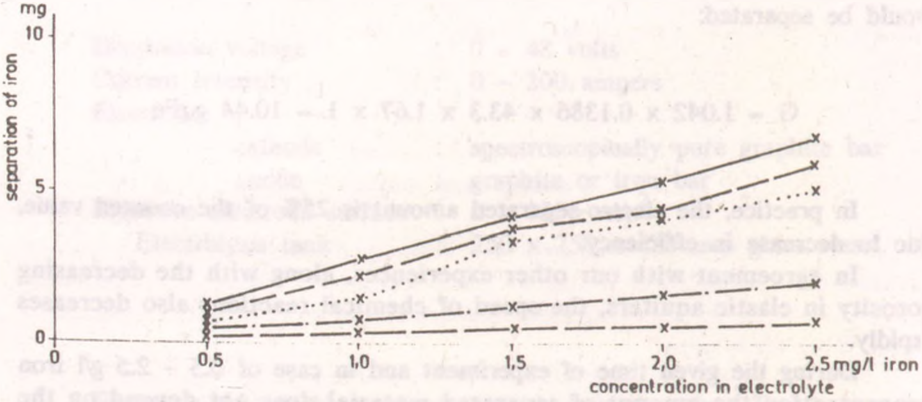


Fig. 3. Connection between iron concentration in electrolyte (0,5-2,5 mg/liter) and spearation of iron

Experiment C, Fig. 4.

The clay content was changed from 0 to 5%, while the Fe concentration remained 2 mg/l.

The efficiency of the electric deposition increased with the clay content in water and in gravel deposits, however in the latter case to a lesser extent. The amount of separated Fe decreases parallelly with grain size diminution and clay minerals are even more holding back the diffusion process.

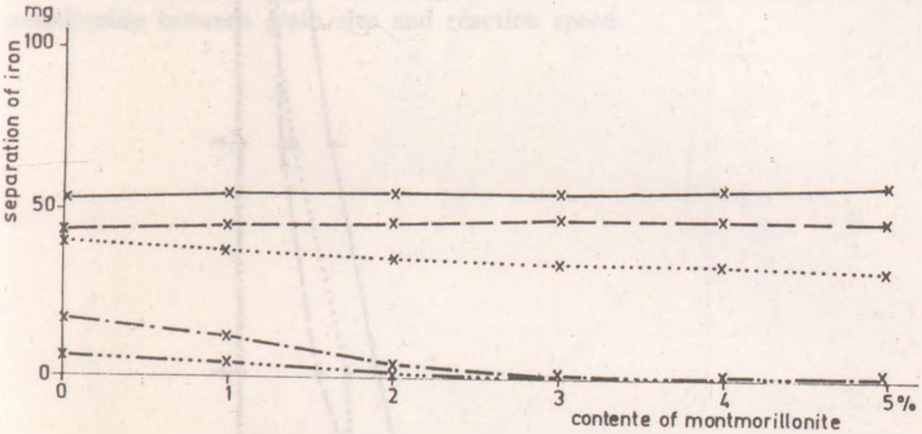


Fig. 4. Connection between content of montmorillonite and separation of iron

Experiment D, Fig. 5.

We added 5% humin acid to an electrolyte containing 2 mg/l $Fe(HCO_3)_2$ to investigate the effects of protecting colloids. The examination of the "sub-terra" method proved that oxygene rich water has little effect if the ground water contains humin acid, because it forms a protecting colloid around the Fe^{2+} ions. The measured values scattered within a very large scale even after repetition, so at *Fig. 5.* the average of the 3 series of measurements can be seen. The shape of the curve shows that the protecting colloid remained active during elecrolysis.

