Magyarhoni Földtani Társulat
Földtani Közlöny
Hungarian Geological Society

151/3, 275–305., Budapest, 2021

DOI: 10.23928/foldt.kozl.2021.151.3.275

Various marginal marine environments in the Central Paratethys: Late Badenian and Sarmatian (middle Miocene) marine and non-marine microfossils from Pécs-Danitzpuszta, southern Hungary

Szuromi-Korecz, Andrea[1], Magyar, Imre[2,3], Sztanó, Orsolya[4], Csoma, Vivien[5], Botka, Dániel[1,5], Sebe, Krisztina[6], Tóth, Emőke[5]

[1]Laboratories MOL, MOL Hungarian Oil and Gas Plc., Budapest; kaszuroka@gmail.com, botkadani@gmail.com, ORCID: 0000-0002-6627-4640
[2]MOL Hungarian Oil and Gas Plc., 1117 Budapest, Október huszonharmadika u. 18, Hungary; immagyar@mol.hu, ORCID: 0000-0002-9236-0040
[3]MTA-MTM-ELTE Research Group for Paleontology, Budapest, Hungary
[4]ELTE Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/c; orsolya.sztano@ttk.elte.hu, ORCID: 0000-0003-0786-3653
[5]Department of Palaeontology, ELTE, Budapest; csoma.vivien7@gmail.com, ORCID: 0000-0002-2593-5537; tothemoke.pal@gmail.com; ORCID: 0000-0002-1733-7828
[6]University of Pécs, Department of Geology and Meteorology, 7624 Pécs, Ifjúság útja 6, Hungary, sebe@gamma.ttk.pte.hu, ORCID: 0000-0002-4647-2199

Késő badeni és szarmata (középső miocén) mikrofosszíliák Pécs-Danitzpusztáról

Összefoglalás

A Középső-Paratethys középső miocén foraminifera és kagylósrák együttesei általában stabil normál tengeri viszonyokat tükröznek a badeniben, míg térben és időben változatosabb, mozaikos környezeteket a szarmatában. A pécs-danitzpusztai homokbányában kiásott kutatóárokban 17 méter vastagságban tárult fel a tektonikusan kibillentett középső miocén rétegsor, amely jelentős környezeti változásokról tanúskodik a késő badeni és a pannóniai között. A rétegsor alján normál tengeri, sekélyvízi, meleg, jól szellőzött, aránylag nagy energiájú, mikrobaszőnyeges aljzatú környezetre utalnak a mészkő-, márgarétegek mikrofosszíliái. A foraminiferák alapján ezek a rétegek a késő badeniben (13,82 és 12,65 millió év között) rakódtak le. A szelvény középső szakaszán a tengeri rétegeket mikrofosszília-mentes, gravitációsan áthalmozott durva homok-breccsa, aleurolit váltakozásából álló sorozat követi, amelyben valószínűleg szárazföldi kitettségre utaló gyökérbekérgezéseket is találtunk. A következő tengerelöntés éles kőzettani váltás mellett a szelvény felső részéből kinyert mikrofosszíliák alapján a késő szarmatában történt, kb. 12 és 11,6 millió év között. Ezek a rétegek a felső szarmata *Porosononion granosum* zónát (foraminiferák) és *Aurila notata* zónát (kagylósrákok) képviselik. Az együttesek kizárólag tágtűrésű fajokból állnak, és változó só-, oxigén- és tápanyagtartalmú, növényzettel rendelkező, brakkvízi tengeri környezetet jeleznek. Az 5 m vastag felső szarmata egységben néhány rétegből, amelyek együttesen egy métert képviselnek, édesvízi vagy legfeljebb oligohalin kagylósrákfauna és kivételesen tág sótűrésű foraminiferák kerültek elő. Az együttesek megváltozását nem kíséri jelentős litológiai váltás, nincs jele megnövekedett szárazföldi eredetű behordásnak, amely egy közeli folyótorkolatot jelezne. Sem a késő szarmata geomorfológiai viszonyok, sem a kőzetminőség nem utal a tengertől részben elzárt környezet (lagúna, parti mocsár) kialakulására. A helyi viszonyokon túlmutató tényezők (pl. az éghajlat változása) nagyobb területen is megfigyelhető lenne, ilyen adatokkal azonban nem rendelkezünk. A tágtűrésű foraminiferák és édesvízi-oligohalin kagylósrákok megjelenése mindenesetre helyben vagy a közelben élő közösségre utal, és így a helyi alacsony (5–10 ‰) sótartalmat jelzi. Ilyen közösséget más szarmata szelvényből a Középső-Paratethys területén eddig nem ismertünk. A szelvény tetején a foraminiferák hirtelen eltűnése és ezzel egy időben a kagylósrákfauna teljes kicserélődése a szarmata és pannóniai emeletek határát jelöli ki (11,6 millió év).

Kulcsszavak: Középső-Paratethys, Mecsek, foraminifera, kagylósrák, taxonómia, biosztratigráfia, paleoökológia

Abstract

The middle Miocene foraminifera and ostracod record of the Central Paratethys usually reflects stable normal marine depositional environments for the Badenian and more patchy, less stable restricted marine environments for the Sarmatian. A 17 m thick outcrop at Pécs-Danitzpuszta, Mecsek Mts, SW Hungary exposed an upper Badenian to Pannonian succession where foraminifers and ostracods document significant environmental changes. The basal layers of the section contain micro- and macrofossils indicating normal marine, shallow, warm, well-oxygenated habitat with relatively high-energy conditions and algal vegetation on the bottom, and represent the upper Badenian (13.82 to 12.65 Ma). The marine deposits are followed by coarse sandstone, breccia and siltstone layers barren of microfossils but containing rhizoliths. The sediments were probably subaerially exposed for some time. The following marine inundation, marked by the appearance of clays and limestones as well as fossils, was dated to the late Sarmatian (ca. 12 to 11.6 Ma) on the basis of the restricted marine microfossil assemblages from the upper part of the succession (*Porosononion granosum* Zone, *Aurila notata* Zone). This community is characterized by exclusively eurytopic forms indicating an unstable and vegetated marginal marine environment with fluctuations in salinity, as well as oxygen and food availability. Within the 5 m thick upper Sarmatian marine interval, a unique fresh- to oligohaline fauna characterizes a few layers in less than 1 m thickness. This fauna consists of highly euryhaline foraminifera and freshwater to oligohaline ostracod assemblages, indicating a temporary salinity reduction to 5–10 ‰. No similar freshwater fauna has been reported from the Sarmatian of the Central Partethys so far. The eventual disappearance of the foraminifera from the paleontological record coupled with a complete turnover in the ostracod fauna indicates the transition from the marginal marine Sarmatian Sea to the brackish Lake Pannon, marking the Sarmatian/Pannonian boundary (11.6 Ma).

Keywords: Central Paratethys, Mecsek Mts, Foraminifera, Ostracoda, taxonomy, biostratigraphy, paleoecology

Introduction

The distribution of marine microorganisms in an epicontinental sea is driven by the local and regional changes of environmental conditions such as salinity, water temperature, oxygen-level, food availability, substrates, and water depth. These environmental conditions and the evolution of the microfauna were controlled by the openings and closures of the seaways towards the adjacent seas and the world ocean in the Paratethys, an epicontinental sea of central and eastern Europe during the Oligocene and Miocene (Rögl 1998, Popov et al. 2004). The connection toward the Mediterranean Sea was terminated due to the uplift of the Dinarides at the Badenian/Sarmatian boundary, triggering an endemic evolution of the marine faunas in the Paratethys (e.g., Palcu et al. 2015). The seaway towards the Indopacific was closed in the late Sarmatian, eliminating the last Indo-Pacific planktonic elements that were detected in the Transylvanian Basin (Filipescu & Silye 2008). All of these changes might have influenced the biota at the study area in SW Hungary.

The present study focuses on the taxonomy and paleoecological and biostratigraphical interpretation of foraminifer and ostracod communities from a middle Miocene succession exposed in an exploratory trench in the Pécs-Danitzpuszta sand pit, Mecsek Mts, SW Hungary. Earlier studies of middle Miocene foraminifera in Hungary (Báldi 1999, 2006; Báldi et al. 2002; Báldi 2006; Görög 1992; Korecz-Laky 1964, 1965, 1968, 1973, 1982; Korecz-Laky & Nagy-Gellai 1985; Tóth & Görög 2008) showed the wide distribution of the normal marine Badenian and restricted marine (brackish and hypersaline) Sarmatian faunas, which are well-known in the entire Central Paratethys. The study of Sarmatian ostracods resulted in a biostratigraphic system for the entire Pannonian Basin (Tóth 2004, 2008), whereas Badenian ostracods from Hungary have not been studied yet. By investigating the Pécs-Danitzpuszta micropaleontological record, we give the first documentation of Badenian ostracods from Hungary and also describe a so far unknown upper Sarmatian non-marine ostracod assemblage.

Geological setting

The Pécs-Danitzpuszta sand pit lies in the eastern outskirts of Pécs, at the foot of the Mecsek Mts (*Figure 1*). The region north of the sand pit is built up of Mesozoic rocks, mostly Lower Jurassic marls and sandstones, overlain by a succession of lower to middle Miocene terrestrial clastics and middle Miocene marine clastics and carbonates (Sebe et al. 2015, 2019; Sebe et al. 2021). These are capped by upper

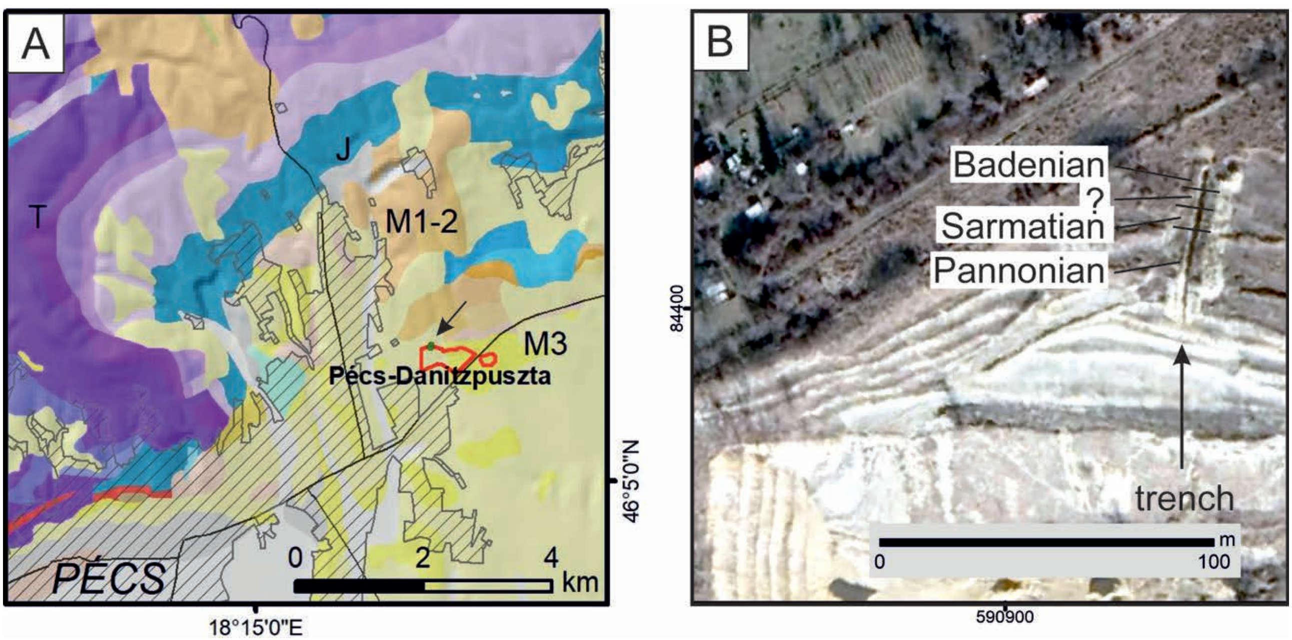


Figure 1. Location of the Pécs-Danitzpuszta sand pit (A) and the exploratory trench (B)
1. ábra. *A pécs-danitzpusztai homokbánya (A) és a kutatóárok (B) elhelyezkedése*

Miocene (Pannonian) marls and sands, exposed in many outcrops around the Mecsek. The boundary between Sarmatian and Pannonian deposits is continuous in (sub)basin centres, while they are separated by an unconformity with increasing hiatus towards the margins. Similar, but several km thick Neogene successions were reported from the Drava Basin to the south and southwest (SAFTIĆ et al. 2003; SEBE et al. 2020) reflecting the opening and evolution of the Pannonian Basin, flooding by the Paratethys sea and later by the brackish Lake Pannon.

Material and methods

Studied section of Pécs-Danitzpuszta sand pit

The sand pit exposes strongly tilted upper Miocene (Pannonian) calcareous marls and sands. In 2018, an exploratory trench was excavated in the northwestern part of the sand pit across the tilted beds that underlie the exposed Pannonian marl (*Figure 1*). The trench revealed the lowermost part of the Pannonian succession and the underlying Sarmatian and Badenian deposits. Due to tectonic deformation, most of the exposed succession is overturned, and the stratigraphically lowest (oldest) layers are located in the north (SEBE 2021). Overturned beds become steeper towards the south (upsection) and they are almost vertical close to the southern end of the trench. The oldest part of the studied section is represented by yellowish white calcareous marl (Layer D72) in the northern end of the trench (*Figures 2, 3*). It contains a typical Badenian mollusk fauna and belongs to the Lajta Formation (SEBE et al. 2021, DULAI et al. 2021). D71 also shows features typical of the Lajta Limestones: it is a sandy limestone with corallinacean algae, echinoids, abundant molluscs, and sporadic fish remains (DULAI et al. 2021, SEBE et al. 2021, SZABÓ et al. 2021). The following beds (D70 to D57) did not provide stratigraphically valuable fossils; thus, their age is uncertain (*Figure 2*). These are unconformably overlain by a ca. 5 m thick unit of alternating thin clay, marl and limestone beds (layers D56–D36), identified as the Sarmatian Kozárd Formation based on its fossil content and lithology (SEBE et al. 2021).

Micropaleontological samples and methods

Fifteen middle Miocene samples from the trench were studied for their foraminiferal and ostracod content (*Figures 2, 3*). The samples derived from soft sediments (about 200 g of air-dried clayey, sandy and marly sediments) were processed with hydrogen-peroxide (10%). Hard limestones and calcareous marls were examined in thin sections, or the samples were treated by acetolysis following a protocol originally worked out by LETHIERS & CRASQUIN-SOLEAU (1988) to extract the isolated carbonate skeletal microfauna. The applied extraction methods and the frequency of the extracted fossil groups from the studied layers are summarized in *Figure 4*.

Thirteen samples yielded interpretable microfossil content; D57 and D69 were free of microfossils (*Appendix*). The microfossils were determinated using a Zeiss SteREO Discovery.V12 modular binocular stereo microscope in the Laboratory of MOL Plc., Budapest. Thin sections were prepared in the Laboratory of MOL Plc., Budapest and they were investigated with a Zeiss Axio Imager.A1 polarizing microscope. Microscopic images were taken by a Zeiss AxioCam MRc 5 camera, mounted on the Zeiss microscope, using the AxioVision 40×64 v.4.9.1.0 software. The SEM images were taken at the Botanical Department of the Hungarian Natural History Museum in Budapest.

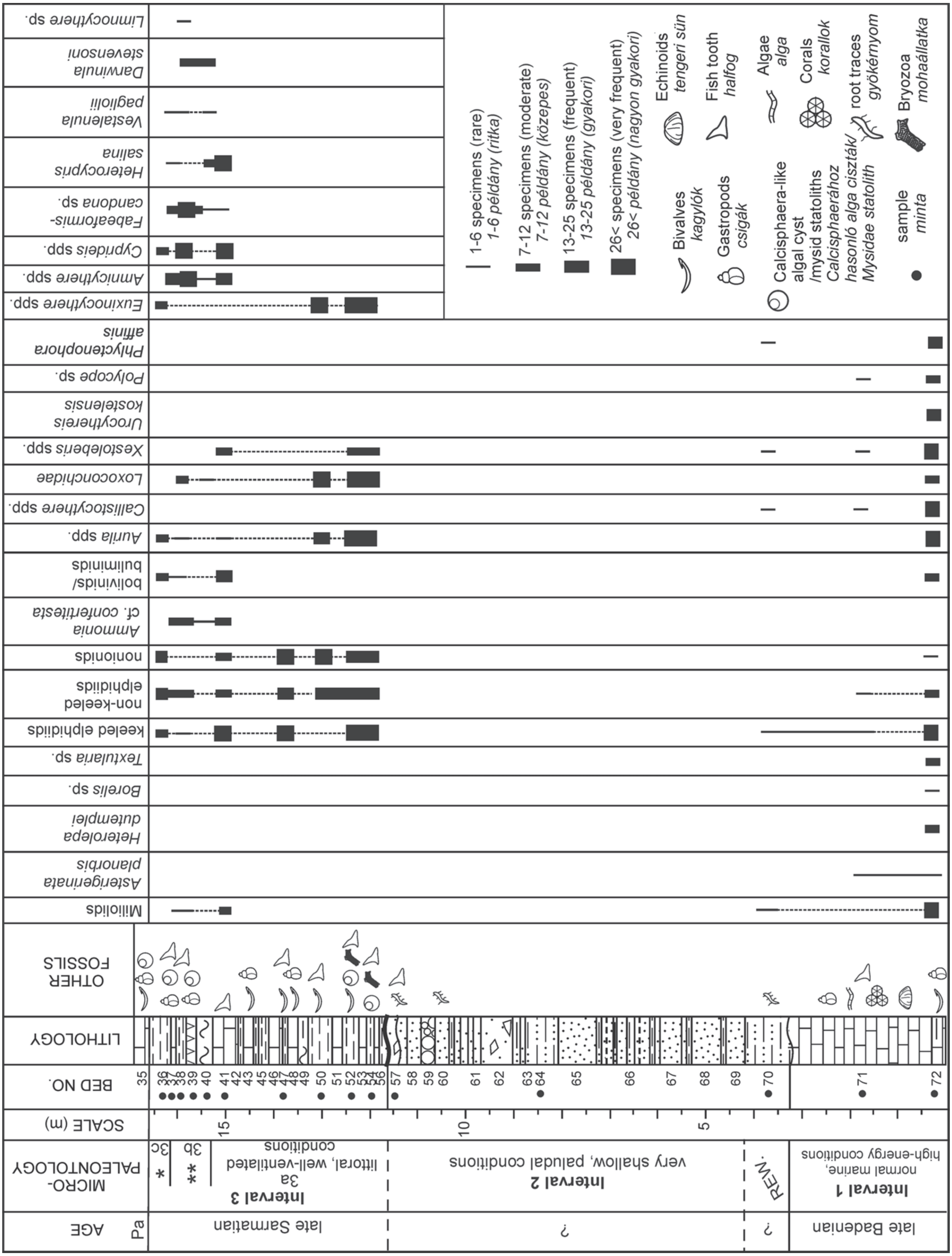
Results

Relatively diverse and well-preserved benthic foraminiferal and ostracod assemblages were found in the studied middle Miocene beds. Altogether, 30 foraminifer and 32 ostracod taxa were identified (see *Appendix* and *Digital annex*). The foraminifera specimens are moderately to well-preserved, except for layers D70 and D71, where they were probably affected by transport of the tests and/or diagenetic processes. The ostracod specimens are disarticulated valves in most cases; however, a few carapaces also occur. The ostracod material is characterized by both adult and juvenile forms.

The oldest layer (D72) yielded the most diverse and abundant microfossil assemblage. Twenty-one foraminifera and 11 ostracod taxa were identified (*Figure 2, Plate I*). The foraminiferal assemblage was dominated by eurytopic taxa of keeled elphidiids (*Elphidium aculeatum, E. crispum,* and *E. macellum*) and miliolids (*Borelis* sp., *Cycloforina contorta*, *Affinetrina ucrainica, Miliolinella selene,* and *Quinqueloculina hauerina*). The ostracod fauna is characterized by the dominance of marine neritic taxa, such as *Aurila cicatricosa, Callistocythere canaliculata,* and *Phlyctenophora arcuata. Urocythereis kostelensis*, *Loxoconcha punctatella, Loxocorniculina hastata, Xestoleberis dispar*, and *Polycope* sp. also occur in low abundance. Besides foraminifers and ostracods, sample D72 also yielded significant amounts of echinoderm skeletal and spike fragments.

The microfossil assemblages of layers D70 and D71 were similar to, but significantly poorer than, that of D72. Poor preservation of the carbonate skeletons allowed only genus level determination in most cases (*Xestoleberis* sp., *Callistocythere* sp., *Polycope* sp., and *Elphidium* sp.). Echinoderm fragments were also more sporadic than in sample D72. The microfossils of layer D70 are probably reworked based on the scarcity and poor preservation of the specimens, although a diagenetic effect cannot be excluded either.