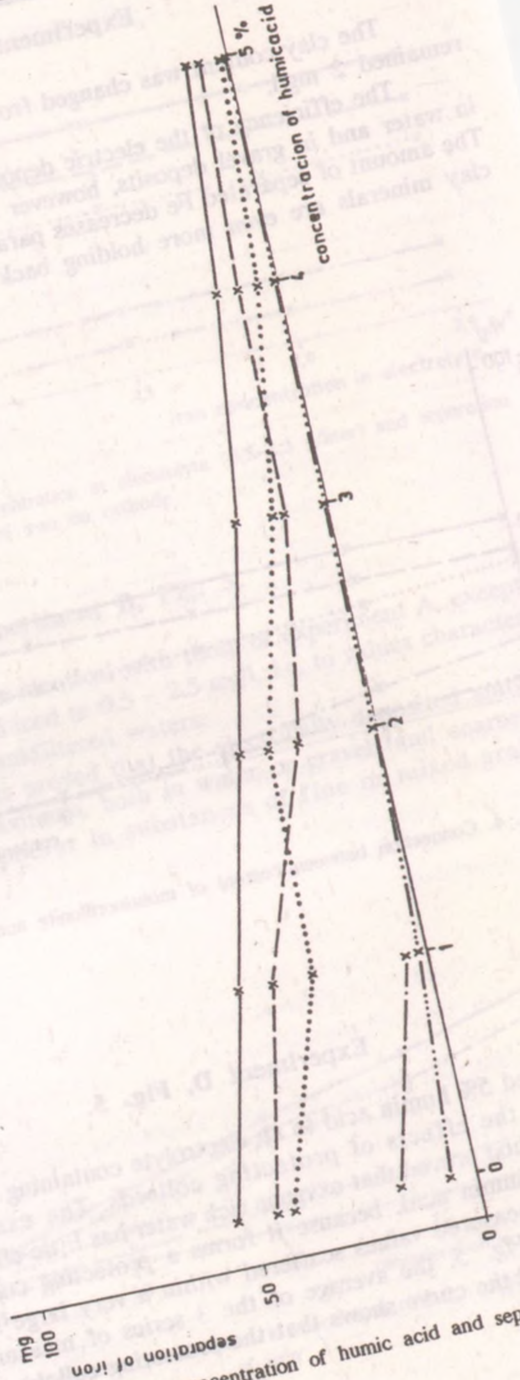


Fig. 5. Connection between concentration of humic acid and separation of iron

Experiment E, Fig. 6. and 7.

In this experiment we investigated the effects of time on electrodeposition both in laboratory and in industrial tests (electode distance = 0.4 and 6 m).

The speed of the reactions decreased remarkably with grain size as shown by data in *Fig. 6.* In case of gravelly and coarse sandy aquifers the reaction speed is just acceptable for economical reasons, but it is insufficient in fine sand and poorly sorted media.

Fig. 7. Shows that if elecrode distance increases up to 6 m the drop in reaction speed is more remarkable and only gravelly aquifers meet the economic demands.

If we compare *Fig.* 6. and *Fig.* 7. it can be seen that there is no direct relationship between grain size and reaction speed.