The soft sediments of layers D54 to D41 yielded a less diverse (5–10 taxa), well-preserved foraminifer and ostracoda fauna (*Figure 2, Plates II–III*). Among the foraminifera, exclusively eurytopic forms (taxa with wide environmental tolerance) were present. Keeled elphidiids with an acute periphery, sometimes equipped with spines, were the most common (e.g., *Elphidium aculeatum*, *E. macellum*, *E. obtu-*



AGE
late Badenian
?
late Sarmatian
Pa
MICRO-PALEONTOLOGY
Interval 1
normal marine, high-energy conditions
REW.
Interval 2
very shallow, paludal conditions
Interval 3
3a
littoral, well-ventilated conditions
3b
3c
SCALE (m)
BED NO.
LITHOLOGY
OTHER FOSSILS
Miliolids
Asterigerinata planorbis
Heterolepa dutemplei
Borelis sp.
Textularia sp.
keeled elphidiids
non-keeled elphidiids
nonionids
Ammonia cf. confertitesta
bolivinids/ buliminids
Aurila spp.
Callistocythere spp.
Loxoconchidae
Xestoleberis spp.
Urocythereis kostelensis
Polycope sp.
Phlyctenophora affinis
Euxinocythere spp.
Amnicythere spp.
Cyprideis spp.
Fabeaformis-candona sp.
Heterocypris salina
Vestalenula pagliolii
Darwinula stevensoni
Limnocythere sp.
1-6 specimens (rare)
1-6 példány (ritka)
7-12 specimens (moderate)
7-12 példány (közepes)
13-25 specimens (frequent)
13-25 példány (gyakori)
26< specimens (very frequent)
26< példány (nagyon gyakori)
Bivalves
kagylók
Gastropods
csigák
Calcisphaera-like algal cyst /mysid statoliths
Calcisphaerához hasonló alga ciszták/ Mysidae statolith
sample
minta
Echinoids
tengeri sün
Fish tooth
halfog
Algae
alga
Corals
korallok
root traces
gyökérnyom
Bryozoa
mohaállatka

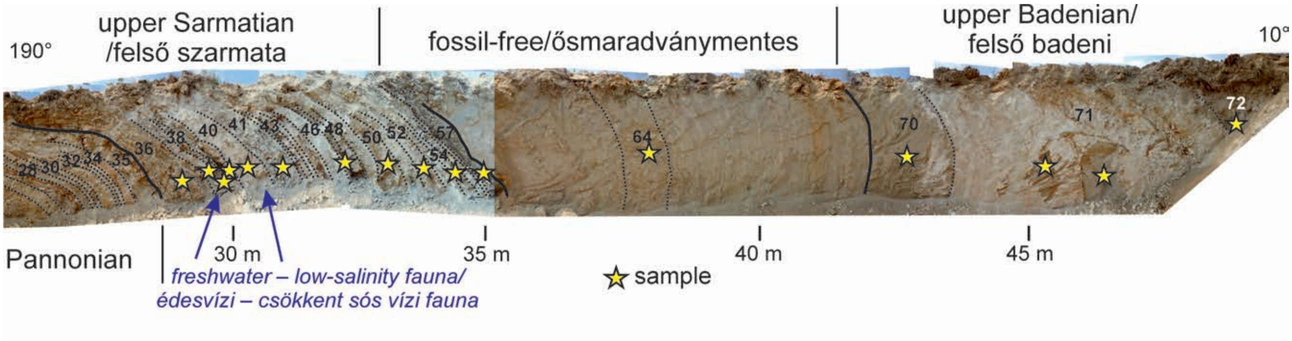


Figure 3. The northern part of the exploratory trench exposes overturned middle Miocene (D72 to D36) and stratigraphically overlying Pannonian (D35 to D28) layers. Sampling locations are indicated by yellow stars

3. ábra. *A kutatóárok északi része, mely az átbuktatott középső miocén (D72 – D26) és a pannóniai rétegeket (D35 – D28) tárja fel. A sárga csillag jelzi a mintavételi helyeket*

sum, and *E. crispum*). Among the non-keeled elphidiids, where the periphery of the tests is rounded or bluntly angular, specimens of *Porosononion granosum* were abundant. The ostracod fauna was characterized by different species of the genera *Aurila*, *Loxoconcha* and *Euxinocythere* (e.g., *Aurila notata, Loxoconcha kochi*, *L. porosa,* and *Euxinocythere [Euxinocythere] praebosqueti*). Specimens of *Xestoleberis tumida* are also present in the samples.

In layers D40 to D37, mainly specimens of the infaunal, non-keeled elphidiid *P. granosum* and *Ammonia* sp. were found (*Figure 2*). Beside the sporadic occurrence of marginal marine ostracods (e.g., *Loxoconcha porosa* and *Aurila* sp.), non-marine, freshwater to oligohaline ostracods, like *Fabaeformiscandona* sp., *Heterocypris salina, Darwinula stevensoni,* and *Vestalenula pagliolii* are present in the recovered assemblages.

Layer D36 is characterized by the dominance of eurytopic non-keeled elphidiids and nonionids and the representatives of leptocytherid *Euxinocythere* (*E. [E.] praebosqueti* and *E. [E.] naca*) (*Plate II*).

Discussion

Biostratigraphy

Benthic foraminifera are instrumental in the biostratigraphy of the middle Miocene sediments of the Central Paratethys, because the best index fossils, such as planktonic foraminifers and nannoplankton, are commonly missing from the fossil record, especially in the coastal regions (*Figure 5*).

← **Figure 2.** Sedimentary log of the middle Miocene part of the Pécs-Danitzpuszta succession, with sample locations, micropaleontological intervals and subintervals based on the stratigraphic distribution and ecological needs of the studied microfossil assemblages and the distribution of the paleoecologically important foraminifer and ostracod taxa and morphogroups in the samples
Abbreviation: Pa= Pannonian

← ***2. ábra.*** *A pécs-danitzpusztai homokbányában kiásott kutatóárok középső miocén szakaszának szelvénye a vizsgált minták feltüntetésével, a mikrofauna biosztratigráfiai és paleoökológiai értékelése alapján elkülönített intervallumokkal, valamint a környezetjelzés szempontjából fontos foraminifera és ostracoda taxonok, illetve morfocsoportok megoszlásával*
Rövidítés: Pa= pannóniai

A commonly used threefold subdivision of the Badenian in the Pannonian, Vienna and Danube basins is partly based on the composition of benthic foraminifers reflecting distinct paleoenvironmental changes (Papp et al. 1978). The lower Badenian is represented by the "Lagenidae Zone," the middle Badenian by the "*Spiroplectammina* Zone," and the upper Badenian by the "*Bulimina*/*Bolivina* Zone" (Grill 1943, Papp et al. 1978). Sarmatian sediments of the Pannonian, Vienna and Danube basins can be divided to four benthic foraminiferal zones: *Anomalinoides dividens*, *Elphidium reginum*, and *Elphidium hauerinum* Zones in the lower Sarmatian, and *Porosononion granosum* Zone in the upper Sarmatian (Grill 1943, Jiřiček 1972, Papp & Seneš 1974). For the Sarmatian of the Pannonian Basin, Tóth (2009) proposed a two-fold ostracod zonation: *Cytheridea hungarica*-*Aurila mehesi* Zone for the lower Sarmatian and *Aurila notata* Zone for the upper Sarmatian.

Layer D72 belongs to the upper Badenian based on the co-eval occurrence of *Pyrgo subsphaerica* (upper Badenian to recent) and *Miliolinella selene* (Badenian) among the foraminifera (Łuczkowska 1974). Some ostracods in these layers, such as *Urocythereis kostelensis* and *Phlyctenophora affinis,* are restricted to the Badenian (Gross & Piller 2006). Although the microfauna is dominated by eurytopic forms, normal marine taxa (e.g., *Callistocythere canaliculata* and *Heterolepa dutemplei*) also occur in these samples; they disappeared from the Central Paratethys at the end of the Badenian. Thus, the microfossil assemblages of layers D72 to D70 indicate late Badenian age, equivalent of the "*Bulimina*/*Bolivina* Zone" (13.82 to 12.65 Ma, according to Hohenegger et al. 2014 and Raffi et al. 2020), which correlates with the standard nannoplankton Zone NN6 (Rögl et al. 2008).

The presence of *Aurila notata* in layers D54 to D36 suggests correlation with the *Aurila notata* Zone (ca. 12 to 11.6 Ma). Several other taxa, such as *Euxinocythere* (*E.*) *praebosqueti, E.* (*E.*) *naca, Loxoconcha kochi* are also restricted to the upper Sarmatian in the Pannonian Basin (Tóth 2009). The foraminiferal assemblages are characterized by a great abundance of *Porosononion granosum* in almost all samples, indicating the *Porosononion granosum* Zone. This cor-

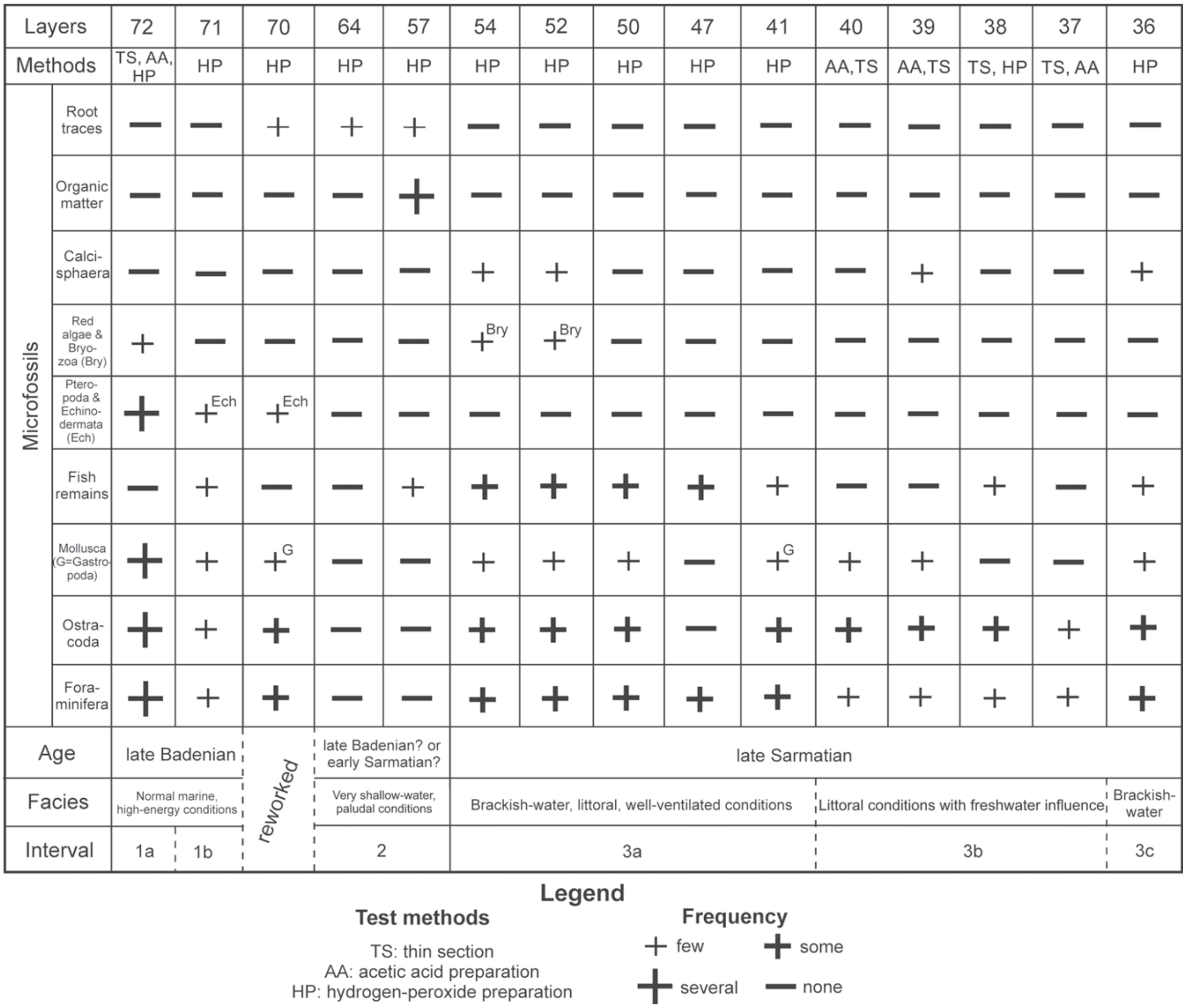


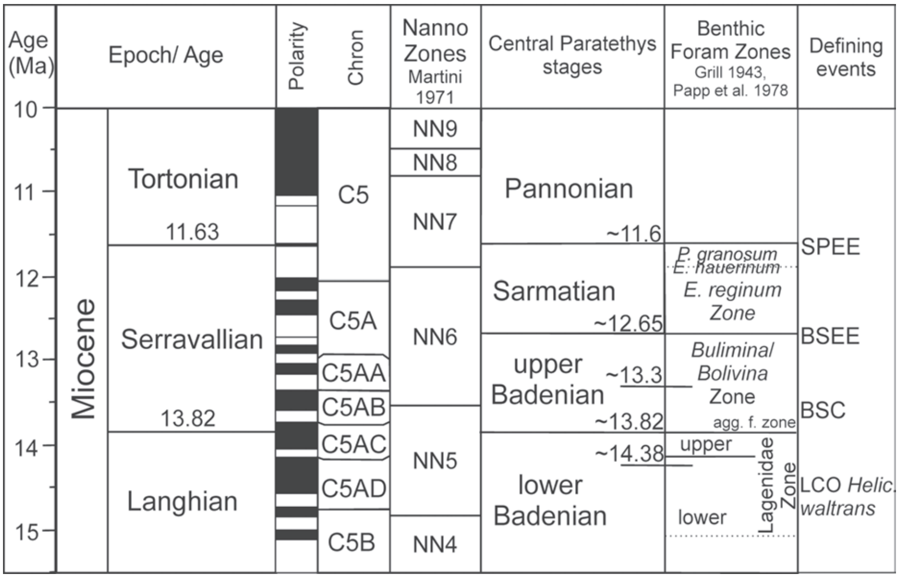
Figure 4. The extraction method of the studied layers and the frequency of the extracted fossil groups from the studied samples

***4. ábra.** Az egyes rétegek mintáinak mikropaleontológiai feltárási módszere, és a kinyert ősmaradványcsoportok gyakorisága a mintákban*

relates with the younger part of the *Aurila notata* Zone (TÓTH 2009). This biostratigraphic interpretation is in accordance with the nannoplankton zonation of the same layers (NN6 or younger, according to ĆORIĆ, 2021).

A sudden change in the microfossil assemblages can be observed between layers D36 and D35, indicating the Sarmatian/Pannonian boundary (11.6 Ma). Foraminifera are entirely missing from sample D35, and the ostracod faunas of the two samples are completely different, without any species in common. In D36, juvenile *Aurila notata* and *Cyprideis* sp. specimens, *Loxocorniculum hastatum*, *Euxinocythere* (*Euxinocythere*) *praebosqueti*, *E.* (*E.*) *naca*, and *Amnicythere tenuis* occur. In contrast, sample D35 is dominated by *Candona* and *Herpetocyprella* species. Calcisphaera-like large algal cysts and mysid statoliths (ballast stones of the shrimplike mysids; following the interpretation of VOICU 1981) are present in sample D35 in low abundance. These are characteristic fossils in strata near the S/P boundary at several locations in Hungary where it was not possible to precisely assign the boundary itself (e.g., KŐVÁRY 1974, BARDÓCZ et al. 1987). Mysids are very common in unanimously Sarmatian layers of the Transylvanian and Dacian Basins (e.g., POPESCU 1995).

Despite the sharp microfaunal change, no major shift can be observed in the lithofacies of the sediment. The mollusc assemblage of sample D35 contains abundant "Sarmatian-type" small-sized cardiids (BOTKA et al. 2021). This fauna, affected by the Lilliput Effect (HARRIES & KNORR 2009), is often related to environmental stress and has been published from the Sarmatian/Pannonian transition by several authors from different parts of the Pannonian Basin (e.g., Zsámbék Basin, Hungary, BOHN-HAVAS 1983; Lajoskomárom–1 well, Hungary, JÁMBOR et al. 1985; Medvednica Mts, Croatia, VRSALJKO 1999). Although the ostracod faunas of layers D36 and D35 are very different, and mollusks are missing from D36 while D35 shows the mass occurrence of tiny cardiid bivalves, it is not obvious if a short gap or continuous sedimentation occurred at the Sarmatian/Pannonian boundary.



Fiure 5. Middle to upper Miocene geochronology, geomagnetic polarity chrons, biozonations of calcareous nannoplankton and benthic foraminifers correlated to regional chronostratigraphy of the Central Paratethys with defining events (modified after HOHENEGGER et al. 2014 and RAFFI et al. 2020).

Abbreviations: BSC= Badenian Salinity Crisis, SPEE = Sarmatian–Pannonian Extinction Event, BSEE=Badenian–Sarmatian Extinction Event (after HARZHAUSER & PILLER 2007)

5. ábra. *Középső miocén rétegtani ábra radiometrikus koradatokkal, magnetosztratigráfiai és biosztratigráfiai (mészvázú nannoplankton, bentosz foraminifera) beosztással, illetve a Középső-Paratethysben lejátszódott meghatározó események feltüntetésével (HOHENEGGER et al. 2014 és RAFFI et al. 2020 után módosítva).*

Rövidítések: BSC= Badeni Sókrízis, SPEE = Szarmata/pannóniai kihalási esemény, BSEE= Badeni/szarmata kihalási esemény (HARZHAUSER & PILLER 2007 után)

Paleoecology

Ecological requirements of the extant relatives of the studied middle Miocene taxa

Extant representatives of keeled elphidiids live in temperate to warm, shallow marine (at water depths up to 50 m) environments (inner shelf) and hypersaline lagoons (MURRAY 1991, 2006). They are mostly epiphytic dwellers (live on plants) and prefer sandy sediment (LANGER 1993, MURRAY 2006). In the Mediterranean Sea, *E. aculeatum* and *E. macellum* live on arborescent algal vegetation (LANGER et al. 1998). They are chromatophore-bearing foraminifera and the "symbionts" may control the phototaxis and the depth distribution of the host organism. The chromatophores are pigment-containing cells that produce color. However, the nature of this symbiosis and the role of the chromatophores in phototaxis – the ability of organisms to move directionally in response to a light source – are poorly known. *E. macellum* is a common member of foraminiferal assemblages in the Black Sea living in the shallow sublittoral zone and coastal pools (down to 20 m depth) (TEMELKOV 2008). *Miliolinella* and *Quinqueloculina* are epiphytic or they cling on hard substrates in the inner shelf or in normal marine to hypersaline lagoons and marshes; they rarely can be found in deep-sea records (MURRAY 2006). Recent miliolids prefer waters rich in calcium carbonate (JORISSEN 1988). *Borelis* is a large, benthic foraminifera with photosynthetic diatom algal symbionts. The recent species are restricted to depths of 5–65 m in, for example, the Gulf of Aqaba, and to minimum sea-surface temperatures greater than 18 °C (REISS & HOTTINGER 1984, LANGER & HOTTINGER 2000). Non-keeled infaunal elphidiids are characteristic species of brackish to hypersaline marshes and lagoons; however, they can also be found in the inner shelf (water depth up to 50 m) (MURRAY 2006). *Ammonia* is widespread in marginal marine environments worldwide and is common in sediments with highly variable mud and organic matter contents, even at low oxygen levels in marsh environments (MURRAY 2006).

Among the ostracods, *Aurila* and *Urocythereis* recently live in great abundance in the infralittoral and uppermost circalittoral zone (water depth up to 40 m) of the Black Sea, the Mediterranean, the Eastern Atlantic, and the Indo-Pacific area (e.g., ATHERSUCH 1977, RUIZ et al. 1997, KILIÇ 2000, AIELLO et al. 2006, TANAKA 2008). Modern representatives of *Aurila*, *Xestoleberis,* and *Loxoconcha* species mainly live on algae or seagrasses (PURI et al. 1969). *Loxoconcha punctatella* and *Xestoleberis dispar* are found in neritic shallow sublittoral, littoral environments in the Mediterranean, Black and Marmara Seas (PERÇIN-PAÇAL et al. 2015). In the present-day Mediterranean Sea, *Xestoleberis dispar* is a phytal marine species, but it also occurs in hypersaline environments (SCIUTO et al. 2015, KOEHN-ZANINETTI & TÉTARD 1982). *Phlyctenophora* occurs in marginal marine estuarine, gulf and lagoonal environments in the Indo-Pacific Realm (WOUTERS 1999, HUSSAIN et al. 2004, MISHRA et al. 2019). Recent polycopids have a nektobenthic lifestyle and are found from abyssal ocean depths (KARANOVIC & BRANDÃO 2012, 2016) to less saline estuarine environments (TANAKA & TSUKAGOSHI 2010).

Recent *Euxinocythere,* similarly to *Aurila* and *Loxoconcha,* occur in shallow marine sublittoral and littoral environments in the Black Sea (PERÇIN-PAÇAL et al. 2015). The extant species *Heterocypris salina* and *Darwinula stevensoni* are cosmopolitan and are known from all continents. *Heterocypris salina* lives in saline coastal and inland water bodies coexisting with other halophilic ostracods and tolerate salinities up to 20‰ (MEISCH 2000). The modern species of *Darwinula* are mostly found in freshwater, although *D. stevensoni* also tolerates stable, brackish conditions in coastal waters (e.g., Baltic Sea) or saline lakes (NEALE 1988, VAN

DONINCK et al. 2003), and is reported to tolerate salinities as high as 15‰ (DE DECKKER 1981). Today, *Vestalenula pagliolii* occurs in Brazil, where it thrives in riverine pools and lakes, semiterrestrial and/or interstitial habitats and occurs in geographically restricted areas (MARTENS et al. 1997).

Paleoenvironments

Three main intervals were differentiated in the studied layers of Pécs-Danitzpuszta trench based on the stratigraphic distribution and ecological needs of the identified foraminifera and ostracod taxa, within which further subintervals were designated (*Figure 2*). The paleocological interpretations are based on the ecology of extant relatives of the studied taxa.

Interval 1 (sample D72) represents the upper Badenian, and it is characterized with the most diverse fossil assemblage within the sedimentary record (*Figure 2*). The dominance of keeled elphidiids and miliolids among the foraminifera and marine neritic genera (*Aurila, Callistocythere, Loxoconcha, Urocythereis, Phlyctenophora,* and *Xestoleberis*) among the ostracods suggests shallow marine, calcium-carbonate rich littoral environment (inner shelf) with water depths up to 50 m. Although several of the identified forms can live today in hypersaline lagoons as well, the high diversity of the microfauna excludes such environmental interpretation. The presence of the large benthic foraminifera *Borelis* in the assemblage indicates warm seawater, with temperatures higher than 18 °C (REISS & HOTTINGER 1984; LANGER & HOTTINGER 2000). Based on the great abundance of epiphytic dweller foraminifera taxa such as *E. aculeatum* and *E. macellum* and phytal ostracods (*Aurila, Loxoconcha* and *Xestoleberis*), a rich arborescent algal vegetation is supposed to have been present on the sea bottom. The keeled elphidiids are cromatophore-bearing foraminifers that must have lived in the euphotic zone with well-ventilated conditions. The abundance of thick-shelled ostracods, often with worn valves, and the abundance of echinoderm fragments indicate high energy conditions in the sea bottom. The red algal and bryozoan fragments also support this environmental interpretation.

Interval 2 (samples D69 and D57) yielded only one fish tooth. Carbonate-cemented cylinders around holes were interpreted as rhizoliths (root traces; *Figure 2*). The Fe-Mn encrusted unconformity on top of bed D57 and the appearance of fossiliferous clays, marls and limestones with upper Sarmatian marine microfossils above the unconformity denote a sharp change in the depositional environment, probably from terrestrial to marine.

Interval 3 (layers D54 to D36) belongs to the upper Sarmatian, suggesting that the area was re-flooded by the sea only during the late Sarmatian.