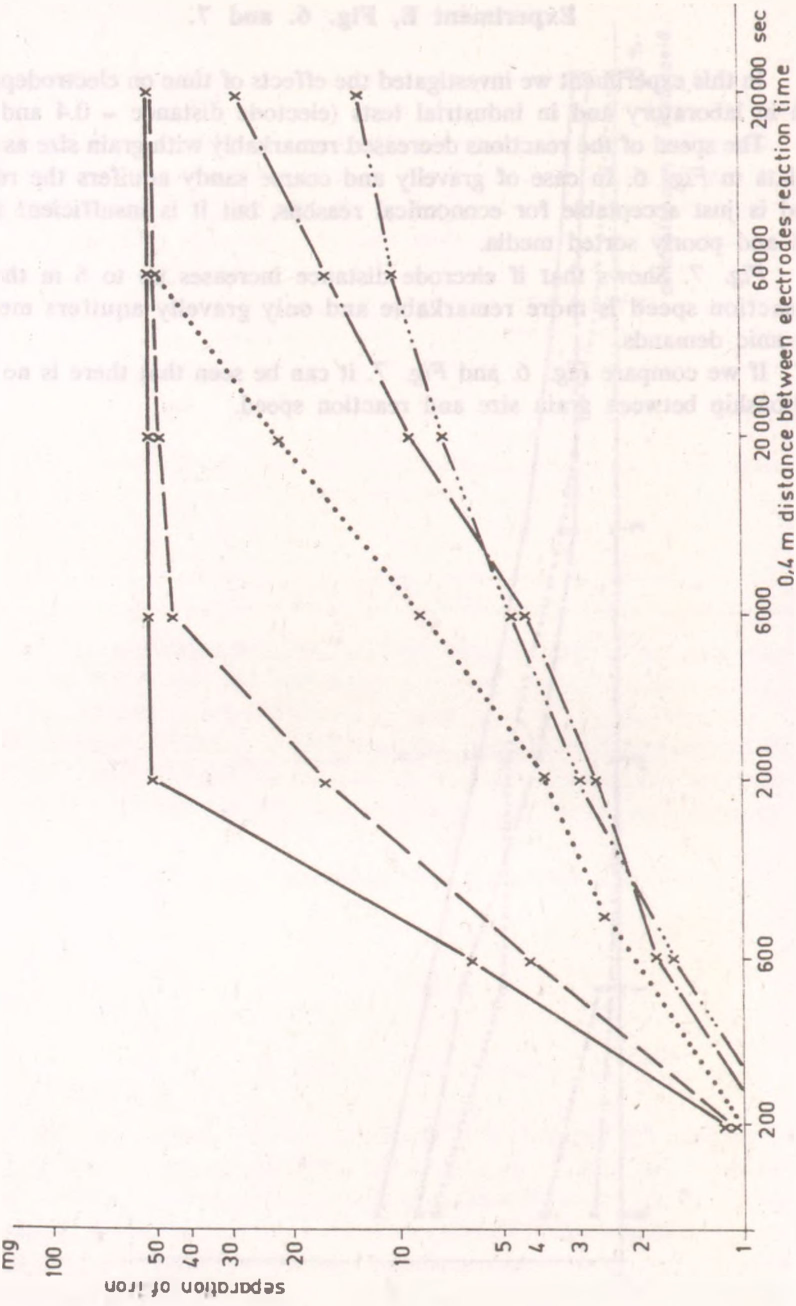


Fig. 6. Connection between reaction time and separation of iron

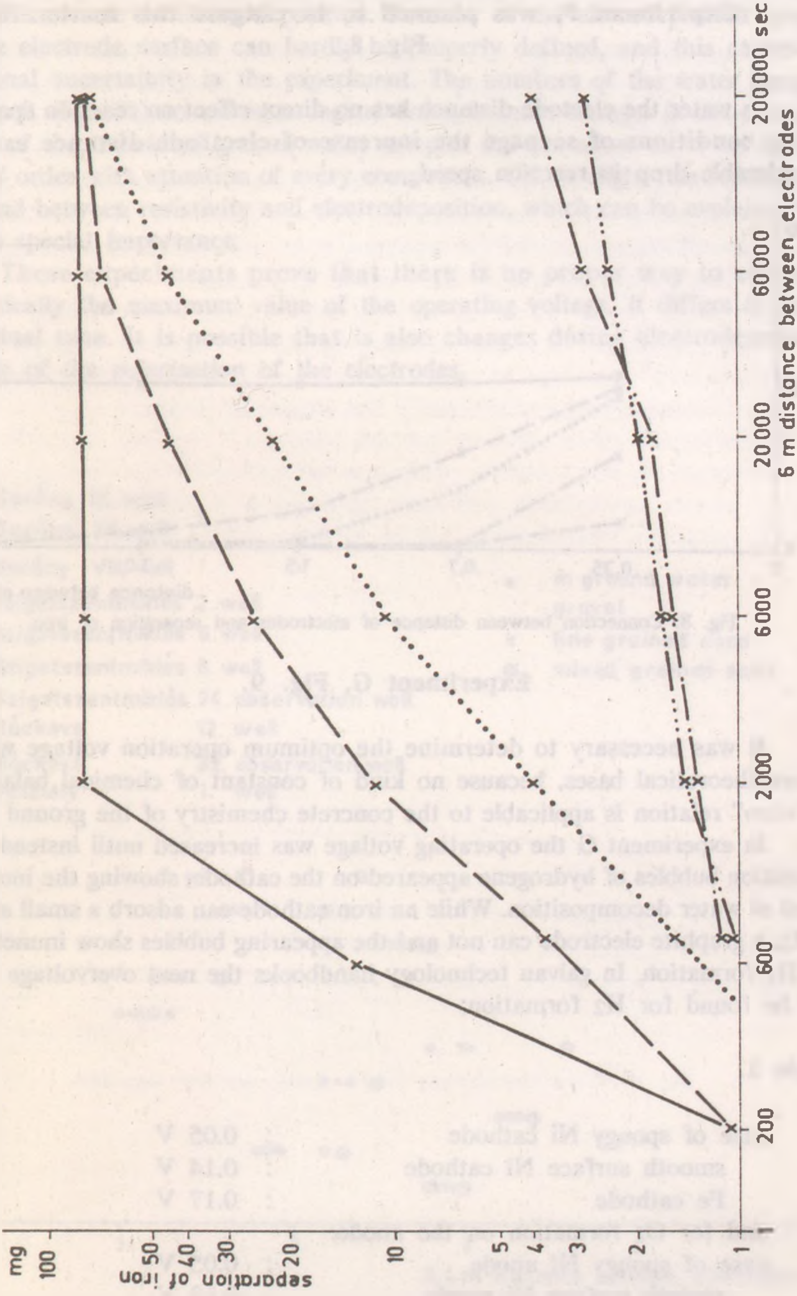


Fig. 7. Connection between reaction time and separation of iron

Experiment F, was planned to investigate this matter.
Fig. 8.