Subinterval 3a (samples D54 to D41) is characterized by exclusively eurytopic forms and lower diversity than in Interval 1 (*Figure 2*). The impoverishment of the marine faunal elements is explained by the Badenian-Sarmatian Extinction event (BSEE) caused by the final isolation of the Central Paratethys from the Mediterranean and coeval reconnection with the Eastern Paratethys (HARZHAUSER & PILLER 2007). Among the elphidiids, non-keeled forms (mainly the specimens of *Porosononion granosum*) appeared in great abundance due to the unstable environment, e.g., slight fluctuation in salinity or other factors such as food availability. The non-keeled infaunal elphidiids tolerate brackish to hypersaline conditions suggesting marginal marine depositional environments such as a lagoon or a hypersaline marsh. The disappearance of *Phlyctenophora* and *Urocythereis* and the dominance of *Euxinocythere* corroborate the marginal marine conditions. The abundance of the keeled elphidiids and phytal ostracods (*Aurila, Loxoconcha* and *Xestoleberis*) implies a rich vegetation on the substrate. The co-occurence of shallow infaunal non-keeled and epiphytic keeled elphidiids suggests mixed assemblages indicating a very differentiated seafloor.

In Subinterval 3b (samples D40 to D37) the faunal composition radically changed (*Figure 2*). The abundance and diversity of foraminifera and ostracoda decreased. Beside the non-keeled infaunal *Porosononion,* the specimens of *Ammonia* cf. *confertitesta* became dominant. *Ammonia* cf. *confertitesta* tolerates a wide range of salinity (10–50‰) and also occurs in non-marine foraminifera faunas (MURRAY 2006). The ostracod fauna is characterized by non-marine, freshwater to oligohaline ostracods, such as *Darwinula stevensoni*, *Heterocypris salina*, *Vestalenula pagliolii*, *Cyprideis* cf. *torosa*, *Fabaeformiscandona* sp., and *Limnocythere* sp. This microfossil assemblage indicates a sudden decrease in salinity (which is also supported by the mollusk fauna represented by *Radix, Gyraulus* and *Theodoxus* occurring without the brackish *Congeria* and cardiids). The interpretation of this phenomenon, however, remains a hard nut to crack. The lithology does not show any sign of increased terrestrial input that the proximity of a river mouth would cause, and the Sarmatian geomorphological position of the outcrop, reconstructed as a tip of a promontory protruding into a wide basin, does not support the idea of a freshened lagoon or coastal marsh either. A more regional cause of the salinity drop, such as a climate change, would have left its mark on the fossil record of a wider region, but we are not aware of such observations. Thus, what we can conclude is only that the euryhaline foraminifera and freshwater-oligohaline ostracods lived together in a brackish water (5–10 ‰ salinity) habitat.

In Subinterval 3c (sample D36), characteristic Sarmatian eurytopic taxa (non-keeled elphidiids, nonionids, and representatives of the leptocytherid *Euxinocythere)* replace the non-marine, freshwater-oligohaline species. The low diversity microfossil assemblage with the dominance of infaunal foraminifera (non-keeled elphidiids, nonionids, and bolivinids) and thin-shelled ostracods indicates low-oxygenated environment and/or higher organic content. The latter is supported by the nannoflora, suggesting increasing nutrient supply in this period (ĆORIĆ 2021).

Conclusions

The microfossil record of the middle Miocene sedimentary succession of Pécs-Danitzpuszta indicates significant environmental changes through the late Badenian–early Pannonian. The lowermost part of the section belongs to the upper Badenian, with typical Badenian faunal elements indicating stable, normal marine, shallow (inner shelf), warm, well-ventilated environment with relatively high-energy conditions and algal vegetation on the bottom. The overlying layers are devoid of marine microfossils and may indicate terrestrial deposition and subaerial exposure. Following an unconformity, the upper part of the middle Miocene succession belongs to the upper Sarmatian with two distinct biofacies. The lower part and the uppermost layer of the upper Sarmatian are characterized by exclusively eurytopic forms, indicating an unstable and vegetated marginal marine environment with fluctuations in salinity, as well as oxygen and food availability. The middle part of the upper Sarmatian, however, contains highly euryhaline forams and a unique freshwater to oligohaline ostracod fauna, indicating low salinity. Finally, the disappearance of foraminifera taxa and a complete turnover in the ostracod fauna indicates the boundary between the marginal marine Sarmatian and the brackish lacustrine Pannonian stages (11.6 Ma).

Acknowledgments

We thank Krisztina Buczkó (Botanical Department of the Natural History Museum, Budapest, Hungary) for her help in taking the SEM images. The research was financially supported by the Hungarian National Research, Development and Innovation Office (NKFIH) project 116618 and by Quartz Ltd., and further supported by the project EFOP 3.6.1-16-2016-00004 of the University of Pécs. This is MTA-MTM-ELTE Paleo contribution No 356.

References – Irodalom

Agalarova, D. A. 1967: *Mikrofauna ponticeskih otlozeni Azerbaidana i Sopregelunih Rajonov.* – Nedra, Leningrad, 420 p.

Aiello, G. & Szczechura, J. 2004: Middle miocene ostracods of the Fore-Carpathian Depression (Central-Paratethys, southwestern Poland). – *Bollettino della Societa Paleontologica Italiana* **43/1–2,** 11–70.

Aiello, G., Barra, D., Coppa, M. G., Valente, A. & Zeni, F. 2006: Recent infralittoral Foraminiferida and Ostracoda from the Porto Cesareo Lagoon (Ionian Sea, Mediterranean). – *Bollettino della Societa Paleontologica Italiana* **45/1,** 1–14.

Ismail, A. A., Boukhary, M. A. K. & Naby, A. I. A. 2010: Subsurface stratigraphy and micropaleontology of the Neogene rocks, Nile Delta, Egypt. – *Geologia Croatica* **63/1,** 1–26. https://doi.org/104154/gc.2010.01

Athersuch, J. 1977: The Genus *Urocythereis* (Crustacea: Ostracoda) in Europe, with particular reference to Recent Mediterranean species. Bulletin of the British Museum (Natural History). – *Zoology* **32/7,** 247–283.

Báldi, K. 1999: Taxonomic notes on benthic foraminifera from SW Hungary, Middle Miocene (Badenian) Paratethys. – *Acta Geologica Hungarica* **42/2,** 193–236.

Báldi, K. 2006: Paleoceanography and climate of the Badenian (Middle Miocene, 16.4–13.0 Ma) in the Central Paratethys based on foraminifera and stable isotope (^{18}O and ^{13}C) evidence. – *International Journal of Earth Sciences* **95/1,** 119–142. https://doi.org/10.1007/s00531-005-0019-9

Báldi, K., Benkovics, L. & Sztanó, O. 2002: Badenian (Middle Miocene) basin development in SW Hungary: subsidence history based on quantitative paleobathymetry of foraminifera. – *International Journal of Earth Sciences* **91/3,** 490–504. https://doi.org/10.1007/s005310100226

Bardócz B., Bíró E., Dank V., Mészáros L., Németh G. & Tormássy I. 1987: A Dunántúli medenceterületek kunsági (pannóniai s. str.) emeletbeli képződményei. [Kunsagian (Pannonian s. str.) formations of the Transdanubian basinal areas]. – *A MÁFI Évkönyve* **69,** 149–166. (in Hungarian)

Bassiouni, M. A. 1979: Brackische und marine Ostrakoden (Cytherideinae, Hemicytherinae, Trachyleberidinae) aus dem Oligozän und Neogen der Türkei. – *Geologisches Jahrbuch Reihe* **B/31,** 1–200.

Bekaert, O., Cahuzac, B., Ducasse, O. & Rousselle, L. 1991: Espèces et populations d'ostracodes a la limite Oligo-Miocéne en Aquitaine: strategie de réponse, microévolution, dans le cadre stratigraphique regional. – *Revue de Paléobiologie* **10/2,** 217–227.

Bogdanovich, A. K. 1952: Miliolidy i Peneroplidy, Iskopaemye foraminifery SSSR [Miliolidae and Peneroplidae, Fossil Foraminifera of the USSR]. – *Trudy Vsesoyuznogo Neftyanogo Nauchnoissledovatel'skogo Geologorazvedochnnogo Instituta (VNIGRI)* **64,** 338 p.

Bohn-Havas, M. 1983: Új típusú szarmata *Cardium*ok a Zsámbéki-medencéből (Budajenő 2. sz. fúrás). (Novel Sarmatian *Cardium* species from the Zsámbék Basin [borehole Budajenő–2]). – *A MÁFI Évi Jelentése 1981-ről,* 335–368. (in Hungarian, with English summary)

Botka, D., Rofrics, N., Katona, L. & Magyar, I. 2021: Pannonian and Sarmatian mollusks from Pécs-Danitzpuszta, southern Hungary: a unique local faunal succession. – *Földtani Közlöny* **151/4**, 335–362.

BRANZILĂ, M. I. H. A. I. 2004: Foraminifera assemblages of the backbulge depozone from the Moldavian Platform – the Basarabian. – *Acta Palaeontologica Romaniae* **4,** 45–54.

BRESTENSKÁ, E. 1975: Ostracoden des Egerien. – In: BRESTENSKÁ, E. (ed.): *Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys* **5,** Bratislava: VEDA, Verlag der Slowakischen Akademie der Wissenschaften, 377–411.

BRESTENSKÁ, E. & JIŘIČEK, R. 1978: Ostrakoden des Badenien der Zentralen Paratethys. – In: BRESTENSKÁ, E. (ed.): Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys **6**, Bratislava: VEDA, Verlag der Slowakischen Akademie der Wissenschaften, 405–439.

BRINKMANN, I., PIPPÈRR, M. & REICHENBACHER, B. 2019: A new well-preserved ostracod fauna from the middle Burdigalian (lower Miocene) of the North Alpine Foreland Basin. – *Geobios* **56,** 65–93. https://doi.org/10.1016/j.geobios.2019.07.005

CABRAL, M. C., COLIN, J. P. & CARBONEL, P. 2005: Espèces pléistocènes de la famille Darwinulidae Brady et Norman, 1889 (Ostracodes), en Algarve, sud Portugal. – *Revue de Micropaléontologie* **48/2**, 51–62.

CAHUZAC, B. & POIGNANT, A. 2000: Les foraminifčres benthiques du Langhien du Bassin d'Aquitaine (SW de la France); donnés paléoécologiques et biogéographiques. – *Geobios* **33/3,** 271–300. https://doi.org/10.1016/S0016-6995(00)80158-8

CARBONNEL, G. 1969: Les ostracodes du Miocéne Rhodanien. – *Documents des laboratoires de géologie de la Faculté des Sciences de Lyon* **32/1–2,** 1–469.

CARBONNEL, G. 1978: L'espéce *Cyprideis pannonica* MEHES, 1908 dans la Téthys au Messinien (Miocéne). – *Documents des laboratoires de géologie de la Faculté des Sciences de Lyon* **72**, 79–97.

CARBONNEL, G. & MAGNÉ, J. 1977: Microfaunes (Ostracodes et Foraminiferes) du Pliocene de l'Ampurdan (Espagne). – *Revista Española de Micropaleontología* **9/3,** 347–359.

CERNAJSEK, T. 1971: Die Entwicklung und Abgrenzung der Gattung *Aurila* Pokorný, 1955 im Neogen Österreichs (Vorbericht). – *Verhandlungen der Geologischen Bundensanstalt* **1971/3,** 571–575.

CERNAJSEK, T. 1974: Die Ostracodenfaunen der Sarmatischen Schichten in Österreich. – In: BRESTENSKÁ, E. (ed.): *Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys* **4,** Bratislava: VEDA, Verlag der Slowakischen Akademie der Wissschaften, 458–491.

CICHA, I. & ZAPLETÁLOVÁ, I. 1961: Die Vertreter der Gattung Bolivina (Foraminifera-Protozoa) in Miozän der Westkarpaten. – *Sborník Ústředního ústavu geologického, Oddíl paleontologický* **28,** 115–184.

CICHA, I., RÖGL, F., RUPP, C. & CTYROKA, J. 1998: Oligocene – Miocene foraminifera of the Central Paratethys. – *Abhandlungen der senckenbergischen naturforschenden Gesellschaft* **549,** Frankfurt am Main: Verlag Waldemar Kramer, 325 p.

ĆORIĆ, S. 2021: Calcareous nannofossils from the middle/upper Miocene succession of Pécs-Danitzpuszta, southern Hungary: cosmopolitan Paratethys and endemic Lake Pannon assemblages. – *Földtani Közlöny* **151/3**, 253–266.

DECKKER, P. de 1981: Ostracods of athalassic saline lakes: A review. – In: WILLIAMS, W. D. (ed.): Salt Lakes. Developments in Hydrobiology **5,** Springer, Dordrecht, 131–144. https://doi.org/10.1007/978-94-009-8665-7_10

DIDKOWSKI, V. J. & SATANOVSKAJA, Z. N. 1970: Foraminifery miocena Ukrainy. – *Paleontologiceskij spravocnik* **4,** 166 p. (in Russian)

DIECI, G. 1959: I foraminiferi tortoniani di Montegibbio e Castelvetro (Appennino–Modenese). – *Palaeontographia Italica* **54,** 1-113.

DIMIZA, M. D., KOUKOUSIOURA, O., TRIANTOAPHYLLOU, M. V. & DERMITZAKIS, M. D. 2016: Live and dead benthic foraminiferal assemblages from coastal environments of the Aegean Sea (Greece): Distribution and diversity. – *Revue de Micropaléontologie* **59/1**, 19–32.

D'ORBIGNY, A. 1846: *Foraminifères fossiles du Bassin Tertiaire de Vienne (Autriche). Die fossilen Foraminiferen des tertiaeren Beckens von Wien.* – Gide et Comp., Paris, 312 p.

DUCASSE, O. & CAHUZAC, B. 1996: Évolution de la faune d'ostracodes dans un cadre paléogéographique et interprétation des paléoenviroments au Langhien en Aquitaine. – *Revue de Micropaléontologie* **39/4,** 247–260. https://doi.org/10.1016/S0035-1598(96)90101-4

DUCASSE, O., BEKAERT, O. & ROUSSELLE, L. 1991: Les Loxoconchidae (Ostracodes) a la limite Oligo-Miocéne en Aquitaine: évolution, adaptation et biostratigraphie. – *Geobios* **24/4,** 435–462. https://doi.org/10.1016/S0016-6995(06)80244-5

DULAI, A., HENN, T. & SEBE, K. 2021: Middle Miocene (Badenian) macroinvertebrates from Pécs-Danitzpuszta (Mecsek Mts., SW Hungary). – *Földtani Közlöny* **151/4**, 329–334.

DUMITRIU, S. D., LOGHIN, S., DUBICKA, Z., MELINTE-DOBRINESCU, M. C., PARUCH-KULCZYCKA, J. & IONESI, V. 2017: Foraminiferal, ostracod, and calcareous nannofossil biostratigraphy of the latest Badenian–Sarmatian interval (Middle Miocene, Paratethys) from Poland, Romania and the Republic of Moldova. – *Geologica Carpathica* **68/5,** 419–444. https://doi.org/10.1515/geoca-2017-0028

FARANDA, C., CIPOLLARI, P., COSENTINO, D., GLIOZZI, E. & PIPPONZI, G. 2008. Late Miocene ostracod assemblages from eastern Mediterranean coral reef complexes (central Crete, Greece). – *Revue de micropaléontologie* **51/4/1–2,** 287–308. https://doi.org/10.1016/j.revmic.2007.06.002

FILIPESCU, S. 1996. Stratigraphy of the Neogene from the western border of the Transylvanian Basin. – *Studia Universitatis Babeş-Bolyai, Geologia* **41/2/1–2,** 3–75.

FILIPESCU, S. 2001: Wielician foraminifera at the western border of the Transylvanian Basin. – *Studia Universitatis Babeş-Bolyai,Geologia* **46/2/1–2,** 115–123. http://dx.doi.org/10.5038/1937-8602.46.2.10

FILIPESCU, S. & SILYE, L. 2008: New Paratethyan biozones of planktonic foraminifera described from the Middle Miocene of the Transylvanian Basin (Romania). – *Geologica Carpathica* **59/6,** 537–544.

FILIPESCU, S., SILYE, L. & KRÉZSEK, CS. 2005: Sarmatian micropaleontological assemblages and sedimentary paleoenvironments in the southern Transylvanian Basin. – *Acta Palaeontologica Romaniae* **5/1–2,** 173–179.

FILIPESCU, S., WANEK, F., MICLEA, A., DE LEEUW, A. & VASILIEV, I. 2011: Micropaleontological response to the changing paleoenvironment across the Sarmatian–Pannonian boundary in the Transylvanian Basin (Miocene, Oarba de Mureş section, Romania). – *Geologica Carpathica* **62/1/1–2,** 91–102. https://doi.org/10.2478/v10096-011-0008-9

FILIPESCU, S., MICLEA, A., GROSS, M., HARZHAUSER, M., ZAGORSEK, K. & JIPA, C. 2014: Early Sarmatian paleoenvironments in the easternmost Pannonian Basin (Borod Depression, Romania) revealed by the micropaleontological data. – *Geologica Carpathica* **65/1/1–2,** 67–81. https://doi.org/10.2478/geoca-2014-0005

Fordinál, K. & Zlinská, A. 1994: Sarmatian Fauna from the Stretava and Kochanovce Formations in the Sečovce Area (Albinovská horka, Eastern Slovakian Basin). – *Práce Panstwowego Instytutu Geologicznego* **99,** 77–82.

Fordinál, K., Zágorsek, K. & Zlinská, A. 2006: Early Sarmatian biota in the northern part of the Danube Basin (Slovakia). – *Geologica Carpathica* **57/2,** 123–130.

Fuhrmann, R. 2012: Atlas quartärer und rezenter Ostrakoden Mitteleuropas. – *Altenburger Naturwissenschaftliche Forschungen* **15**, 1–320.

Garecka, M. & Olszewska, B. 2011: Correlation of the Middle Miocene deposits in SE Poland and western Ukraine based on foraminifera and calcareous nannoplankton. – *Annales Societatis Geologorum Poloniae* **81/3,** 309–330.

Gebhardt, H., Zorn, I. & Roetzel, R. 2009: The initial phase of the early Sarmatian (Middle Miocene) transgression. Foraminiferal and Ostracod assemblages from an incised valley fill in the Molasse Basin of Lower Austria. – *Austrian Journal of Earth Sciences* **102/2,** 100–119.

Gedl, P. & Peryt, D. 2011: Dinoflagellate cyst, palynofacies and foraminiferal records of environmental changes related to the Late Badenian (Middle Miocene) transgression at Kudryntsi (western Ukraine). – *Annales Societatis Geologorum Poloniae* **81/3,** 331–349.

Gonera, M. 2012: Palaeoecology of the Middle Miocene foraminifera of the Nowy Sącz Basin (Polish Outer Carpathians). – *Geological Quarterly* **56/1,** 107–116.

Görög, Á. 1992: Sarmatian foraminifera of the Zsámbék Basin, Hungary. – *Annales Universitatis Scientiarium Budapestinensis de Rolando Eötvös Nominate, Sectio Geologica* **29,** 31–153.

Grill, R. 1943: Über mikropaläontologische Gliederungsmöglichkeiten im Miozän des Wiener Becken. – *Mitteilungen der Reichsanstalt für Bodenforschung* **6,** 33–44.

Gross, M. & Piller, E. W. 2006: Mittelmiozäne Ostracoden aus dem Wiener Becken (Badenium/Sarmatium, Österreich). – *Österreichische Akademie der Wissenschaften Schriftenreihe der Erdwissenschaftlichen Komissionen.* Sonderband **1,** 378–425.

Gross, M., Harzhauser, M., Mandic, O., Piller, W. E. & Rögl, F. 2007: A stratigraphic enigma: the age of the Neogene deposits of Graz (Styrian Basin; Austria). – *Joannea Geologie und Paläontologie* **9**, 195–220.

Hageman, J. 1979: Benthic foraminiferal assemblages from Pleistocene open bay to lagoonal sediments of the western Peloponnesus (Greece). – *Utrecht Micropaleontological Bulletins* **37,** 174 p. https://doi.org/10.1016/S0035-1598(00)90200-9

Hajek-Tadesse, V. & Prtoljan, B. 2011: Badenian Ostracoda from the Pokupsko area (Banovina, Croatia). – *Geologica Carpathica* **62/5,** 447–461. http://doi.org/10.2478/v10096-011-0032-9

Hanganu, E. 1974: Observations sur l'ostracofaune pontienne de la region comprise entre la vallée du Danube et la vallée du Motru. – *Revista Española de Micropaleontología* **6/3,** 335–345.

Harries, P. J. & Knorr, P. O. 2009: What does the 'Lilliput Effect' mean? – *Palaeogeography, Palaeoclimatology, Palaeoecology* **284/1–2,** 4–10. https://doi.org/10.1016/j.palaeo.2009.08.021

Harzhauser, M. & Piller, W. E. 2007: Benchmark data of a changing sea – palaeogeography, palaeobiogeography and events in the Central Paratethys during the Miocene. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **253/1–2,** 8–31. https://doi.org/10.1016/j.palaeo.2007.03.031

Hartmann, G. & Puri, H. S. 1974: Summary of Neontological and Paleontological Classification of Ostracoda. – *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* **70,** 7–73.

Harzhauser, M. & Piller, W. E. 2007: Benchmark data of a changing sea. Palaeogeography, Palaeobiogeography and events in the Central Paratethys during the Miocene. *Palaeogeography, Palaeoclimatology, Palaeoecology* **253,** 8-31. https://doi.org/10.1016/j.palaeo.2007.03.031

Harzhauser, M., Theobalt, D., Strauss, P., Mandic, O., Carnevale, G. & Piller, W. 2017: Miocene biostratigraphy and paleoecology of the Mistelbach Halfgraben in the northwestern Vienna Basin (Lower Austria). – *Jahrbuch der Geologischen Bundesanstalt* **157,** 57–108.