In water the electode distance has no direct effect on reaction speed but in the conditions of seepage the increase of electrode distance causes a considerable drop in reaction speed.

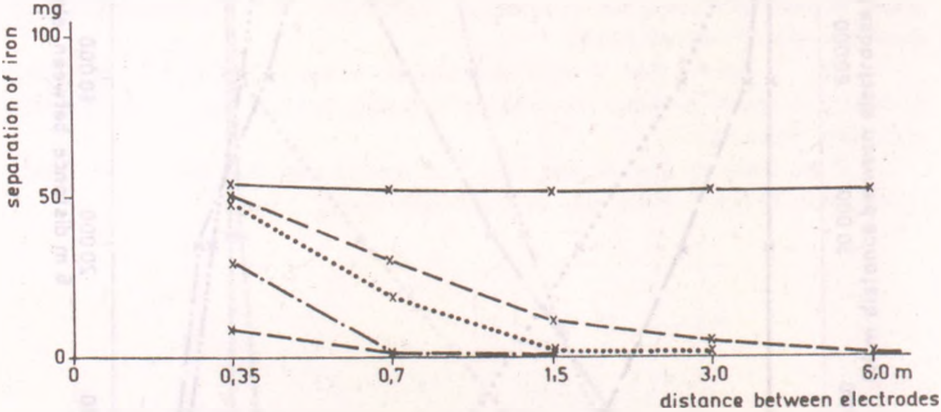


Fig. 8. Connection between distance of electrodes and separation of iron

Experiment G, Fig. 9.

It was necessary to determine the optimum operation voltage without proper theoretical bases, because no kind of constant of chemical balance or "in vitro" relation is applicable to the concrete chemistry of the ground water.

In experiment G the operating votlage was increased until instead of Fe deposition bubbles of hydrogene appeared on the cathode, showing the increased speed of water decomposition. While an iron cathode can adsorb a small amount of H_2, a graphite electrode can not and the appearing bubbles show immediately the H_2 formation. In galvan technology handbooks the next overvoltage values can be found for H_2 formation:

Table 1.

case of spongy Ni cathode : 0.05 V
smooth surface Ni cathode : 0.14 V
Fe cathode : 0.17 V
and for O_2 formation on the anode:
case of spongy Ni anode : 0.05 V
smooth surface Ni anode : 0.12 V
Fe anode : 0.24 V

Data, shown in Table 1, indicate that the surface of the electrodes play a significant role in electrodeposition. Because of the elctrodeposited spongy Fe, the electrode surface can hardly be properly defined, and this causes an additional uncertainity in the experiment. The numbers of the water samples on *Fig. 9.* (I. to X.) do not mean logical order, because changes in the chemical nature of the individual ground water samples did not allow us to set up any kind of order with attention of every component. Only a slight relationship can be found between resistivity and electrodeposition, which can be explained but has no special importance.

These experiments prove that there is no proper way to estimate theoretically the maximum value of the operating voltage, it differs in every individual case. It is possible that is also changes during electrodeposition because of the polarisation of the electrodes.

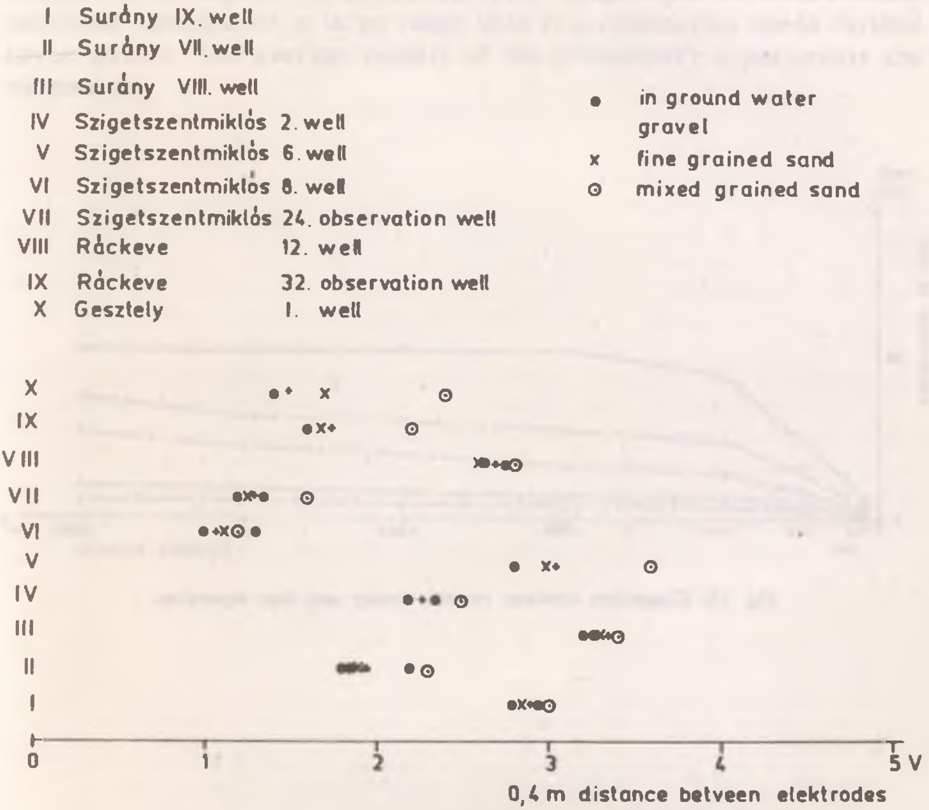


Fig. 9. Operating voltage at the different samples

Experiment H, Fig. 10.

In galvan technology current density defines the quality of electrically deposited metal, so in plating baths it is always kept constant. When elecrodeposition is used for the elimination of the Fe and Mn content of ground waters, only the amount of the deposited metal is important. The next series of experiments were done to determine the optimum value of current density. The next problem, which has already been mentioned, was that the electrode surface is well defined only at the beginning of the experiment and the deposited more or less spongy Fe makes the surface undefinable.

To avoid this problem the time of experiments was reduced.

Fig. 10. proves that current density has no optimum level but above 2000–3000 A/m^2 the slope of the curve decreases, which can be evaluated as the point of the maximum efficiency for industrial tests.

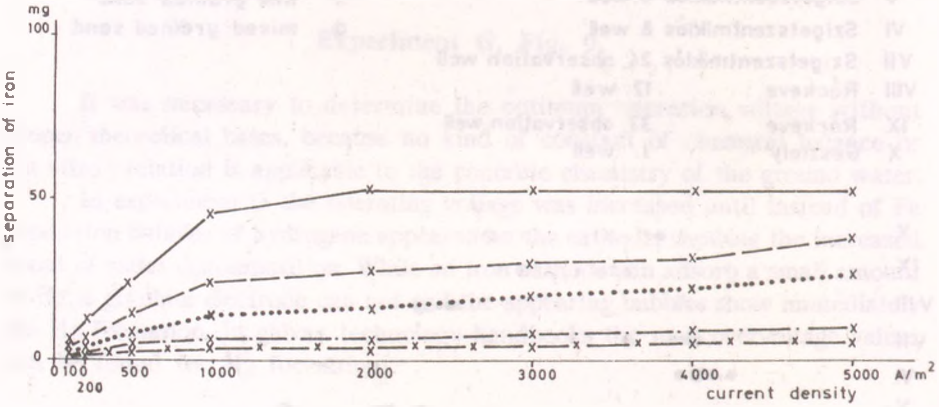


Fig. 10. Connection between current density and iron separation

Experiment I, Fig. 11.

As previous experiments let is suppose the "in situ" application of the electrolysis alone is not economical. In the next experiment electrolysis was combined with the batch-type "sub-terra" method.

There are several ways to express the efficiency of the "sub-terra" method, in this case the rate of the produced and recharged oxygene-rich water seemed to be the best. *Fig. 11.* shows that the producing/recharging rate improved remarkably, and this fact suggests further economical calculations.

Experiment J,

As there are continuous in situ Fe-Mn elimination methods too, an experiment was planned to combine the two methods under the conditions of seepage. As the required equipment was rather complex and the measurements scattered within such a large range that this application needs further investigation. The average results of the preliminary experiments are encouraging.