Harzhauser, M., Mandic, O., Kranner, M., Lukeneder, P., Lern, A., Gross, M., Varnevali, G. & Jawecki, C. 2018: The Sarmatian/Pannonian boundary at the western margin of the Vienna Basin (City of Vienna, Austria). – *Austrian Journal of Earth Sciences* **111/1,** 26–47. http://doi.org/10.17738/ajes.2018.0003

Hohenegger, J., Ćorić, S. & Wagreich, M. 2014: Timing of the Middle Miocene Badenian Stage of the Central Paratethys. – *Geologica Carpathica* **65/1,** 55–66. https://doi.org/10.2478/geoca-2014-0004

Horne, D. J., Cohen, A. C. & Martens, K. 2002: Taxonomy, Morphology and Biology of Quaternary and Living Ostracoda. – In: Holmes, J. A. & Chivas, A. R. (eds): *The Ostracoda: applications in Quaternary research.* Geophysical monograph, 5–36. https://doi.org/10.1029/131GM02

Hussain, S. M., Ravi, G., Mohan, S. P. & Rao, N. R. 2004: Recent benthic Ostracoda from the inner shelf off Chennai, south east coast of India-implication of microenvironments. – *Environmental Micropaleontology Microbiology Microbenthology* **1,** 105–121.

Ionesi, B. & Chintăuan, I. 1975: Studiul ostracodelor din depositele Volhiniene de pe Platforma Moldovenească (sectorul dintre valea siretului şi valea Moldovei). – *Dări de seamă ale şedinţelor* **61 (1973–1974)** , 3–14.

Ionesi, B. & Chintăuan, I. 1980: Contributii la cunoaşterea faunei de ostracode din Basarabianul Platformei a Moldovaneşti (Regiunea dintre Siret si Moldova). – *Analele ştiinţifice ale Universităţii "Al. I. Cuza" din Iaşi* **26/2b,** 59–66.

Ionesi, B. & Chintăuan, I. 1985: Ostracofaune des dépôts Besarabiens de la région Văleni (Dobrogea du sud). – *Analele ştiinţifice ale Universităţii "Al. I. Cuza" din Iaşi* **31/2b,** 32–36.

Ionesi, V. & Pascariu, F. 2011: The relationship between the Sarmatian and Quaternary formations from the Păcurari area (Iaşi, Romania). – *Analele ştiinţifice ale Universităţii "Al. I. Cuza" din Iaşi Seria Geologie* **57,** 5–14.

Jámbor, Á., Korpás-Hódi, M., Széles, M. & Sütő-Szentai, M. 1985: Zentrales Mittleres Donaubecken: Bohrung Lajoskomárom Lk-1, S-Balaton. – In: PAPP, A., JÁMBOR, Á. & STEININGER, F. F. (eds): *Chronostratigraphie und Neostratotypen: Miozän der Zentralen Paratethys, Band VII. M6, Pannonien (Slavonien und Serbien)*. Akadémiai Kiadó, Budapest, pp. 204–241.

JANZ, H. & VENNEMANN, T. W. 2005: Isotopic composition (O, C, Sr, and Nd) and trace element ratios (Sr/Ca, Mg/Ca) of Miocene marine and brackish ostracods from North Alpine Foreland deposits (Germany and Austria) as indicatos for palaeoclimate. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **225,** 216–247. https://doi.org/10.1016/j.palaeo.2005.06.012

JASIONOWSKI, M., PERYT, D. & PERYT, T. M. 2012: Neptunian dykes in the Middle Miocene reefs of western Ukraine: preliminary results. – *Geological Quarterly* **56/4,** 881–894. http://dx.doi.org/10.7306/gq.1066

JIŘIČEK, J. 1972. Problém hranice sarmat/panon ve Vídeňské, Podunajské a Východoslovenské pánvi (Das Problem der Grenze Sarmat/Pannon in dem Wiener Becken, dem Donaubecken und dem ostslowakischen Becken). – *Mineralia Slovaca* **4/14,** 39–81.

JIŘIČEK, R. 1974: Biostratigraphische Bedeutung der Ostracoden des Sarmats s. str. – In: BRESTENSKA, E. (ed.): *Chronostratigraphie und Neostratotypen, Miozän der Zentralen Paratethys* **4,** Bratislava: VEDA, Verlag der Slowakischen Akademie der Wissenschaften, 434–458.

JIŘIČEK, R. 1983: Redefinition of the Oligocene and Neogene ostracod zonation of the Paratethys. – *Miscellanea Micropalaentolologica.* Memoire Vol. 18th European Colloquium of Micropaleontological, Bratislava–Praha, 195–236.

JORISSEN, F., J. 1988: Benthic foraminifera from the Adriatic Sea: principles of phenotypic variation. – *Doctoral dissertation,* Utrecht University, 174 p.

JOVANOVIĆ, G., ĆORIĆ, S. & VRABAC, S. 2019: The First evidence of marine Badenian transgression near Koceljeva (central Paratethys, western Serbia). – *Geoloski anali Balkanskoga poluostrva* **80/1,** 1–15.

KARANOVIC, I. & BRANDÃO, S. N. 2012: Review and phylogeny of the Recent Polycopidae (Ostracoda, Cladocopina), with descriptions of nine new species, one new genus, and one new subgenus from the deep South Atlantic. – *Marine Biodiversity* **42,** 329–393. https://doi.org/10.1007/s12526-012-0116-5

KARANOVIC, I. & BRANDÃO, S. N. 2016: The genus *Polycope* (Polycopidae, Ostracoda) in the North Atlantic and Arctic: taxonomy, distribution, and ecology. – *Systematics and Biodiversity* **14**, 198–223. https://doi.org/10.1080/14772000.2015.1131756

KHEIL, J. 1967: Die Ostracoden der Karpatischen Serie. – In: CICHA, I. (ed.): *Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys* **3,** Verlag: Vydavatelstvo Slovenskej Akademie Vied Bratislava, 213–230.

KILIÇ, M. 2001: Recent ostracoda (Crustacea) fauna of the Black Sea coasts of Turkey. – *Turkish Journal of Zoology* **25/4,** 375–388.

KIRCI-ELMAS, E. & MERIÇ, E. 2016: Benthic foraminiferal fauna of the Sea of Marmara. – In: ÖZSOY, E., ÇAĞATAY, M. N., BALKIS, N. & ÖZTÜRK, B. (eds): *The Sea of Marmara: Marine biodiversity, fisheries, conservation and governance,* Turkish Marine Research Foundation, Istanbul, pp. 401–417.

KOEHN-ZANINETTI, L. & TÉTARD, J. 1982: Les Ostracodes des marais salants de Salin-de-Giraud (Sud de la France). – *Géologie Méditerranéenne* **9/4,** 471–478.

KOLLMANN, K. 1971: Die Ostracoden der Eggenburger Schichtengruppe Niederösterreichs. – In: SENES, J. (ed.): *Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys* **1**, Verlag: Vydavatelstvo Slovenskej Akademie Vied Bratislava, 605–717.

KORECZ-LAKY I. 1964: Magyarországi szarmata foraminiferák. (Sarmatische Foraminiferen Ungarns.). – *Annual Report of the Hungarian Geological Institute of 1964*, 475–493.

KORECZ-LAKY I. 1965: A telkibányai szarmata üledékek foraminifera faunája. (Foraminiferen-fauna der Sarmatischen Ablagerungen von Telkibánya). – *Annual Report of the Hungarian Geological Institute of 1965*, 351–365.

KORECZ-LAKY I. 1968: A keleti Mecsek miocén Foraminiferái. (Miozäne Foraminiferen des östlichen Mecsek-Gebirges). – *A Magyar Állami Földtani Intézet évkönyve* **52/1,** 229 p.

KORECZ-LAKY I. 1973: Foraminifera vizsgálatok a Tokaji-hegység miocén képződményeiből. (Examination of the Foraminifera in Miocene rocks of the Tokaj Mountains). – *Annual Report of the Hungarian Geological Institute of 1973*, 83–119.

KORECZ-LAKY, I. 1982. Miocene Foraminifera Fauna from the borehole Tengelic–2. – *Annales of the Hungarian Geological Institute* **65,** 151–187.

KORECZ-LAKY, I. & NAGY-GELLAI, Á. 1985: Foraminiferal fauna from the Oligocene and Miocene in the Börzsöny Mountains. – *Annals of the Hungarian Geological Institute* **68,** 1–527.

KOVÁCS Z. 2001: A Kolozsvár környéki bádeni és szarmata üledékek biosztratigráfiája. (Studiul biostratigrafic al depozitelor sarmațiene din împrejurimile Clujului). – *Collegium Geologicum* **2,** 67–97.

KOVÁČOVÁ, P. & HUDÁČKOVÁ, N. 2005: Lower/Middle Badenian foraminiferal associations from the Vienna Basin (Slovak part) and Carpathian Foredeep: Biostratigraphy and paleoecology. – *Slovak Geological Magazine* **4,** 233–248.

KOUBOVÁ, I. & HUDÁČKOVÁ, N. 2010: Foraminiferal successions in the shallow water Sarmatian sediments from the MZ 93 borehole (Vienna Basin, Slovak part). – *Acta Geologica Slovaca* **2/1,** 47–58.

KŐVÁRY J. 1974: Délnyugat-Dunántúl jugoszláv határmenti területén szénhidrogénkutató fúrások által feltárt tengeri üledékek mikrobiofácies-vizsgálata. I. rész: Harmadidőszak (tercier). [Microbiofacies studies of marine sediments explored by hydrocarbon exploration wells along the Yugoslav border of the southwestern part of Transdanubia. I. part: Tertiary]. – *Manuscript*, Kőolaj- és Földgázbányászati Ipari Kutató Laboratórium, 42 p. (in Hungarian, with 28 photo plates)

KRSTIĆ, N. 1972: Ostrakodi kongeriskih slojeva: 10. Loxoconcha. – *Bulletin of the Natural History Museum, Belgrade* **A/27,** 243–275.

KRSTIĆ, N. 1973: Ostrakodi kongeriskih slojeva: 11. Amnicythere. – *Radova Instituta geolosko-rudarska istrazivanja ispitivanja nuklearnih drugih mineralnih sirovina* **8/8,** 53–99.

KRSTIĆ, N. & STANCHEVA, N. 1989: Ostracods of Eastern Serbia and Northern Bulgaria with notice on a Northern Turkey assemblage. – In: STEVANOVIC, P. M., NEVESSKAJA, L. A., MARINESCU, F., SOKAČ, A. & JÁMBOR, Á. (eds): *Chronostratigraphie und Neostratotypen. Neogen der Westlichen ('Zentrale') Paratethys* **8,** Pl1, Pontien, 753–819.

LANGER, M. R. 1993: Epiphytic foraminifera. – *Marine Micropaleontology* **20,** 235–265. https://doi.org/10.1016/0377-8398(93)90035-V

Langer, M. R. & Hottinger, L. 2000: Biogeography of selected "larger" foraminifera. – *Micropaleontology* **46,** 105–126. https://www.jstor.org/stable/1486184

Langer, M. R., Frick, H. & Silk, M. T. 1998: Photophile and sciaphile foraminiferal assemblages from marine plant communities of Lavezzi Islands (Corsica. Mediterranean Sea). – *Revue de Paléobiologie* **17,** 525–530.

Lethiers, F. & Crasquin-Soleau, S. 1988: Comment extraire les microfossiles à tests calcitiques des roches calcaires dures. – *Revue de Micropaléontologie* **31,** 56–61.

Loeblich, A. R. & Tappan, H. 1992: Present status of foraminiferal classification. – In: Takayanagi, Y. & Saito, T. (eds): *Studies in Benthic foraminifera. Proceedings of the Fourth Symposium on benthic foraminifera, Sendai, 1990,* Tokai University Press, Tokyo, pp. 93–102.

Łuczkowska, E. 1974: Miliolidae (Foraminiferida) from Miocene of Poland, part II. Biostratigraphy, paleoecology and systematics. – *Acta Paleontologica Polonica* **19/1,** 1–176.

Marks, P. 1951: A Revision of the Smaller Foraminifera from the Miocene of the Vienna Basin. – *Contributions from the Cushman Foundation for Foraminiferal Research* **2/2,** 33–73.

Martens, K., Rossetti, G. & Fuhrmann, R. 1997: Pleistocene and Recent species of the family Darwinulidae Brady et Norman, 1889 (Crustacea, Ostracoda) in Europe. – *Hydrobiologia* **357,** 99–116. https://doi.org/10.1023/A:1003130702375

Martini, E. 1971: Standard Tertiary and Quaternary calcareous nannoplankton zonation. – In: Farinacci A. (Ed.): *Proceedings II Planktonic Conference*, *Rome* **2,** 739—785.

Méhes, Gy. 1908: Adatok Magyarország pliocén Ostracodáinak ismeretéhez II. Az alsópannóniai emelet Darwinulidae-i és Cytheridae-i. – *Földtani Közlöny* **38,** 61–65.

Meisch, C. 2000: Freshwater Ostracoda of Western and Central Europe. – In: Schwoerbel, J. & Zwick, P., (eds*): Süßwasserfauna von Mitteleuropa* **8/3,** 1–522. Spektrum Akademischer Verlag, Heidelberg, Berlin 522.

Melis, R., Furlani, S., Antonioli, F., Biolchi, S., Degrassi, V. & Mezgec, K. 2012: Sea level and paleoenvironment during roman times inferred from coastal archaeological sites in Trieste (northern Italy). – *Alpine and Mediterranean Quaternary* **25/1,** 41–55.

Meriç, E., Avsar, N., Görmüs, M. & Bergin, F. 2004: Twin and triplet forms of Recent benthic foraminifera from the eastern Aegean Sea, Turkish coast. – *Micropaleontology* **50/3**, 297–300.

Milker, Y. & Schmiedl, G. 2012: A taxonomic guide to modern benthic shelf foraminifera of the western Mediterranean Sea. – *Palaeontologia electronica* **15/2**, 1–134.

Mischke, S., Schudack, U., Bertrand, S. & Leroy, S. A. 2012: Ostracods from a Marmara Sea lagoon (Turkey) as tsunami indicators. – *Quaternary International* **261**, 156–161.

Mischke, S., Ashkenazi, S., Almogi-Labin, A. & Goren-Inbar, N. 2014: Ostracod evidence for the Acheulian environment of the ancient Hula Lake (Levant) during the early-mid Pleistocene transition. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **412**, 148–159.

Mishra, R., Hussain, S. M. & Nazeer, M. N. 2019: Distribution of ostracoda and foraminifera from sediments of Chilika Lagoon, Odisha, East Coast of India. – *Journal of the Palaeontological Society of India* **64/1,** 115–120.

Morigi, C., Jorissen, F. J., Fraticelli, S., Horton, B. P., Principi, M., Sabbatini, A., Capotondi, L., Curzi, P. V. & Negri, A. 2005: Benthic foraminiferal evidence for the formation of the Holocene mud-belt and bathymetrical evolution in the central Adriatic Sea. – *Marine Micropaleontology* **57/1–2,** 25–49. https://doi.org/10.1016/j.marmicro.2005.06.001

Mostafawi, N. 1986: Pleistozäne Ostracoden aus der Nikolaos-Formation von Ost-Kos, Griechenland. – *Senckenbergiana lethaea* **67/1–4,** 275–303.

Murray, J. W. 1991: *Ecology and Palaeoecology of Benthic Foraminifera.* – Longman Scientific & Technical, Essex, England, 397 p.

Murray, J. W. 2006: *Ecology and applications of benthic foraminifera.* – Cambridge: Cambridge University Press, 318 p.

Náñez, C. & Malumián, N. 2019: Foraminíferos miocenos en la cuenca Neuquina, Argentina: implicancias estratigráficas y paleoambientales. – *Andean geology* **46/1,** 183–210. http://dx.doi.org/10.5027/andgeov46n1-3142

Nazik, A., Tuerkmen, I., Koc, C., Aksoy, E., Avşar, N. & Yayik, H. 2008: Fresh and Brackish Water Ostracods of Upper Miocene Deposits, Arguvan/Malatya (Eastern Anatolia). – *Turkish Journal of Earth Sciences* **17/3**, 481–495.

Neale, J. W. 1988: Ostracodes and paleosalinity reconstructions. – In: de Deckker, P., Colin, J. P. & Peypouquet, J.-P. (eds): *Ostracoda in Earth Sciences*. Elsevier, Amsterdam, 125–155.

Oblak, K. 2007: Most abundant Middle Miocene rotaliinas (suborder Rotaliina, Foraminifera) of Kozjansko (Eastern Slovenia). – *Geologija* **50/2,** 293–322

Olteanu, R. 1989: La faune d'ostracodes ponties du Bassin Dacique. – In: Malez, M. & Stevanovic, P. (eds): *Chronostratigraphie und Neostratotypen,* **8,** Verlag der Jugoslawischen Akademie der Wissenschaften und Künste und der Serbischen Akademie der Wissenschaften und Künste, Zagreb, 722–752.

Olteanu, R. 1998: Orthogenesis and orthoselection, *Leptocythere* lineages in brackish-water Neogene (Ostracoda). – *Revista Roumania Géologie* **42,** 141–153.

Olteanu, R. 2001: Hemicytherinae subfamily (Ostracoda, Crustacea) and its species in Paratethys brackish-water facieses (Neogene, Carpathian areas). Their morphology and taxonomy. – *Studii i cercetări de Geologie* **46,** 71–110.

Olteanu, R. 2011: Atlas of the Pannonian and Pontian Ostracods from the Eastern Area of the Pannonian Basin. – *Geo-Eco-Marina* **17/2011,** 135–177. https://doi.org/10.5281/zenodo.45062

Ozsvárt, P. 2007: *Middle and Late Eocene benthic foraminiferal fauna of the Hungarian Paleogene Basin: systematics and paleoecology.* – Hantken Press, Budapest, 129 p.

Palcu, D. V., Tulbure, M., Bartol, M., Kouwenhoven, T. J. & Krijgsman, W. 2015: The Badenian–Sarmatian Extinction Event in the Carpathian foredeep basin of Romania: Paleogeographic changes in the Paratethys domain. – *Global and Planetary Change* **133,** 346–358. https://doi.org/10.1016/j.gloplacha.2015.08.014

PAPP, A. 1963: Die biostratigraphische Gliederung des Neogens im Wiener Becken, Die Elphidien im Neogen des Wiener beckens, Genus Ammonia BRÜNNICH, 1772 (= Rotalia partim), Die biostratigraphischen Grundlagen der Gliederung des Neogens im Wiener Becken. – *Mitteilungen der Geologischen Gesellschaft in Wien* **56/1,** 255–289.

PAPP, A. 1974: Die Entwicklung des Sarmats in Österreich. – In: BRESTENSKÁ, E. (ed.): *Chronostratigraphie und Neostratotypen, Miozän der Zentralen Paratethys* **4,** 75–77. Bratislava: VEDA, Verlag der Slowakischen Akademie der Wissenschaften.

PAPP, A. & SENEŠ, J. 1974: Grundzüge der Entwicklung der Fauna und die Biozonen im Sarmatien s. str. der Zentralen Paratethys. – In: BRESTENSKÁ, E. (ed.): *Chronostratigraphie und Neostratotypen Miozän der Zentralen Paratethys* **4,** 41–44.

PAPP, A., CICHA, I., SENEŠ, J. & STEININGER, F. 1978: M4 – Badenien (Moravien, Wielicien, Kosovien). – *Chronostratigraphie und Neostratotypen, Miozän der Zentralen Paratethys* **6,** 594 p.

PARLAK, D. & NAZIK, A. 2016: Ostracods of the Mediterranean (The Gulf of Antalya) and the Aegean Sea (Ayvalik and Kuşadasi) and their biogeographical distributions. – *Bulletin of the Mineral Research and Exploration* **152**, 63–83.

PARUCH-KULCZYCKA, J. 1992: Malzoraczki srodkowego miocenu (badenu) z otwour Broniszowice (SW Polska). – *Kwartalnik Geologiczny* **36/2,** 259–280. (in Polish)

PARUCH-KULCZYCKA, J. & SZCZECHURA, J. 1996: Ostracoda. – In: MALINOWSKA, L. & PIWOCKI, M. (ed.): *Budowa geologiczna Polski* **3,** 727–742.

PERÇIN-PAÇAL, F., ALTINSAÇLI, S. & BALKIS, H. 2015: An updated checklist of recent marine and coastal brackish water ostracods (Crustacea Ostracoda) in Turkey. – *Journal of Entomology and Zoology Studies* **3/3,** 20–33.

PERYT, D. 2013: Foraminiferal record of the Middle Miocene climate transition prior to the Badenian salinity crisis in the Polish Carpathian Foredeep Basin (Central Paratethys). – *Geological Quarterly* **57/1,** 141–164. https://doi.org/10.7306/gq.1080

PERYT, D., GEDL, P. & PERYT, T. M. 2020: Marine transgression (s) to evaporite basin: The case of middle Miocene (Badenian) gypsum in the Central Paratethys, SE Poland. – *Journal of Palaeogeography* **9,** 1–18. https://doi.org/10.1186/s42501-020-00062-0

PEZELJ, D., MANDIC, O. & ĆORIĆ, S. 2013: Paleoenvironmental dynamics in the southern Pannonian Basin during initial Middle Miocene marine flooding. – *Geologica Carpathica* **64/1,** 81–100. http://doi.org/10.2478/geoca-2013-0006

PEZELJ, D., SREMAC, J. & BERMANEC, V. 2016: Shallow-water benthic foraminiferal assemblages and their response to the palaeoenvironmental changes — example from the Middle Miocene of Medvednica Mt. (Croatia, Central Paratethys). – *Geologica Carpathica* **67/4,** 329–345. http://doi.org/10.1515/geoca-2016-0021

PIETRZENIUK, E. 1973: Neue Callistocythere-Arten (Ostracoda) aus dem Unteren Sarmat des Tokajer Gebirges (Nördliche Ungarische VR). – *Zeitschrift für Geologische Wissenschaften* **1,** 703–733.

PIPÍK, R. & BODERGAT, A. M. 2004: Euxinocythere (Ostracoda, Cytheridae, Leptocytherinae) du Miocène supérieur du Bassin de Turiec (Slovaquie): taxonomie et paléoécologie. – *Revue de Micropaléontologie* **47**, 36–52.

PIPÍK , R., FORDINÁL, K., SLAMKOVÁ, M., STAREK, D. & CHALUPOVÁ, B. 2004: Annotated checklist of the Pannonian microflora, evertebrate and vertebrate community from Studienka, Vienna Basin. – *Scripta Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Geology* **31–32,** 47–54.

POPESCU, GH. 1995. Contributions to the knowledge of the Sarmatian foraminifera of Romania. – *Romanian Journal of Paleontology* **76,** 85–98.

POPOV, S. V., RÖGL, F., ROZANOV, A.Y., STEININGER, F. F., SCHERBA, I. G. & KOVAC, M. 2004: Lithological-Paleogeographic maps of the Paratethys (10 maps Late Eocene to Pliocene). – *Courier Forschungsinstitut Senckenberg* **250,** 1–46.

PURI, H. S., BONADUCE, G., & GERVASIO, A. M. 1969: Distribution of Ostracoda in the Mediterranean. – In: NEALE, J. W. (ed.): *The Taxonomy, Morphology and Ecology of Recent Ostracoda*, Edinburgh, 356–412.

RAFFI, I., WADE, B. S. & PÄLIKE, H. 2020: The Neogene Period. – IN: GRADSTEIN, F. M., OGG, J. G., SCHMITZ, M. D. & OGG, G. M. (eds): *Geologic Time Scale 2020.* Elsevier, 1141–1215. https://doi.org/10.1016/B978-0-12-824360-2.00029-2

REISS, Z. & HOTTINGER, L. 1984: Shell producers in the water column. – In: REISS, Z. & HOTTINGER, L. (eds): *The Gulf of Aqaba*, Springer, Berlin, Heidelberg, 89–138.

REUSS, A. E. 1850: Die fossilen Entomostraceen des österreichischen Tertiärbecken. – *Haidinger's Naturwissenschaftliche Abhandlungen* **31,** 1–92.

ROSLIM, A., BRIGUGLIO, A., KOCSIS, L., ĆORIĆ, S. & GEBHARDT, H. 2019: Large rotaliid foraminifera as biostratigraphic and palaeoenvironmental indicators in northwest Borneo: An example from a late Miocene section in Brunei Darussalam. – *Journal of Asian Earth Sciences* **170,** 20–28. https://doi.org/10.1016/j.jseaes.2018.10.019

RÖGL, F. 1969: Die miozäne Foraminiferenfauna von Laa an der Thaya in der Molassenzone on Niederösterreich. – *Mitteilungen der Geologischen Gesellschaft in Wien* **61/1968,** 63–123.

RÖGL, F. 1998: Palaeogeographic Considerations for Mediterranean and Paratethys Seaways (Oligocene to Miocene). – *Annalen des Naturhistorischen Museums in Wien* **99A (1998) ,** 279–310.

RÖGL, F., ĆORIĆ, S., HARZHAUSER, M., JIMENEZ-MORENO, G., KROH, A., SCHULTZ, O., WESSELY, G. & ZORN, I. 2008: The Middle Miocene Badenian stratotype at Baden-Sooss (Lower Austria). – *Geologica Carpathica* **59/5,** 367–374.

RUIZ, F., GONZÁLEZ-REGALADO, M. L. & MUÑOZ, J. M. 1997: Multivariate analysis applied to total and living fauna: seasonal ecology of recent benthic Ostracoda off the North Cádiz Gulf coast (southwestern Spain). – *Marine Micropaleontology* **31/3–4,** 183–203. https://doi.org/10.1016/S0377-8398(96)00060-6

SAFTIĆ, B., VELIĆ, J., SZTANÓ, O., JUHÁSZ, GY. & IVKOVIĆ, Z. 2003: Tertiary Subsurface Facies, Source Rocks and Hydrocarbon Reservoirs in the SW Part of the Pannonian Basin (Northern Croatia and South-Western Hungary). – *Geologia Croatica* **56,** 101–122.

SALEL, T., BRUNETON, H. & LEFÈVRE, D. 2016: Ostracods and environmental variability in lagoons and deltas along the north-western Mediterranean coast (Gulf of Lions, France and Ebro delta, Spain). – *Revue de Micropaléontologie* **59/4**, 425–444.

SCHÜTZ, K., HARZHAUSER, M., RÖGL, F., ĆORIĆ, S. & GALOVIĆ, I. 2007: Foraminiferen and Phytoplankton aus dem unteren Sarmatium des südlichen Wiener Beckens (Petronell, Niederöstereich). – *Jahrbuch der Geologischen Bundesanstalt* **147,** 449–488.

Sciuto, F., Rosso, A., Sanfilippo, R. & Di Martino, E. 2015: Ostracods from mid-outer shelf bottoms of the Ciclopi Islands Marine Protected Area (Ionian Sea, Eastern Sicily). – *Bollettino della Società Paleontologica Italiana* **54/2,** 131–145. https://doi.org/10.4435/BSPI.2015.09

Sebe, K. 2021: Structural features in the Miocene sediments of the Pécs-Danitzpuszta sand pit (SW Hungary). – *Földtani Közlöny* **151/4**, 411–422.

Sebe, K., Csillag, G., Dulai, A., Gasparik, M., Magyar, I., Selmeczi, I., Szabó, M., Sztanó, O. & Szuromi-Korecz, A. 2015: Neogene stratigraphy in the Mecsek region. In: Bartha, I-R., Kriván, Á., Magyar, I. & Sebe, K. (eds): Neogene of the Paratethyan Region. 6th Workshop on the Neogene of Central and South-Eastern Europe. – *An RCMNS Interim Colloquium. Programme, Abstracts, Field Trip Guidebook. 2015.05.31-06.03, Orfű. Hungarian Geological Society, Budapest,* 102–124.

Sebe, K., Selmeczi, I., Szuromi-Korecz, A., Hably, L., Kovács, Á. & Benkó, Zs. 2019: Miocene syn-rift lacustrine sediments in the Mecsek Mts. (SW Hungary). – *Swiss Journal of Geosciences* **112,** 83–100., https://doi.org/10.1007/s00015-018-0336-1

Sebe, K., Kovačić, M., Magyar, I., Krizmanić, K., Špelić, M., Bigunac, D., Sütő-Szentai, M., Kovács, Á., Szuromi-Korecz, A., Bakrač, K., Hajek-Tadesse, V., Troskot-Čorbić, T. & Sztanó, O. 2020: Correlation of upper Miocene–Pliocene Lake Pannon deposits across the Drava Basin, Croatia and Hungary. – *Geologia Croatica* **73/3,** 177–195. https://doi.org/10.4154/gc.2020.12

Sebe, K., Konrád, Gy. & Sztanó, O. 2021: An exceptional surface occurrence: the middle to upper Miocene succession of Pécs-Danitzpuszta (SW Hungary). – *Földtani Közlöny* **151/3**, 235–252.

Seko, M., Pipík, R. & Dolakova, N. 2012: Early Badenian ostracod assemblage of the Židlochovice stratotype (Carpathian Foredeep, Czech Republic). – *Open Geosciences* **4/1,** 111–125. https://doi.org/10.2478/s13533-011-0049-8

Silye, L. 2015: *Sarmatian foraminiferal assemblages from southern Transylvanian Basin and their significance for the reconstruction of depositional environments.* – Cluj University Press, Cluj, 229 p.

Sokač, A. 1967: Pannonische und Pontische Ostracoden fauna des südwestlichen Teiles des Pannonischen Becken. – *Carpatho-Balkan Geological Association, 8th Congress, Belgrade, Rep. Stratigrafia,* 445–453.

Sokač, A. 1972: Pannonian and Pontian Ostracoda Fauna of Mt. Medvednica. – *Palaentologia Jugoslavica* **11,** 73 p.

Sokač, A. 1989: Pontian Ostracod fauna in the Pannonian Basin. – In: Malez, M. & Stevanovic, P. (eds): *Chronostratigraphie und Neostratotypen* **8,** Verlag der Jugoslawischen Akademie der Wissenschaften und Künste und der Serbischen Akademie der Wissenschaften und Künste, Zagreb, 672–721.

Stancheva, M. 1962: Ostracodna fauna ot neogena v severozapadna Bulgariia. I. tortonskii ostracodi. – *Travaux sur la Géologie de Bulgaria, series Paléontologie* **4,** 5–75.

Stancheva, M. 1963: Ostracodna fauna ot neogena v severozapadna Bulgariia. II: sarmatskii ostracodi. – *Travaux sur la Géologie de Bulgaria, series Paléontologie* **5,** 1–75.

Stancheva, M. 1972: Sarmatian ostracods from north-eastern Bulgaria. – *Bulletin of the Geological Institute, series Paleontology* **21,** 103–128.

Stancheva, M. 1990: Upper Miocene ostracods from northern Bulgaria – *Geologica Balcanica series operum singulorum* **5,** 7–102.

Steininger, F. F. & Rögl, F. 1984: Paleogeography and palinspastic reconstruction of the Neogene of the Mediterranean and Paratethys. – *Geological Society, London, Special Publications* **17/1,** 659–668. https://doi.org/10.1144/GSL.SP.1984.017.01.52

Steininger, F. F. & Wessely, G. 2000: From the Tethyan Ocean to the Paratethys Sea: Oligocene to Neogene Stratigraphy, Paleogeography and Paleobiogeography of the circum-Mediterranean region and the Oligocene to Neogene Basin evolution in Austria. – *Mitteilungen der Österreichischen Geologischen Gesellschaft* **92,** 95–116.

Stojanova, V. & Petrov, G. 2014: Foraminifer fauna in paleogene sediments at Rabrovo and Dedeli sites in the Stojanovae Valandovo-Gevgelia basin, Republic of Macedonia. – *Geologica Macedonica* **28/1,** 45–53.

Suciu, A.-A. 2005: Preliminary data on the Sarmatian deposits from Lombi Hill (Popeşti locality) Northwest from Cluj-Napoca. – *Analele ştiinţifice ale Universităţii "Al. I. Cuza" din Iaşi, Geologie* **51,** 121–130.

Suzin, A. V. 1956: *Ostracodi tretichnih otlozhenii Severnava Predkavkazia.* – Groznemsk. ordena Krasnaveznameni neft. Institut Gostoptechnizdat, 1–184.

Szabó, M., Kocsis, L., Bosnakoff, M. & Sebe, K. 2021: A diverse Miocene fish assemblage (Chondrichthyes and Osteichthyes) from the Pécs-Danitzpuszta sand pit (Mecsek Mts., Hungary). – *Földtani Közlöny* **151/4**, 363–410.

Szczechura, J. 1982: Middle Miocene foraminiferal biochronology and ecology of SE Poland. – *Acta Palaeontologica Polonica* **27/1–4,** 3–44.

Szczechura, J. 2000: Age and evolution of depositional enviroments of the supra-evaporitic deposits in the northern, marginal part of the Carpathian Foredeep: micropaleontological evidence. – *Geological Quarterly* **44/1,** 81–100.

Szczechura, J. 2006: Middle Miocene (Badenian) ostracods and green algae (Chlorophyta) from Kamienica Nawojowska, Nowy Sacz Basin (Western Carpathians, Poland). – *Geologica Carpathica* **57/2,** 103–122.

Széles, M. 1982: Pannonian ostracoda fauna from the borehole Tengelic 2. – *Annals of Hungarian Geological Institute* **65,** 235–289.

Szuromi-Korecz, A. & Szegő, É. 2001: Data for knowledge of foraminifera and ostracoda microfauna of Kovácsszénája (SW-Hungary) – *Folia Komloensis* **10,** 51–74.

Tanaka, G. 2008: Recent benthonic ostracod assemblages as indicators of the Tsushima Warm Current in the southwestern Sea of Japan. – *Hydrobiologia* **598,** 271–284.

Tanaka, H. & Tsukagoshi, A. 2010: Two new interstitial species of the genus Parapolycope (Crustacea: Ostracoda) from central Japan. – *Zootaxa* **2500/1,** 39–57. https://doi.org/10.11646/zootaxa.2500.1.2.

Temelkov, B. K. 2008: Ecological characteristics of the foraminiferal fauna (Protozoa: Foraminifera) of the Bulgarian South Black Sea area. – *Acta Zoologica Bulgarica* **2,** 275–282.

ter Borgh, M., Vasiliev, J., Stoica, M., Knežević, S., Matenco, L., Krijgsman, W., Rundić, L. & Cloetingh, S. 2013: The isolation of the Pannonian Basin (Central Paratethys): New constraints from magnetostratigraphy and biostratigraphy. – *Global and Planetary Change* **103,** 99–118. https://doi.org/10.1016/j.gloplacha.2012.10.001

TER BORGH, M., STOICA, M., DONSELAAR, M., MATENCO, L. & KRIJGSMAN, W. 2014: Miocene connectivity between the Central and Eastern Paratethys: Constraints from the western Dacian Basin. – *Palaeogeography, Palaeoclimatology, Palaeoecology* **412,** 45–67. http://dx.doi.org/10.1016/j.paleo.2014.07.016

TÓTH, E. 2004: Sarmatian ostracods from Budapest (Hungary). – *Hantkeniana* **4,** *Shallow Tethys 6 Symposium proceedings, 25–29 August 2003*, 129–159.

TÓTH, E. 2008: Sarmatian (Middle Miocene) ostracod fauna from the Zsámbék Basin, Hungary. – *Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös Nominatae, Sectio Geologica* **36,** 101–151.

TÓTH E. 2009: Őskörnyezeti változások a Középső-Paratethysben a szarmata folyamán a mikrofauna őslénytani és geokémiai vizsgálata alapján. [Changements paléoenvironnementaux dans la Paratéthys Centrale pendant le Sarmatien (Miocène moyen): étude paléontologique de microfaunes et analyses géochimiques]. – *Doktori értekezés*, ELTE Őslénytani Tanszék, Université Claude Bernard Lyon 1, Budapest/Lyon, 153 p.

TÓTH, E. & GÖRÖG, Á. 2008: Sarmatian foraminifera fauna from Budapest (Hungary). – *Hantkeniana* **6,** 187–217.

TUNCER, A., TUNOĞLU, C., AYDAR, E., YILMAZ, İ. Ö., GÜMÜŞ, B. A. & ŞEN, E. 2019: Holocene paleoenvironmental evolution of the Acıgöl paleo maar lake (Nevşehir, Central Anatolia). – *Mediterranean Geoscience Reviews* **1/2**, 255–269

VALCHEV, B. & STOJANOVA, V. 2016: Benthic foraminiferal morphogroups from the Paleogene of the Republic of Macedonia–characterization and paleoecological significance. – *Review of the Bulgarian Geological Society* **77/2–3**, 3–21.

VAN BAAK, C. G., VASILIEV, I., STOICA, M., KUIPER, K. F., FORTE, A. M., ALIYEVA, E. & KRIJGSMAN, W. 2013: A magnetostratigraphic time frame for Plio-Pleistocene transgressions in the South Caspian Basin, Azerbaijan. – *Global and Planetary Change* **103,** 119–134. https://doi.org/10.1016/j.gloplacha.2012.05.004

VAN DONINCK, K., SCHÖN, I., MARTENS, K. & GODDEERIS, B. 2003: The life-cycle of the asexual ostracod *Darwinula stevensoni* (Brady & Robertson, 1870) (Crustacea, Ostracoda) in a temporate pond. – *Hydrobiologia* **500/1,** 331–340. https://doi.org/10.1023/A:1024656920904

VENGLINSKY I. V. 1958: Miocene foraminifera from the Transcarpathian area [Foraminiferi miocenu Zakarpatja]. – *Vidavictvo Akademia Nauk Ukrainskoi RSR, Kiev,* 1–246 (in Ukrainian)

VENGLINSKY, I. V. 1975: *Foraminifery i biostratigrafia miocenovih otlozenij zakarpatskovo progiba.* – Vidavictvo Akademia Nauk Ukrainskoi RSR, Kiev, 263 p.

VOLOSHINOVA, N. A. 1952. Nonionidae. – In: VOLOSHINOVA, N. A. & DAIN, L. G. (eds): *Noniony, Cassidulinidy I Hilostomellidy.* Trudy VNIGRI **63,** 13–75.

VOICU, G. 1981: Upper Miocene and recent mysid statoliths in Central and Eastern Paratethys. – *Micropaleontology* **27/3,** 227–244. https://doi.org/10.2307/1485236

VON FICHTEL, L. & VON MOLL, J. P. C. 1798: *Testacea Microscopica alique minuta ex Generibus Argonauta et Nautilus.* – Anton Pichler, Wien, 123 p.

VRSALJKO, D. 1999: The Pannonian palaeoecology and biostratigraphy of molluscs from Kostanjek-Medvednica Mt., Croatia. – *Geologia Croatica* **52/1,** 9–27.

WOUTERS, K. 1999: Two new species of the genus *Phlyctenophora* Brady, 1880 (Crustacea, Ostracoda) from the Indo-Pacific realm. – *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Biologie* **69,** 83–92.

YOKES, M. B., MERIÇ, E., AVŞAR, N., BARUT, I., TAS, S., ERYILMAZ, M., DINÇER, F. & BIRCAN, C. 2014: Opinions and comments on the benthic foraminiferal assemblage observed around the mineral submarine spring in Kuşadas (Aydin, Turkey). – *Marine Biodiversity Records* **7,** 1–17. https://doi.org/10.1017/S1755267214000840

ZELENKA, J. 1985: Badenian Ostracoda from Podivin (Vienna Basin – Southern Moravia). – *Věstník Ústředního ústavu geologického* **60/4,** 245–248.

ZELENKA, J. 1990: A review of the Sarmatian ostracoda of the Vienna basin. – In: WHATLEY, R. & MAYBURY, C. (eds): *Ostracoda and Global Events*, London, British Micropaleontological Society Publication, Chapman and Hall, 263–269.

ZHENG, S. Y., CHENG, T., WANG, X. & FU, Z. 1978: The Quaternary Foraminifera of the Dayuzhang Irrigation area, Shandong Province, and a preliminary attempt at an interpretation of its depositional environment. – *Studia Marina Sinica* **13,** 72–78.

ZLINSKÁ, A. 1997: Biostratigraphy of Sarmatian sediments from the Kosicka kotlina depression on the basis of Foraminifers. – *Slovak Geological Magazine* **3–4,** 285–298.

ZLINSKÁ, A. 1998: Microbiostratigraphy of the Badenian sediments in the East Slovakian Basin on the Foraminifera study basis. – *Zemny Plyn a Nafta* **43,** 11–153.

ZLINSKÁ, A. & FORDINÁL, K. 1995: A Spodnosarmatská fauna zo stretavského súvrstvia z okolia Slanskej Huty (východoslovenská panva). – *Práce Panstwowego Instytutu Geologicznego* **100,** 71–75. (in Slovak)

ZORN, I. 1998: Ostracoda aus dem Karpat (Unter-Miozän) des Korneuburger Beckens (Niederösterreich). – *Beiträge zur Paläontologie* **23,** 175–271.

ZORN, I. 2004: Ostracoda from the lower Badenian (middle Miocene) Grund Formation (Molasse Basin, Lower Austria). – *Geologica Carpathica* **55/2,** 179–189.

Manuscript recieved: 30/07/2021

Plate I – I. tábla

Badenian microfossils from the studied exploratory trench in Pécs-Danitzpuszta: 1: *Callistocythere canaliculata* (Reuss), RV in lateral view, layer D72, scale bar: 250 µm; 2–3: *Aurila cicatricosa* (Reuss), 2: LV in lateral view, 3: C in right view, layer D72, scale bar: 250 µm; 4: *Urocythereis kostelensis* (Reuss), LV in lateral view, layer D72, scale bar: 250 µm; 5: *Loxoconcha punctatella* (Reuss), LV in lateral view layer D72, scale bar: 200 µm; 6: *Senesia cinctella* (Reuss), C in right view, layer D72, scale bar: 250 µm; 7: *Xestoleberis tumida* (Reuss), RV in lateral view, layer D72, scale bar: 250 µm; 8: *Xestoleberis dispar* Mueller, C in left view, layer D72, scale bar: 250 µm; 9: *Borelis* sp., SV, layer D72, scale bar: 200 µm; 10: *Heterolepa dutemplei* (d'Orbigny), UV, layer D72, scale bar: 500 µm; 11: *Cycloforina contorta* (d'Orbigny), SV, layer D72, scale bar: 200 µm; 12: *Affinetrina ucrainica* (Serova), SV, layer D72, scale bar: 500 µm; 13: *Nonion commune* (d'Orbigny), SV, layer D72, scale bar: 500 µm; 14: *Elphidium crispum* (Linné), SV, scale bar: 500 µm; 15: *Textularia* sp., layer D72; 16: *Pyrgo subsphaerica* (d'Orbigny), layer D72; 17: *Asterigerinata planorbis* (d'Orbigny), layer D72; 18: *Heterolepa dutemplei* (d'Orbigny), layer D72; 19: echinoid spine, layer D72; 20: sponge spicule, layer D72; 21: red algae fragment, layer D72; 22: serpulid worm burrow, layer D72

Abbreviations: LV= left valve, RV= right valve, C= carapace, SV= side view, UV= umbilical view

Badeni mikrofosszíliák a pécs-danitzpusztai homokbányában ásott kutatóárokból: 1: Callistocythere canaliculata *(Reuss), RV oldalnézetben, D72 réteg, méretarány: 250 µm; 2–3:* Aurila cicatricosa *(Reuss), 2: LV oldalnézetben, 3: C jobb oldali nézetben, D72 réteg, méretarány: 250 µm; 4:* Urocythereis kostelensis *(Reuss), LV oldalnézetben, D72 réteg, méretarány: 250 µm; 5:* Loxoconcha punctatella *(Reuss), LV oldalnézetben, D72 réteg, méretarány: 200 µm; 6:* Senesia cinctella *(Reuss), C jobb oldali nézetben, D72 réteg, méretarány: 250 µm; 7:* Xestoleberis tumida *(Reuss), RV oldalnézetben, D72 réteg, méretarány: 250 µm; 8:* Xestoleberis dispar *Mueller, C in bal oldali nézetben, D72 réteg, méretarány: 250 µm; 9:* Borelis *sp., SV, D72 réteg, méretarány: 200 µm; 10:* Heterolepa dutemplei *(d'Orbigny), UV, D72 réteg, méretarány: 500 µm; 11:* Cycloforina contorta *(d'Orbigny), SV, D72 réteg, méretarány: 200 µm; 12:* Affinetrina ucrainica *(Serova), SV, D72 réteg, méretarány: 500 µm; 13:* Nonion commune *(d'Orbigny), SV, D72 réteg, méretarány: 500 µm; 14:* Elphidium crispum *(Linné), SV, méretarány: 500 µm; 15:* Textularia *sp., D72 réteg; 16:* Pyrgo subsphaerica *(d'Orbigny), D72 réteg; 17:* Asterigerinata planorbis *(d'Orbigny), D72 réteg; 18:* Heterolepa dutemplei *(d'Orbigny), D72 réteg; 19: tengerisüntüske, D72 réteg; 20: szivacstű, D72 réteg; 21: vörösalga-töredék, D72 réteg; 22: féregjárat, D72 réteg*

Rövidítések: LV= bal teknő, RV= jobb teknő, C= kettősteknő, SV= oldalnézet, UV= köldökoldali nézet