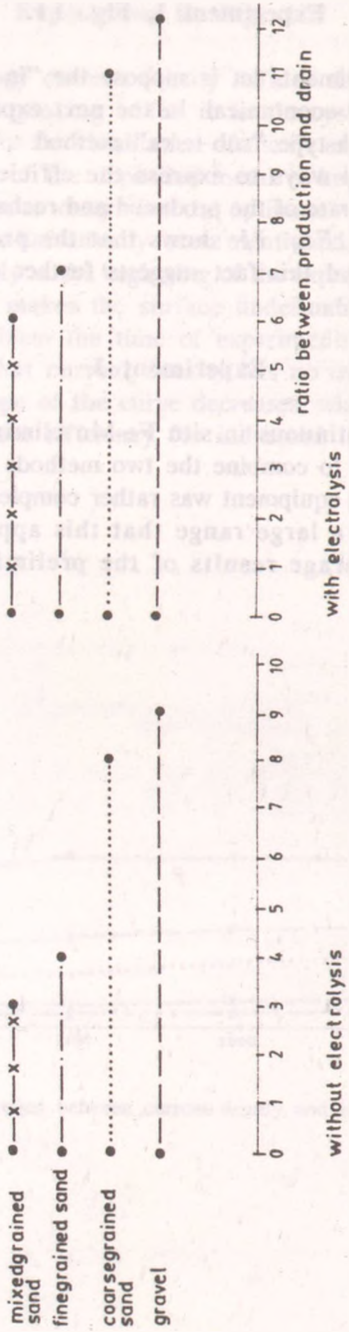


Fig. 11. Ratio of production and drain at different granulometric compositions

Conclusions

The efficiency of the above described cathodic metal deposition method is proportional to grain size and porosity, and varying within a range of 20-90%. Compared with other "in situ" Fe-Mn elimination methods, both the factors working against efficiency (clay minerals, humin acid content), and their effects are the same.

When estimating the required depositional voltage several individual experiments have to be done because of the complexity of numerous influencing factors. The range of the optimal current density is within 2000–3000 A/m^2. Electrolysis can be economical only as a complementary of the "sub-terra" batch-type "in situ" Fe-Mn eliminiation method. The combined use of electrolysis and "sub-terra" methods needs further testing. The anodic processes also require a detailed investigation because this side process should also increase the efficiency of the method.

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GROUPING GEOLOGICAL SAMPLES WITH MATHEMATICAL METHODS

by

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Abstract of doctoral thesis accepted by Eötvös University, Budapest
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(Received: 23rd February, 1989)

The dissertation consists of two parts. The first is essentially methodological. It contains short descriptions of the most important multivariate methods used for clustering geological samples (cluster analysis, ANDREWS function plot, principal component analysis, principal coordinates analysis, ZAHN's graph-theoretical method, correspondence analysis, non-linear mapping, non-metric multidimensional scaling, Q-type factor analysis, RODIONOV's automatic clustering, eigenvector biplot, special graphic representations, variation diagrams) and their comparison and evaluation in respect to their possibilities in geology. Then a sort of analysis of the relevant (to clusteing) properties of geoscience data (like cluster-structures of great complexity, variables of different types etc.) is given. The concept of *clusters derived from one another* is introduced and investigated. It is pointed out that in geological researches on often encounters groups, classes or types of objects that, as results of successive stages of one or more processes, can be originated one from another. At last, a *data analysing strategy* for processing geolgoical data is developed: applying hierarchical agglomerative cluster analysis and nonlinear mapping jointly for detecting incorrectly classified samples, erroneous groupings, outliers, well-separated, touching, derived from one another and of special form clusters.

The second part comprises four studies of real geolgoical questions using the data analysing strategy developed in the first part. In the first one, petrochemical types (alkaline-rich, K-rich, Mg-rich and average types) of

Transdanubian young alkaline basalts are revealed and for their interpretation a Mg-rich-average-K-rich differentiation trend is proposed. In the second, the Árpádtető (Mecsek-Mts.) *Coenothyris vulgaris* (SCHLOTHEIM) (an Anisian Brachiopoda-species) shells are investigated and existence of three morphotypes (Alpine, German, juvenile) is proved. The third one states and shows that the granite-pluton of the Velence Mts. is petrochemically rather uniform with a slightly more homogeneous and basic central part. In the fourth study lithochemical-lithogenetic types of karst bauxites from Németbánya and a formation-controlled variation in their compositions are showed.

It is stressed that in geological scientific researches only little-automized, expert-controlled clustering can lead to good results.

As a non-primary part of the theses, some written by the author FORTRAN 77 source program listings, including cluster-analysis methods and non-linear mapping, are also given.

MTA Könyvtára
Periodika 1993/903

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Felelős vezető: Arató Tamás
ELTE 92166

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