Plate II – II. tábla

Sarmatian ostracods from the studied exploratory trench in Pécs-Danitzpuszta: 1: *Amnicythere tenuis* (Reuss), RV in lateral view, layer D50, scale bar: 200 µm; 2–3: *Amnicythere cernajseki* Stancheva, 2: LV in lateral view, 3: RV in lateral view, layer D38, scale bar: 200 µm; 4–6: *Euxinocythere* (*Euxinocythere*) *praebosqueti* (Suzin), 4: ecophenotype, LV in lateral view, layer D36, scale bar: 250 µm; 5: RV in lateral view, layer D36, scale bar: 200 µm; 6: LV in lateral view, layer D50, scale bar: 200 µm; 7: *Euxinocythere* (*Euxinocythere*) *naca* (Méhes), RV in lateral view, layer D50, scale bar: 200 µm; 8–9: *Cyprideis pokorny* Jiřiček, 8: male, RV in lateral view, 9: female, RV in lateral view, layer D38, scale bar: 250 µm; 10: *Cyprideis* sp., layer D38, scale bar: 250 µm; 11: *Hemicytheria omphalodes* (Reuss), juvenile, RV in lateral view, layer D36, scale bar: 200 µm; 12–13: *Aurila notata* (Reuss), 12: RV in lateral view, 13: LV in lateral view, layer D50, scale bar: 500 µm; 14–15: *Loxoconcha kochi* Méhes, 14: LV in lateral view, 15: RV in lateral view, layer D50, scale bar: 250 µm; 16: *Loxoconcha laeta* Stancheva, LV in lateral view, layer D54, scale bar: 200 µm; 17: *Loxoconcha porosa* Méhes, RV in lateral view, layer D54, scale bar: 200 µm; 18: *Loxocauda* sp., layer D38, scale bar: 250 µm; 19–20: *Loxocorniculum hastatum* (Reuss), 19: LV in lateral view, 20: RV in lateral view, layer D36, scale bar: 250 µm; 21: *Darwinula stevensoni* (Brady & Robertson), C in right view, layer D 40, scale bar: 250 µm; 22–23: *Vestalenula pagliolii* (Pinto & Kotzian), 22: RV in lateral view, 23: C in left view, layer D38, scale bar: 200 µm; 24: *Fabaeformiscandona* ? sp. juv., RV in lateral view, layer D38, scale bar: 200 µm; 25: *Limnocythere* sp., LV in lateral view, layer D38, scale bar: 200 µm; 26: *Heterocypris salina* (Brady), C in left view, layer D40, scale bar: 500 µm

Abbreviations: LV= left valve, RV= right valve, C= carapace

Szarmata kagylósrákok a pécs-danitzpusztai homokbányában ásott kutatóárokból: 1: Amnicythere tenuis *(Reuss), RV oldalnézetben, D50 réteg, méretarány: 200 µm; 2–3:* Amnicythere cernajseki *Stancheva, 2: LV oldalnézetben, 3: RV oldalnézetben, D38 réteg, méretarány: 200 µm; 4–6:* Euxinocythere *(*Euxinocythere*)* praebosqueti *(Suzin), 4: ökofenotípus, LV oldalnézetben, D36 réteg, méretarány: 250 µm; 5: RV oldalnézetben, D36 réteg, méretarány: 200 µm; 6: LV oldalnézetben, D50 réteg, méretarány: 200 µm; 7:* Euxinocythere *(*Euxinocythere*)* naca *(Méhes), RV oldalnézetben, D50 réteg, méretarány: 200 µm; 8–9:* Cyprideis pokorny *Jiřiček, 8: hím, RV oldalnézetben, 9: nőstény, RV oldalnézetben, D38 réteg, méretarány: 250 µm; 10:* Cyprideis *sp., D38 réteg, méretarány: 250 µm; 11:* Hemicytheria omphalodes *(Reuss), juvenilis, RV oldalnézetben, D36 réteg, méretarány: 200 µm; 12–13:* Aurila notata *(Reuss), 12: RV oldalnézetben, 13: LV oldalnézetben, D50 réteg, méretarány: 500 µm; 14–15:* Loxoconcha kochi *Méhes, 14: LV oldalnézetben, 15: RV oldalnézetben, D50 réteg, méretarány: 250 µm; 16:* Loxoconcha laeta *Stancheva, LV oldalnézetben, D54 réteg, méretarány: 200 µm; 17:* Loxoconcha porosa *Méhes, RV oldalnézetben, D54 réteg, méretarány: 200 µm; 18:* Loxocauda *sp., D38 réteg, méretarány: 250 µm; 19–20:* Loxocorniculum hastatum *(Reuss), 19: LV oldalnézetben, 20: RV oldalnézetben, D36 réteg, méretarány: 250 µm; 21:* Darwinula stevensoni *(Brady & Robertson), C jobb oldali, D40 réteg, méretarány: 250 µm; 22–23:* Vestalenula pagliolii *(Pinto & Kotzian), 22: RV oldalnézetben, 23: C baloldali nézetben, D38 réteg, méretarány: 200 µm; 24:* Fabaeformiscandona *? sp. juv., RV oldalnézetben, D38 réteg, méretarány: 200 µm; 25:* Limnocythere *sp., LV oldalnézetben, D38 réteg, méretarány: 200 µm; 26:* Heterocypris salina *(Brady), C bal oldali nézetben, D40 réteg, méretarány: 500 µm*

Rövidítések: LV= bal teknő, RV= jobb teknő, C= carapace

Plate III – III. tábla

Sarmatian foraminifers and other microfossils from the studied exploratory trench in Pécs-Danitzpuszta: 1: *Articulina* sp. indet., fragmented specimen, layer D41, scale bar: 200 µm; 2: *Bolivina sarmatica* Didkowski, SV, layer D41, scale bar: 250 µm; 3: *Buliminella elegantissima* (d'Orbigny), SV, layer D41, scale bar: 500 µm; 4: *Ammonia* cf. *confertitesta* Zheng, UV, layer D41, scale bar: 200 µm; 5: *Porosononion granosum* (d'Orbigny), SV, layer D54, scale bar: 250 µm; 6: *Elphidium hauerinum* (d'Orbigny), SV, layer D54, scale bar: 200 µm; 7–8: *Elphidium aculeatum* (d'Orbigny), SV, layer D54, scale bar: 250 µm; 9: *Porosononion granosum* (d'Orbigny), layer D37; 10: *Vestalenula pagliolii* (Pinto & Kotzian), layer D38; 11–12: *Fabaeformiscandona* ? sp. juv., layer D38; 13: *Calcisphaera*-like large algal cyst, layer D35; 14: Mysid statolith, layer D35.

Abbreviations: SV= side view, UV= umbilical view

S*zarmata foraminiferák és egyéb mikrofosszíliák a pécs-danitzpusztai homokbányában ásott kutatóárokból: 1:* Articulina *sp. indet., töredékes példány, D41 réteg, méretarány: 200 µm; 2:* Bolivina sarmatica *Didkowski, SV, D41 réteg, méretarány: 250 µm; 3:* Buliminella elegantissima *(d'Orbigny), SV, D41 réteg, méretarány: 500 µm; 4:* Ammonia *cf.* confertitesta *Zheng, UV, D41 réteg, méretarány: 200 µm; 5:* Porosononion granosum *(d'Orbigny), SV, D54 réteg, méretarány: 250 µm; 6:* Elphidium hauerinum *(d'Orbigny), SV, D54 réteg, méretarány: 200 µm; 7–8:* Elphidium aculeatum *(d'Orbigny), SV, D54 réteg, méretarány: 250 µm; 9:* Porosononion granosum *(d'Orbigny), D37 réteg; 10:* Vestalenula pagliolii *(Pinto & Kotzian), D38 réteg; 11–12:* Fabaeformiscandona *? sp. juv., D38 réteg; 13:* Calcisphaerá*hoz hasonló nagyméretű alga ciszta, D35 réteg; 14: Misidae statolith, D35 réteg.*

Rövidítések: SV= oldalnézet, UV= köldökoldali nézet

Plate I – I. tábla

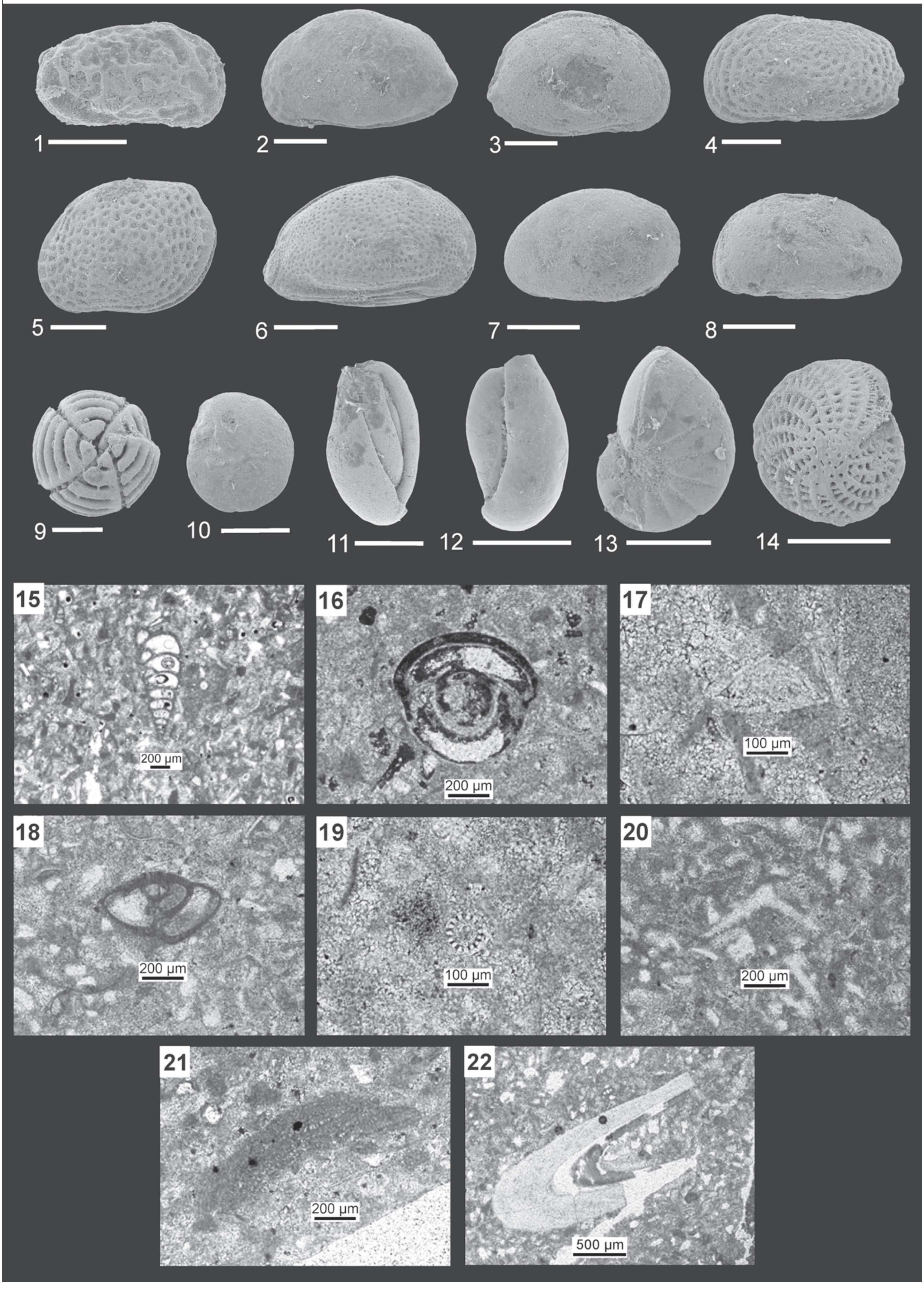


Plate II – II. tábla

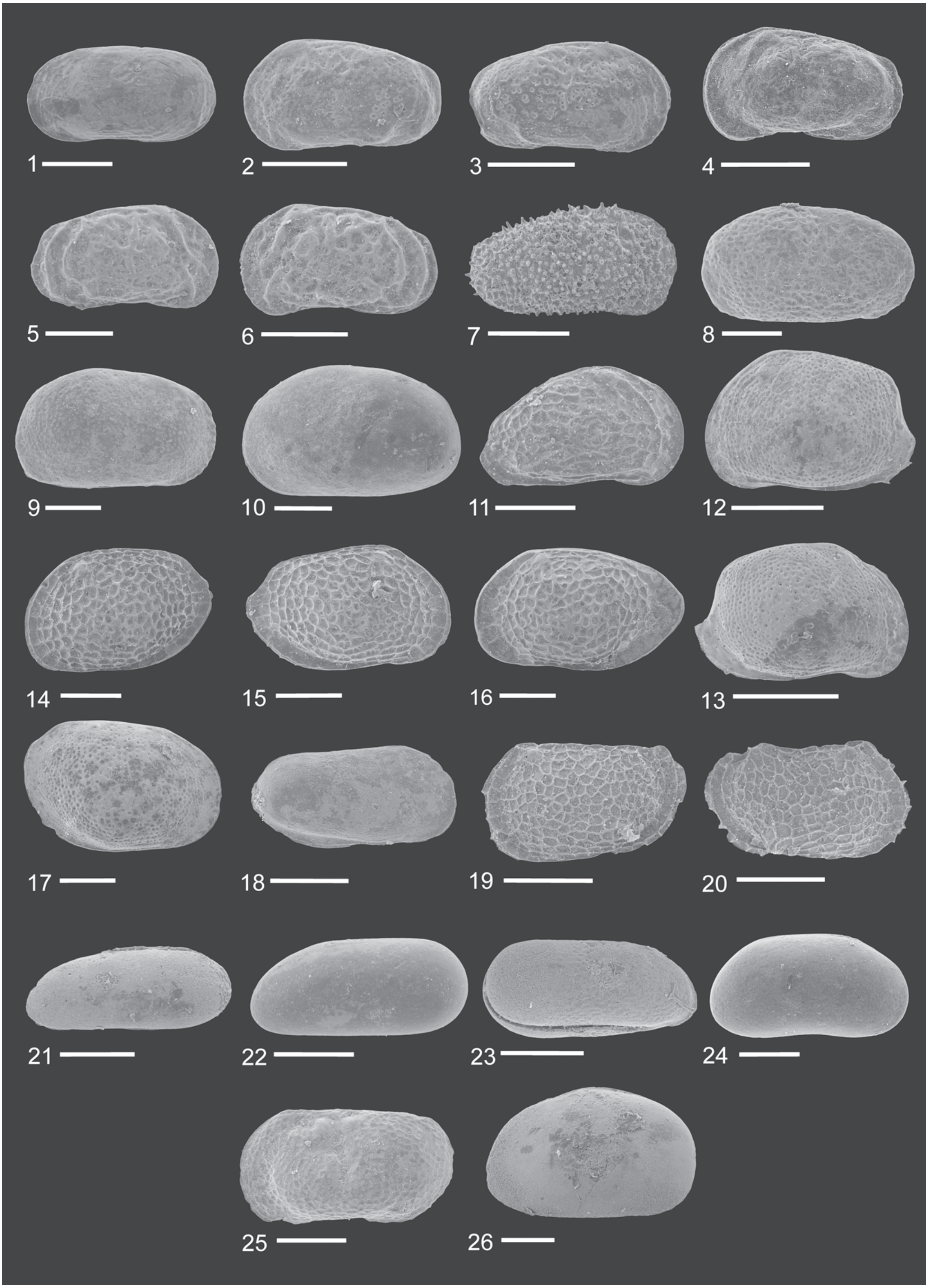
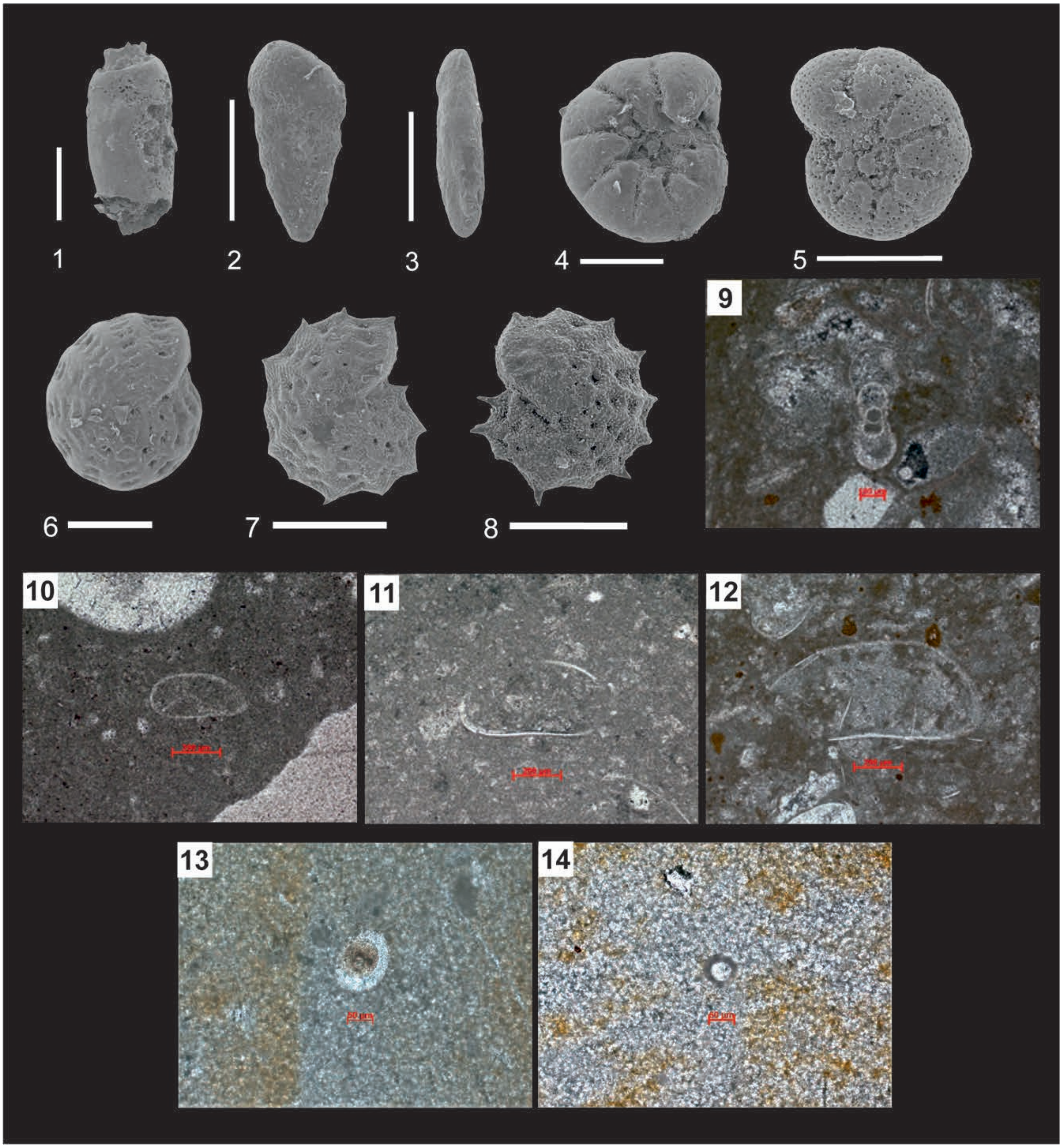


Plate III – III. tábla



Appendix

Systematic Palaeontology

The specimens of foraminifers and ostracods are reposited in the Laboratory of MOL Plc., Exploration and Production Division (Budapest, Hungary).

Foraminifera

Higher classification of the foraminifera follows that of LOEBLICH & TAPPAN (1992). Abbreviations: L: length, B: breadth, D: diameter and Th: thickness.

Phylum Protista
Subphylum Sarcodina SCHMARDA, 1871
Class Foraminifera J.J. LEE, 1990
Order Miliolida LANKESTER, 1885
Suborder Miliolina DELAGE & HERUARD, 1896
Superfamily Milioloidea EHRENBERG, 1839
Family Hauerinidae SCHWAGER, 1876
Subfamily Hauerininae SCHWAGER, 1876
Genus *Cycloforina* LUCZKOWSKA, 1972

Cycloforina contorta (D'ORBIGNY, 1846)
Plate I, fig. 11

1846 *Quinqueloculina contorta* n. sp. D'ORBIGNY, p. 298, pl. 20, figs 4–6.
2008 *Cycloforina contorta* (D'ORBIGNY) – TÓTH & GÖRÖG, p. 196, pl. 1, fig. 1. (cum syn.)
2012 *Cycloforina contorta* (D'ORBIGNY) – GONERA, fig. 2/M.
2012 *Cycloforina contorta* (D'ORBIGNY) – MILKER & SCHMIEDL, pp. 53–54, fig. 14/6.
2014 *Cycloforina contorta* (D'ORBIGNY) – YOKES et al., fig. 8/2.
2016 *Cycloforina contorta* (D'ORBIGNY) – LEI & LI, pp. 98–99, fig. 6.
2016 *Cycloforina contorta* (D'ORBIGNY) – KIRCI-ELMAS & MERIÇ, fig. 3/8.

Dimensions: L= 530–540 µm, B=400–410 µm, Th= 220–240 µm

Stratigraphic range and geographic distribution: Miocene: Carpathian Foredeep and Transcarpathian Basin, Ukraine (BOGDANOWICH 1952, DIDKOWSKY & SATANOVSKAJA 1970); Badenian: Carpathian Foredeep, Poland (LUCZKOWSKA 1974; GONERA 2012), Vienna Basin, Austria (D'ORBIGNY 1846); Badenian to Sarmatian: Mecsek Mts, Hungary (KORECZ-LAKY 1968); Sarmatian: Zsámbék Basin and Budapest, Hungary (GÖRÖG 1992, TÓTH & GÖRÖG 2008). Recently widely distributed over the world.

Subfamily Miliollinellinae VELLA, 1957
Genus *Affinetrina* LUCZKOWSKA, 1972

Affinetrina ucrainica (SEROVA, 1952)
Plate I, fig. 12

1952 *Miliolina ucrainica* n. sp. SEROVA in BOGDANOWICH, p. 104, pl. 8, fig. 2.
1992 *Affinetrina ucrainica* (SEROVA) – GÖRÖG, pp. 79-80, pl. 6, figs 1–3. (cum syn.)
2007 *Affinetrina ucrainica* (SEROVA) – SCHÜTZ et al., p. 453, pl. 2, fig. 2.
2012 *Affinetrina ucrainica* (SEROVA) – MILKER & SCHMIEDL, p. 61, fig. 16/11–13.
2015. *Affinetrina ucrainica* (SEROVA) – SILYE, p. 111, pl. 1, figs 4–5.

Dimensions: L= 500–530 µm, B=200–300 µm, Th= 160–220 µm

Stratigraphic range and geographic distribution: Upper Badenian: Carpathian Foredeep, Poland (LUCZKOWSKA 1974); Upper Badenian – Sarmatian: Transcarpathian Basin and Carpathian Foredeep, Ukraine (DIDKOWSKY & SATANOVSKAJA 1970); Lower Sarmatian: Vienna Basin, Austria (SCHÜTZ et al. 2007); Sarmatian: Moesian Platform, Bulgaria (STANCHEVA 1960), Transylvanian Basin, Romania (SILYE 2015); Zsámbék Basin, Hungary (GÖRÖG 1992). Recently widely distributed in the Mediterranean Sea.

Genus *Pyrgo* DEFRANCE, 1824

Pyrgo subsphaerica (D'ORBIGNY, 1839)
Plate I, fig. 16 (thin section)

1839 *Biloculina subsphaerica* n. sp. D'ORBIGNY, p. 162, pl. 8, figs 25–27.
1974 *Pyrgo subsphaerica* (D'ORBIGNY) – LUCZKOWSKA, pp. 118–119, pl. 22, figs 4a, b.
2008 *Pyrgo subsphaerica* (D'ORBIGNY) – DE ARAÚJO & MACHADO, pl. 1, fig. 3.

Dimensions: B= 660 µm (other dimensions are not examined)

Stratigraphic range and geographic distribution: Upper Badenian: Carpathian Foredeep, Poland (LUCZKOWSKA 1974). Recently widely distributed in the Mediterraen Sea, Caribbean Sea and Atlantic Ocean.

Order Buliminida FURSENKO, 1958
Superfamily Bolivinoidea GLAESSNER, 1937
Family Bolivinidae GLAESSNER, 1937
Genus *Bolivina* D'ORBIGNY, 1839

Bolivina sarmatica DIDKOWSKY, 1959
Plate III, fig. 2

1970 *Bolivina sarmatica* DIDKOWSKY – DIDKOWSKY & SATANOVSKAJA, p. 144, pl. 82, fig. 9. (holotype)
2008 *Bolivina sarmatica* DIDKOWSKY – TÓTH & GÖRÖG, p. 198, pl. 1, fig. 12. (cum syn.)
2011 *Bolivina sarmatica* DIDKOWSKY – GARECKA & OLSZEWSZKA, fig. 6/e.
2011 *Bolivina sarmatica* DIDKOWSKY – FILIPESCU et al., fig. 5/3.
2014 *Bolivina sarmatica* DIDKOWSKY – FILIPESCU et al., fig. 5/19.
2015 *Bolivina sarmatica* DIDKOWSKY – SILYE, p. 129, pl. 4, fig. 17.
2017 *Bolivina sarmatica* DIDKOWSKY – DUMITRIU et al., fig. 13/p.
2018 *Bolivina sarmatica* DIDKOWSKY – HARZHAUSER et al., fig. 5/10.

Dimensions: L= 150–160 μm, B= 90–95 μm

Stratigraphic range and geographic distribution: Sarmatian: Moldavian Plateau (DIDKOWSKY & SATANOVSKAJA 1970), Transcarpathian Basin, Carpathian Foredeep, Volhynian-Podolian Plateau, Ukraine (VENGLINSKY 1975), Western Carpathians (CICHA & ZAPLETALOVÁ 1961), easternmost Pannonian and Transylvanian Basins, Romania (FILIPESCU 1996; FILIPESCU et al. 2011, 2014), Zsámbék Basin and Budapest, Hungary (GÖRÖG 1992, TÓTH & GÖRÖG 2008), Carpathian Foredeep, Poland and Romania (GARECKA & OLSZEWSZKA 2011, DUMITRIU et al. 2017), Vienna Basin, Austria (HARZHAUSER et al. 2018).

Superfamily Buliminoidea JONES, 1875
Family Buliminellidae HOFKER, 1951
Genus *Buliminella* CUSHMAN, 1911

Buliminella elegantissima (D'ORBIGNY, 1839)
Plate III, fig. 3

1839 *Bulimina elegantissima* n. sp. D'ORBIGNY, p. 51, pl. 7, figs 13–14.
2004 *Buliminella elegantissima* (D'ORBIGNY) – VILELA et al., fig. 4/4.
2008 *Buliminella elegantissima* (D'ORBIGNY) – TÓTH & GÖRÖG, pp. 198-199, pl. 2, figs 2–4. (cum syn.)
2011 *Buliminella elegantissima* (D'ORBIGNY) – FILIPESCU et al., fig. 5/10.
2014 *Buliminella elegantissima* (D'ORBIGNY) – FILIPESCU et al., fig. 6/13.

Dimensions: L= 230–320 μm, D= 90–100 μm

Stratigraphic range and geographic distribution: Sarmatian: Black Sea Depression, Ukraine, Moldavian Plateau (DIDKOWSKY & SATANOVSKAJA 1970), Zsámbék Basin and Budapest, Hungary (GÖRÖG 1992, TÓTH & GÖRÖG 2008), easternmost Pannonian and Transylvanian Basins, Romania (FILIPESCU et al. 2011, 2014). Recently widely distributed over the world.

Superfamily Asterigerinoidea D'ORBIGNY, 1839
Family Asterigerinatidae REISS, 1963
Genus *Asterigerinata* REISS, 1963

Asterigerinata planorbis (D'ORBIGNY, 1846)
Plate I, fig. 17 (thin-section)

1846 *Asterigerina planorbis* n. sp. D'ORBIGNY, p. 225, pl. 11, figs 1–3.
1985 *Asterigerina planorbis* D'ORBIGNY – PAPP & SCHMID, pl. 66, figs 9–14.
1985 *Asterigerina planorbis* D'ORBIGNY – KORECZ-LAKY & NAGY-GELLAI, pl. 158, figs 1–4.
1998 *Asterigerinata planorbis* (D'ORBIGNY) – CICHA et al., pl. 64, figs 8–10.
1998 *Asterigerinata planorbis* (D'ORBIGNY) - ZLINSKÁ, pl. 8, figs 10–11.
2007 *Asterigerinata planorbis* (D'ORBIGNY) – SCHÜTZ et al., p. 457, pl. 4, fig. 6.
2010 *Asterigerina planorbis* D'ORBIGNY – ISMAIL et al., pl. 4, figs 4–5.
2012 *Asterigerinata planorbis* (D'ORBIGNY) – GONERA, fig. 4/c.
2013 *Asterigerinata planorbis* (D'ORBIGNY) – PEZELJ et al., fig. 6/17.
2016 *Asterigerinata planorbis* (D'ORBIGNY) – PEZELJ et al., fig. 5/A–H.
2014 *Biasterigerina planorbis* (D'ORBIGNY) – TER BORGH et al., fig. 5/31–32.
2019 *Asterigerinata planorbis* (D'ORBIGNY) – JOVANOVIĆ et al., pl. 1, figs f/6, g/5, h/6.
2020 *Asterigerinata planorbis* (D'ORBIGNY) – PERYT et al., fig. 4/h.

Dimensions: D= 250–350 μm

Stratigraphic range and geographic distribution: Kiscellian: Börzsöny Mts, Hungary (KORECZ-LAKY & NAGY-GELLAI 1985); Badenian: Vienna Basin, Austria (D'ORBIGNY 1846), East-Slovakian Basin (ZLINSKÁ 1998), Dacian Basin, Romania (TER BORGH et al. 2014), Mt Majevica, Bosnia and Herzegovina (PEZELJ et al. 2013, 2016); Koceljeva area, Western Serbia (JOVANOVIĆ et al. 2019); Carpathian Foredeep, Poland (GONERA 2012, PERYT et al. 2020), North-Croatian Basin, Croatia (PEZELJ et al. 2016); Lower Sarmatian: Vienna Basin, Austria (SCHÜTZ et al. 2007); Pliocene: Nile Delta, Egypt (ISMAIL et al. 2010).

Superfamily Nonionoidea SCHULTZE, 1854
Family Nonionidae SCHULTZE, 1854
Subfamily Nonioninae SCHULTZE, 1854
Genus *Nonion* MONTFORT, 1808

Nonion commune (D'ORBIGNY, 1846)
Plate I, fig. 13

1798 *Nautilus scapha* n. sp. FICHTEL & MOLL, p. 105, pl. 19, figs d–f.
1846 *Nonionina communis* D'ORBIGNY – D'ORBIGNY, p. 106, pl. 5, figs 7–8.
2008 *Nonion commune* (D'ORBIGNY) – TÓTH & GÖRÖG, pp. 22–203, pl. 2, figs 14–18. (cum syn.)
2009 *Nonion commune* (D'ORBIGNY) – GEBHARDT et al., pl. 2, fig. 39.
2010 *Nonion commune* (D'ORBIGNY) – KOUBOVÁ & HUDAČKOVÁ, pl. 1, fig. 15.
2012 *Nonion commune* (D'ORBIGNY) – FERRER GARCÍA & BLÁZQUEZ MORILLA, fig. 4/6.

2012 *Nonion commune* (d'Orbigny) – Gonera, fig. 4/e.
2013 *Nonion commune* (d'Orbigny) – Peryt, fig. 4/F.
2013 *Nonion commune* (d'Orbigny) – Pezelj et al., fig. 6/18.
2014 *Nonion commune* (d'Orbigny) – Filipescu et al., fig. 6/7.
2019 *Nonion commune* (d'Orbigny) – Jovanović et al., pl. 1, figs f/14, g/6, h/3.
2019 *Nonion commune* (d'Orbigny) – Roslim et al., fig. 4/33–36.

Dimensions: D= 350–370 μm, Th= 130–160 μm

Stratigraphic range and geographic distribution: Karpatian: Molasse Basin, Austria (Rögl 1969); Badenian: Vienna Basin, Austria and Slovakia (d'Orbigny 1846, Kováčová & Hudáčková 2005), Carpathian Foredeep, Poland (Szczechura 1982, Peryt 2013); Volhynian-Podolian Plateau, Carpathian Foredeep, Transcarpathian Basin, Crimea-Caucasus region and Kuban Lowland, Ukraine and Russia (Voloshinova 1952, Didkowsky & Satanovskaja 1970), Slovenia (Oblak 2007), Mt Majevica, Bosnia and Herzegovina (Pezelj et al. 2013), Koceljeva area, Western Serbia (Jovanović et al. 2019); Badenian to Sarmatian: Mecsek Mts, Tokaj Mts and SW-Hungary, Budapest (Korecz-Laky 1968, 1973, 1982; Báldi 1999; Tóth & Görög 2008), Appenines, Italy (Dieci 1959); Sarmatian: E-Slovakian Basin, Slovakia (Zlinská 1997, Koubová & Hudačková, 2010), Vienna Basin, Austria (Schütz et al. 2007, Gebhardt et al. 2009), easternmost Pannonian Basin, Romania (Filipescu et al. 2014); Upper Miocene: Ambug Hill, Borneo (Roslim et al. 2019). Recently widely distributed over the world.

Superfamily Rotalioidea Ehrenberg, 1839
Family Rotaliidae Ehrenberg, 1839
Subfamily Ammoniinae Saidova, 1981
Genus *Ammonia* Brünnich, 1772

Ammonia cf. *confertitesta* Zheng, 1978
Plate III, fig. 4

Dimensions: D= 250–450 μm

Remaks: The studied specimens are very similar (mainly the spiral side of the test) to the holotype described by Zheng (1978) however the last chamber of the studied specimens in most cases is missing.

Family Elphidiidae Galloway, 1933
Subfamily Elphidiinae Galloway, 1933
Genus *Elphidium* Montfort, 1808

Elphidium aculeatum (d'Orbigny, 1846)
Plate III, figs 7–8

1846 *Polystomella josephina* n. sp. d'Orbigny, p. 130, pl. 6, figs 25–26.
1846 *Polystomella aculeata* n. sp. – d'Orbigny, p. 131, pl. 6, figs 27–28.
1995.*Elphidium aculeatum* (d'Orbigny) – Popescu, p. 94, pl. 7, figs 4–7.
2004 *Elphidium aculeatum* (d'Orbigny) – Brânzilă, pl. 4, fig. 5.
2004 *Elphidium aculeatum* (d'Orbigny) – Meriç et al., pl. 32, figs 5–8.
2005 *Elphidium aculeatum* (d'Orbigny) – Goldbeck et al., pl. 1, fig. 12.
2008 *Elphidium aculeatum* (d'Orbigny) – Tóth & Görög, pp. 204–205, pl. 3, figs 5–6. (cum syn.)
2010 *Elphidium josephinum* (d'Orbigny) – Koubova & Hudačkova, pl. 1, fig. 26.
2011 *Elphidium aculeatum* (d'Orbigny) – Gedl & Peryt, pl. 1, fig. 9/F, I–K.
2012 *Elphidium aculeatum* (d'Orbigny) – Aloulou et al., pl. 1, fig. 13.
2012 *Elphidium aculeatum* (d'Orbigny) – Milker & Schmiedl, p. 119, fig. 27/5–6.
2012 *Elphidium aculeatum* (d'Orbigny) – Gonera et al., fig. 4/K.
2012 *Elphidium aculeatum* (d'Orbigny) – Melis et al., pl. 1, fig. 1.
2012 *Elphidium aculeatum* (d'Orbigny) – Peryt & Jasionowski, fig. 4/C, D, L, M.
2012 *Elphidium aculeatum* (d'Orbigny) – Jasionowski et al., fig. 12/A, B, D, E.
2013 *Elphidium aculeatum* (d'Orbigny) – ter Borgh et al., fig. 6, 8–9.
2014 *Elphidium josephium* (d'Orbigny) – Filipescu et al., fig. 7/10.
2014 *Elphidium aculeatum* (d'Orbigny) – Yokes et al., fig. 11/8.
2015 *Elphidium aculeatum* (d'Orbigny) – Silye, p. 150, pl. 8, figs 1–2, 4.
2017 *Elphidium aculeatum* (d'Orbigny) – Dumitriu et al., fig. 11/Q, R.
2020 *Elphidium aculeatum* (d'Orbigny) – Peryt et al., fig. 3/h.

Dimensions: D= 450–600 μm, Th= 200–350 μm.

Stratigraphic range and geographic distribution: Badenian: Carpathian Foredeep, Poland and Ukraine (Gedl & Peryt 2011, Gonera et al. 2012, Peryt et al. 2020); Late Badenian to Sarmatian: Volhynian–Podolian Plateau, Moldavian Plateau, Moldavia and Carpathian Foredeep, Ukraine (Venglinsky 1958; Didkowsky & Satanovskaja 1970, Brânzilă 2004), Crimea-Caucasus region, South-Caspian Depression, Russia and Azerbaijan (Voloshinova 1952); Sarmatian: Carpathian Foredeep, Poland, Romania and Ukraine (Szczechura 1982, 2000; Jasionowski et al. 2012; Dumitriu et al. 2017), Vienna Basin, Austria and Slovakia (Marks 1951, Papp 1963; Schütz et al. 2007; Koubova & Hudačkova 2010), Danube Basin and East-Slovakian Basin, Slovakia (Brestenská 1974; Zlinská 1997), Tokaj Mts, Mecsek Mts, Zsámbék Basin and Budapest, Hungary (Korecz-Laky 1973, 1968, 1964, 1965, 1982; Görög 1992; Tóth & Görög 2008), easternmost Pannonian and Transylvanian basins, Romania (Kovács 2001, Suciu 2005, Filipescu et al. 2014, Silye 2015); Romanian Plain, Romania (Popescu 1995), Moesian Platform, Bulgaria (Stancheva 1960); Pannonian Basin, Serbia (ter Borgh et al. 2013); Holocene: Mediterranean Sea, Italy (Melis et al. 2012, Yokes et al. 2014). Recently widely distributed over the world.

Remarks: The number and size of spines are variable, it seems to be intraspecific variability. Making the species *Elphidium josephinum* described by d'Orbigny the junior synonym of *E. aculeatum*, thus an invalid name.

Elphidium crispum (Linne, 1758)
Plate I, fig. 14

1758 *Nautilus crispus* n. sp. Linnaeus, p. 709, pl. 1, figs 2d–e.
1988 *Elphidium crispum* (Linné) – Jorissen, p. 120, pl. 3, figs 8–9, pl. 24, figs 1–2.

2004 *Elphidium crispum* (LINNÉ) – MERIÇ et al., pl. 1, figs 16–18.
2004 *Elphidium crispum* (LINNÉ) – MENDES et al., pl. 1, fig. 6.
2004 *Elphidium crispum* (LINNÉ) – BRÂNZILĂ, pl. 4, fig. 11.
2005 *Elphidium crispum* (LINNÉ) – MORIGI et al., pl. 2, fig. 9a–c.
2008 *Elphidium crispum* (LINNÉ) – TÓTH & GÖRÖG, pp. 205–206, pl. 3, figs 7–8. (cum syn.)
2009 *Elphidium crispum* (LINNÉ) – FREZZA & CARBONI, pl. 1, fig. 16.
2010 *Elphidium crispum* (LINNÉ) – KOUBOVA & HUDAČKOVA, pl. 1, fig. 24.
2011 *Elphidium crispum* (LINNÉ) – GEDL & PERYT, fig. 9/C, R.
2012 *Elphidium crispum* (LINNÉ) – FERRER GARCÍA & BLÁZQUEZ MORILLA, pl. 4, fig. 12.
2012 *Elphidium crispum* (LINNÉ) – GONERA, fig. 4/j.
2012 *Elphidium crispum* (LINNÉ) – MILKER & SCHMIEDL, p. 120, fig. 27/13–14.
2012 *Elphidium crispum* (LINNÉ) – MELIS et al., pl. 1, fig. 4.
2012 *Elphidium crispum* (LINNÉ) – ALOULOU et al., pl. 1, fig. 15.
2014 *Elphidium crispum* (LINNÉ) – FILIPESCU et al., fig.7/3.
2014 *Elphidium crispum* (LINNÉ) – YOKES et al., fig. 11/10–11.
2014 *Elphidium crispum* (LINNÉ) – TER BORGH et al., fig. 6/8.
2016 *Elphidium crispum* (LINNÉ) – LEI & LI, p. 361, fig. 84.
2016 *Elphidium crispum* (LINNÉ) – DIMIZA et al., pl. 4, fig. 20.
2016 *Elphidium crispum* (LINNÉ) – PEZELJ et al., fig. 5/ D, I.
2019 *Elphidium crispum* (LINNÉ) – JOVANOVIĆ et al., pl. 1, figs f/3, g/7.
2019 *Elphidium crispum* (LINNÉ) – ROSLIM et al., fig. 4/25.

Dimensions: D= 450–1200 µm, Th=330–350 µm

Stratigraphic range and geographic distribution: Langhian: Aquitaine Basin, France (CAHUZAC & POIGNANT 2000); Karpatian-Badenian: East-Mecsek Mts, Hungary (KORECZ-LAKY 1968); Badenian: Dacian Basin, Romania and Serbia (TER BORGH et al. 2014), Carpathian Foredeep, Poland and Ukraine (GEDL & PERYT 2011, GONERA 2012), Vienna Basin, Austria (PAPP 1963), Apennines, Italy (DIECI 1959), Koceljeva area, Western Serbia (JOVANOVIĆ et al. 2019); Badenian: North-Croatian Basin, Croatia (PEZELJ et al. 2016), Karpatian–Sarmatian: Transcarpathian Basin, Volhynian-Podolian Plateau and Caucasus, Ukraine and Russia (VENGLINSKY 1958, DIDKOWSKY & SATANOVSKAJA 1970); Sarmatian: Carpathian Foredeep, Poland (SZCZECHURA 1982), Mecsek Mts, Zsámbék Basin and Budapest, Hungary (KORECZ-LAKY 1964, 1968; GÖRÖG 1992; TÓTH & GÖRÖG 2008), Vienna Basin, Slovakia (KOUBOVA & HUDAČKOVA 2010); Moldavian Plateau, Moldavia (BRÂNZILĂ 2004); Lower Sarmatian: easternmost Pannonian Basin, Romania (FILIPESCU et al. 2014); Upper Miocene: Ambug Hill, Borneo (ROSLIM et al. 2019); Pliocene: Toscana, Italy (FICHTEL & MOLL 1798); Holocene: Mediterranean Sea, Italy (MORIGI et al, 2005, MELIS et al. 2012). Recently widely distributed over the world.

Elphidium hauerinum (D'ORBIGNY, 1846)
Plate III, fig. 6

1846 *Polystomella Hauerina* n. sp. D'ORBIGNY, p.122, pl. 6, figs 5–10.
1995 *Elphidium hauerinum* (D'ORBIGNY) – POPESCU, p. 95, pl. 8, fig. 10.
2005 *Elphidium hauerinum* (D'ORBIGNY) – FILIPESCU et al., pl. 2, figs 4–5.
2008 *Elphidium hauerinum* (D'ORBIGNY) – TÓTH & GÖRÖG, pl. 3, figs 10–12. (cum syn.)
2010 *Elphidium hauerinum* (D'ORBIGNY) – KOUBOVÁ & HUDAČKOVÁ, pl. 1, fig. 18.
2011 *Elphidium hauerinum* (D'ORBIGNY) – FILIPESCU et al., fig. 4/3.
2011 *Elphidium hauerinum* (D'ORBIGNY) – IONESI & PASCARIU, pl. 1, fig. 29.
2012 *Elphidium hauerinum* (D'ORBIGNY) – JASIONOWSKI et al., fig. 14/E, H, I, M.
2014 *Elphidium hauerinum* (D'ORBIGNY) – FILIPESCU et al., figs 7–9.
2015 *Elphidium hauerinum* (D'ORBIGNY) – SILYE, p. 152, pl. 8, figs 5–7.
2017 *Elphidium hauerinum* (D'ORBIGNY) – DUMITRIU et al., fig. 12/G, H.

Dimensions: D=240–430 µm, Th= 100–150 µm

Stratigraphic range and geographic distribution: Badenian?: Vienna Basin, Austria (D'ORBIGNY 1846); Badenian-Sarmatian: Transcarpathian Basin, Carpathian Foredeep, Ukraine (VENGLINSKY 1958, DIDKOWSKY & SATANOVSKAJA 1970); Sarmatian: Carpathian Foredeep, Ukraine, Poland and Romania (JASIONOWSKI et al. 2012, DUMITRIU et al. 2017), Moldavian Plateau, Romania (IONESI & PASCARIU 2011), N-Caucasus, Russia (VOLOSHINOVA 1952); Moesian Platform, Bulgaria (STANCHEVA 1960), easternmost Pannonian and Transylvanian basins, Romania (FILIPESCU 1996; KOVÁCS 2001; SUCIU 2005; FILIPESCU et al. 2005, 2011, 2014), Romanian Plain, Romania (POPESCU 1995), Vienna Basin, Austria (D'ORBIGNY 1846, PAPP 1963, SCHÜTZ et al. 2007), Tokaj Mts, Zsámbék Basin, Mecsek Mts and Budapest, Hungary (KORECZ-LAKY 1964, 1965, 1968, 1973, 1982; GÖRÖG 1992; TÓTH & GÖRÖG 2008); Danube Basin and East-Slovakian Basin, Slovakia (BRESTENSKÁ 1974, ZLINSKÁ 1997, KOUBOVÁ & HUDAČKOVÁ 2010), Carpathian Foredeep, Poland (SZCZECHURA 1982, 2000).

Genus *Porosononion* PUTRYA in VOLOSHINOVA, 1958

Porosononion granosum (D'ORBIGNY, 1846)
Plate III, figs 5, 9 (thin section)

1846 *Nonionina granosa* n. sp. D'ORBIGNY, p. 110, pl. 5, figs 19–20.
1988 *Elphidium granosum* (D'ORBIGNY) – JORISSEN, p. 104, pl. 2, figs 1–3, pl. 16–19.
1992 *Porosononion granosum* (D'ORBIGNY) – GÖRÖG, pp. 112–113, pl. 11. fig. 5. (cum syn.)
2000 *Porosononion granosum* (D'ORBIGNY) – POIGNANT et al., pp. 400–401, pl. 1, figs 13–14. (cum syn.)
2000 *Porosononion granosum* (D'ORBIGNY) – SZCZECHURA, pl. 5, figs 3, 6.
2000 *Elphidium granosum* (D'ORBIGNY) – CARBONI et al., fig. 10.
2001 *Porosononion granosum* (D'ORBIGNY) – FILIPESCU et al., pl. 3, fig. 11.
2004 *Porosononion subgranosus monogranulata* GERKE – BRÂNZILĂ, pl. 2, figs 7–9.
2007 *Porosononion* ex gr. *granosum* (D'ORBIGNY) – SCHÜTZ et al., pl. 6, fig.6.
2007 *Porosononion granosum* (D'ORBIGNY) – GROSS et al., pp. 210–211, fig. 4 a–e, h–i.
2008 *Cribroelphidium* ex gr. *granosum* (D'ORBIGNY) – TÓTH & GÖRÖG, p. 204, pl. 3., figs 3–4.
non 2010 *Porosononion granosum* (D'ORBIGNY) – KOUBOVÁ & HUDAČKOVÁ, pl. 1, fig. 20.

2011 *Porosononion granosum* (D'ORBIGNY) – FILIPESCU et al., fig. 4/9.
2012 *Elphidium granosum* (D'ORBIGNY) – MILKER & SCHMIEDL, p. 121, fig. 27/17–18.
2013 *Porosononion granosum* (D'ORBIGNY) – TER BORGH et al., fig. 6/4–5.
2015 *Porosononion granosum* (D'ORBIGNY) – SILYE, p. 147, pl. 7, figs 4–5.
2018 *Porosononion granosum* (D'ORBIGNY) – HARZHAUSER et al., fig. 5/1–2.
2019 *Porosononion granosum* (D'ORBIGNY) – NÁÑEZ & MALUMIÁN, pp. 197–201, figs 5–6.

Dimensions: D= 200–500 µm

Stratigraphic range and geographic distribution: Middle Miocene: Atlantic Ocean, Argentina (NÁÑEZ & MALUMIÁN 2019); Badenian: Transylvanian Basin, Romania (FILIPESCU 2001); Badenian–Sarmatian: Vienna Basin, Austria (D'ORBIGNY 1846); Sarmatian: Vienna Basin and Styrian Basin, Austria (GROSS et al. 2007, SCHÜTZ et al. 2007, HARZHAUSER et al. 2018), Zsámbék Basin and Budapest, Hungary (GÖRÖG 1992, TÓTH & GÖRÖG 2008), Transcarpathian Basin, Ukraine (VOLOSHINOVA 1952, VENGLINSKY 1958), Carpathian Foredeep, Poland (SZCZECHURA 2000), Transylvanian Basin, Romania (FILIPESCU et al. 2011, SILYE 2015), Moldavian Plateau (BRÂNZILĂ 2004); Pliocene: Mediterranean Sea, Spain (CARBONNEL & MAGNÉ 1977) and Greece (HAGEMAN 1979). Recently widely distributed over the world.

Remarks: The umbilical region is very variable in this group. Due to the large morphological variation, the taxonomic status of fossil specimens is uncertain. The studied specimen is identical (including umbilical region) to the holotype described by D'ORBIGNY (1846).

Family Cibicididae CUSHMAN, 1927
Subfamily Cibicidinae CUSHMAN, 1927
Genus *Heterolepa* FRANZENAU, 1884

Heterolepa dutemplei (D'ORBIGNY, 1846)
Plate I, figs 10, 18 (thin section)

1846 *Rotalia dutemplei* n. sp. D'ORBIGNY, p. 157, pl. 8, figs 19–21.
1982 *Heterolepa dutemplei* (D'ORBIGNY) – SZCZECHURA, pl. 16, figs 8–9.
1985 *Heterolepa dutemplei* (D'ORBIGNY) – PAPP & SCHMID, p. 59, pl. 50, figs 1–3.
1985 *Heterolepa dutemplei* (D'ORBIGNY) – KORECZ-LAKY & NAGY-GELLAI, pl. 20, fig. 4a–b.
1998 *Heterolepa dutemplei* (D'ORBIGNY) – CICHA et al., pp.107–108, pl. 71, figs 1–3.
1999 *Heterolepa dutemplei* (D'ORBIGNY) – BÁLDI, pp. 209–210, pl. 9, figs 1–6, pl. 10, figs 1–2.
2000 *Heterolepa dutemplei* (D'ORBIGNY) – SZCZECHURA, pl. 1, figs 6, 13.
2001 *Heterolepa dutemplei* (D'ORBIGNY) – FILIPESCU, pl. 3, figs 12–13.
2007 *Heterolepa dutemplei* (D'ORBIGNY) – OZSVÁRT, pp. 84–85, pl. 11, figs 11–13. (cum syn.)
2013 *Heterolepa dutemplei* (D'ORBIGNY) – PERYT, figs 4/V, W, 7/Y
2013 *Heterolepa dutemplei* (D'ORBIGNY) – PEZELJ et al., fig. 6/20.
2014 *Heterolepa dutemplei* (D'ORBIGNY) – TER BORGH et al., fig. 5/41–42.
2014 *Heterolepa dutemplei* (D'ORBIGNY) – STOJANOVA & PETROV, pl. 1, fig. 11.
2016 *Heterolepa dutemplei* (D'ORBIGNY) – VALCHEV & STOJANOVA, pl. 2, figs 3–4.
2016 *Heterolepa dutemplei* (D'ORBIGNY) – PEZELJ et al., fig. 5/M
2017 *Heterolepa dutemplei* (D'ORBIGNY) – HARZHAUSER et al., pl. 2, fig. 13.
2017 *Heterolepa dutemplei* (D'ORBIGNY) – DUMITRIU et al., fig. 9/I, J.
2019 *Heterolepa dutemplei* (D'ORBIGNY) – JOVANOVIĆ et al., pl. 1, fig. h/1.
2019 *Heterolepa dutemplei* (D'ORBIGNY) – ROSLIM et al., fig. 4/8–13.

Dimensions: D=450–600 µm, Th= 200–350 µm

Stratigraphic range and geographic distribution: Middle to Upper Eocene: Paleogene Basin, Hungary (OZSVÁRT 2007); Upper Eocene – Lower Oligocene: Valandovo-Gevgelia Basin, Republic of Macedonia (STOJANOVA & PETROV 2014; VALCHEV & STOJANOVA 2016); Kiscellian to Badenian: Börzsöny Mts, Hungary (KORECZ-LAKY & NAGY-GELLAI 1985); SW-Hungary (BÁLDI 1999); Ottnangian: Austria, Vienna Basin (HARZHAUSER et al. 2017); Badenian: Koceljeva area, Western Serbia (JOVANOVIĆ et al. 2019); Mt Majevica, Bosnia and Herzegovina (PEZELJ et al. 2013); North-Croatian Basin, Croatia (PEZELJ et al. 2016), Austria, Vienna Basin (D'ORBIGNY 1846), Dacian and Transylvanian basins, Serbia and Romania (FILIPESCU 2001, TER BORGH et al. 2014); Carpathian Foredeep, Poland (SZCZECHURA 1982, 2000; PERYT 2013; DUMITRIU et al. 2017), Upper Miocene: Ambug Hill, Borneo (ROSLIM et al. 2019).

Ostracoda

Classification of the ostracods follows that of HARTMANN & PURI (1974) and HORNE et al. (2002). Abbreviations: L: length, H: height.

Phylum Arthropoda SIEBOLD, STANNIUS, 1845
Subphylum Crustacea PENNANT, 1777
Class Ostracoda LATREILLE, 1802
Order Podocopida MÜLLER, 1894
Suborder Cytherocopina BAIRD, 1850
Superfamily Cytheroidea BAIRD, 1850
Family Cytherideidae SARS, 1925
Subfamily Cytherideinae SARS, 1925
Genus *Cyprideis* JONES, 1857

Cyprideis pokorny JIŘIČEK, 1974
Plate II, figs 8–9

1974 *Cyprideis pokorny* n. sp. JIŘIČEK, p. 439, pl. 2, figs 1–4.
2009 *Cyprideis pokorny* JIŘIČEK – TÓTH, p. 87, pl. 4, figs 3,6.

Dimensions: L= 660–720 µm, H= 350–410 µm, L/H= 1.6–1.8.

Stratigraphic range and geographic distribution: Upper Sarmatian: Vienna Basin, Slovakia (JIŘIČEK 1974); Vértes Hill, Hungary (TÓTH 2009).

Family Hemicytheridae PURI, 1953
Subfamily Hemicytherinae PURI, 1953
Genus *Aurila* POKORNÝ, 1955

Aurila cicatricosa (REUSS, 1850)
Plate I, figs 2–3

1850 *Cypridina cicatricosa* n. sp. REUSS, pp. 67–68, pl. 9, fig. 21.
1962 *Mutilus (Aurila) cicatricosa* (REUSS) – STANCHEVA, p. 32, pl. 4, fig. 8.
1971 *Aurila cicatricosa* (REUSS) – CERNAJSEK, pp. 65–69, pl. 6, figs 7–14, pl. 14, fig. 7, pl. 17, fig. 4 a–b. [partim, pl. 14, fig. 8]
1978 *Aurila cicatricosa* (REUSS) – BRESTENSKÁ & JIŘIČEK, p. 409, 432, pl. 6, fig. 1.
2008 *Aurila cicatricosa* (REUSS) – FARANDA et al., pl. 2, figs 4–5.
2004 *Aurila cicatricosa* (REUSS) – AIELLO & SZCZECHURA, pp. 28–30, pl. 5, fig. 2.
2006 *Aurila cicatricosa* (REUSS) – GROSS & PILLER, pp. 47–48, text-fig. 6/1, pl. 21, figs 1-12, pl. 22, figs 8–10.
2006 *Aurila cicatricosa* (REUSS) – SZCZECHURA, fig. 9/9–10.
2012 *Aurila cicatricosa* (REUSS) – SEKO et al., fig.8/P.
2014 *Aurila (Aurila) cicatricosa* (REUSS) – TER BORGH et al., fig.7/16.

Dimensions: L= 900–950 µm, H= 530–580 µm, L/H= 1.6–1.7.

Stratigraphic range and geographic distribution: Badenian: Vienna Basin, Austria (CERNAJSEK 1971, GROSS & PILLER 2006); Carpathian Foredeep, Czech Republic, Poland (BRESTENSKÁ & JIŘIČEK 1978, AIELLO & SZCZECHURA 2004, SZCZECHURA 2006, SEKO et al. 2012); Dacian Basin, Romania (TER BORGH et al. 2014); Late Miocene: Mediterranean, Greece (FARANDA et al. 2008).

Aurila notata (REUSS, 1850)
Plate II, figs 12–13.

1850 *Cypridina notata* n. sp. REUSS, p. 66, pl. 9, fig. 16.
2006 *Aurila (Euaurila?) notata* (REUSS) – GROSS & PILLER, p. 83–84, pl. 29, figs 1–9.
2008 *Aurila notata* (Reuss) – TÓTH, pp. 122–123, pl.8. figs 3–7. (cum syn.)
2017 *Aurila notata* (Reuss) – DUMITRIU et al., fig. 12/Q.
2018 *Aurila notata* (Reuss) – HARZHAUSER et al., fig. 7/10.

Dimensions: L= 900–950 µm, H= 530–580 µm, L/H= 1.6–1.7.

Stratigraphic range and geographic distribution: Upper Sarmatian: Vienna Basin, Austria and Slovakia (CERNAJSEK 1974, JIŘIČEK 1983, ZELENKA 1990, JANZ & VENNEMANN 2005, GROSS & PILLER 2006, HARZHAUSER et al. 2018); Zsámbék Basin, Hungary (TÓTH 2008); Caucasus, Russia (SUZIN 1956); Lower Sarmatian: Moldovian Plateau. Romania (DUMITRIU et al. 2017).

Genus *Hemicytheria* POKORNÝ, 1952

Hemicytheria omphalodes (REUSS, 1850)
Plate II, fig. 11

1850 *Cypridina omphalodes* n. sp. REUSS, p. 75, pl. 10, fig. 7.
2008 *Hemicytheria omphalodes* (REUSS) – TÓTH, pl. 6, figs 2–6. (cum syn.)
2011 *Hemicytheria omphalodes* (REUSS) – OLTEANU, pl. 18, fig. 8.
2014 *Hemicytheria omphalodes* (REUSS) – FILIPESCU et al., fig. 8/10.

Dimensions: L= 810–820 µm, H= 470–480 µm, L/H= 1.7–1.75.

Stratigraphic range and geographic distribution: Upper Badenian: Transylvanian Basin, Romania (OLTEANU 2001); Sarmatian: Vienna Basin, Slovakia (JIŘIČEK 1974, ZELENKA 1990); Zsámbék Basin, Hungary (TÓTH 2008); Lower Sarmatian: Danube Basin and the eastern region, Slovakia (FORDINÁL et al. 2006, FORDINÁL & ZLINSKÁ 1994); Upper Sarmatian: Vienna Basin, Austria (CERNAJSEK 1974); Pannonian: easternmost Pannonian Basin, Transylvanian Basin, Romania (OLTEANU 2001, 2011; FILIPESCU et al. 2014), Pannonian Basin, Croatia (SOKAČ 1972).

Genus *Senesia* JIŘIČEK, 1974

Senesia cinctella (REUSS, 1850)
Plate I, fig. 6

1850 *Cypridina cinctella* n. sp. REUSS, p. 67, pl. 9, fig. 19.
1962 *Mutilus (Aurila) cinctella* (REUSS) – STANCHEVA, p. 35, pl. 4, fig. 9.
1979 *Aurila (Aurila) cinctella* n. ssp. – BASSIOUNI, pp. 118–119, pl. 19, figs 7–8.
2006 *Senesia cinctella* (REUSS) – GROSS & PILLER, pp. 57–58, pl. 31, figs 1–5.

Dimensions: L= 750–760 µm, H= 410–420 µm, L/H= 1.8–1.82

Stratigraphic range and geographic distribution: Lower Miocene: Black Sea Depression, Turkey (BASSIOUNI 1979); Badenian: Vienna Basin, Austria and Slovakia (REUSS 1850, CERNAJSEK 1971, BRESTENSKÁ & JIŘIČEK 1978, GROSS & PILLER 2006); Moesian Plateau, Bulgaria (STANCHEVA 1962).

Subfamily Urocythereidinae HARTMANN & PURI, 1974
Genus *Urocythereis* RUGGIERI, 1950

Urocythereis kostelensis (REUSS, 1850)
Plate I, fig. 4

1850 *Cypridina kostelenis* n. sp. REUSS, p. 68, pl. 9, fig. 22.
1978 *Urocythereis kostelensis* (REUSS) – BRESTENSKÁ & JIŘIČEK, p. 410, 432, pl. 6, fig. 12.
1985 *Urocythereis kostelenis* (REUSS) – ZELENKA, p. 246, pl. 3, fig. 2.
2004 *Urocythereis kostelenis* (REUSS) – ZORN, p. 180, fig. 4/10–11.
2006 *Urocythereis kostelenis* (REUSS) – GROSS & PILLER, pp. 106–108, pl. 38, figs 1–5,9,11–12.

Dimensions: L= 820–835 µm, H= 410–420 µm, L/H= 1.9–2.

Stratigraphic range and geographic distribution: Badenian: Carpathian Foredeep, Poland (REUSS 1850), Vienna and Molasse basins, Austria and Slovakia (REUSS 1850, BRESTENSKÁ & JIŘIČEK 1978, ZELENKA 1985, ZORN 2004; GROSS & PILLER 2006).

Family Leptocytheridae Hanai, 1957
Subfamily Leptocytherinae Hanai, 1957
Genus *Amnicythere* Devoto, 1965

Amnicythere cernajseki Stancheva, 1984
Plate II, figs 2–3

1963 *Leptocythere modesta* n. sp. Stancheva, p. 22, pl. 3, fig. 8.
1974 *Leptocythere* sp. – Cernajsek, p. 476, pl. 2, fig. 7.
1984 *Amnicythere cernajseki* nom. nov. – Stancheva, p. 39, pl. 1, fig. 5.
1998 *Amnicyther* aff. *plana* (Schneider) – Olteanu, p. 153, pl. 8, fig. 7.
2008 *Amnicythere* (?) sp.– Tóth, p. 110, pl. 2, figs 5–6.
2011 *Amnicythere cernajseki* Stancheva – Filipescu et al., fig. 5/20.

Dimensions: L= 570–600 µm, H= 260–300 µm, L/H= 2–2.19.

Stratigraphic range and geographic distribution: Sarmatian: Vienna Basin, Austria (Cernajsek 1974); Lower Sarmatian: Transylvanian Basin, Romania (Olteanu 1998); Upper Sarmatian: Zsámbék Basin, Hungary (Tóth 2008); Transylvanian Basin, Romania (Filipescu et al. 2011).

Amnicythere tenuis (Reuss, 1850)
Plate II, fig. 1

1850 *Cytherina tenuis* n. sp. Reuss, p. 53, pl. 8, fig. 14.
2008 *Amnicythere tenuis* (Reuss) – Tóth, p. 109–110, pl. 2, figs 1–3, 5. (cum syn.)
2013 *Amnicythere tenuis* (Reuss) – ter Borgh et al., fig. 6/14–15.
2014 *Amnicythere tenuis* (Reuss) – ter Borgh et al., fig. 8/27–28.
2015 *Amnicythere tenuis* (Reuss) – Silye, pl. 10, figs 1–3.
2018 *Amnicythere tenuis* (Reuss) – Harzhauser et al., fig. 7/3.

Dimensions: L= 510–550 µm, H= 250–290 µm, L/H= 1.96–2.3.

Stratigraphic range and geographic distribution: Sarmatian: Vienna Basin, Austria (Cernajsek 1974, Harzhauser et al. 2018); Carpathian Foredeep, Poland (Szczechura 2000); Zsámbék Basin and Budapest, Hungary (Tóth 2004, 2008); Lower Sarmatian: East-Slovakian Basin, Slovakia (Zlinská & Fordinál 1995); Transylvanian Basin, Romania (Olteanu 1998, Silye 2015); Pannonian and Dacian basins, Serbia and Romania (ter Borgh et al. 2013, 2014); Bessarabian: Moesian Plate, Bulgaria (Stancheva 1963, 1990); Pannonian: Pannonian Basin, Hungary (Méhes 1908); Pontian: Dacian Basin, Romania (Hanganu 1974).

Genus *Callistocythere* Ruggieri, 1953

Callistocythere canaliculata (Reuss, 1850)
Plate I, fig. 1

1850 *Cypridina canaliculata* n. sp. Reuss, p. 76, pl. 9, fig. 12.
2006 *Callistocythere canaliculata* (Reuss) – Gross & Piller, pp. 25–26, pl. 8, figs 1–4, 8–9, pl. 10, figs 1–2. (cum syn.)
2011 *Callistocythere* aff. *canaliculata* (Reuss) – Hajek-Tadesse & Prtoljan, figs 4, 9.
2019 *Callistocythere canaliculata* (Reuss) – Brinkmann et al., fig. 4/P.

Dimensions: L= 570–600 µm, H= 260–300 µm, L/H= 2–2.19.

Stratigraphic range and geographic distribution: Ottnangian: North Alpine Foreland Basin, Germany (Brinkmann et al. 2019); Karpatian: Molasse Basin, Austria (Zorn 2003, 2004); Badenian: Vienna Basin and Danube Basin, Slovakia (Brestenská & Jiřiček 1978, Gross & Piller 2006); Transylvanian Basin, Romania (Olteanu 1998); Carpathian Foredeep, Poland (Paruch-Kulczycka 1992; Paruch-Kulczycka & Szczechura 1996, Aiello & Szczechura 2004); Sarmatian: Tokaj Mts, Hungary (Pietrzeniuk 1973); North-Croatian Basin, Croatia (Hajek-Tadesse & Prtoljan 2011).

Genus *Euxinocythere* Stancheva, 1968

Euxinocythere (Euxinocythere) naca (Méhes, 1908)
Plate II, fig. 7

1908 *Cythere naca* n. sp. Méhes, p. 548–549, pl. 10, figs 8–12.
1989 *Leptocythere naca* (Méhes) – Sokač, p. 687, pl. 8, fig 10.
1989 *Leptocythere (Amnicythere) naca* (Méhes) – Olteanu, pl. 8, fig. 6.
1989 *Euxinocythere (Euxinocythere)* cf. *naca* (Méhes) – Krstić & Stancheva, p. 778, pl. 11, fig. 3.
2008 *Euxinocythere (Euxinocythere) naca* (Méhes) – Tóth, pp. 112–113, pl. 1, fig.7. (cum syn.)
2009 *Euxinocythere (Euxinocythere) naca* (Méhes) – Tóth, p. 84, pl. 3, fig. 3.
2011 *Leptocythere (Euxinocythere) naca* (Méhes) – Olteanu, pl. 19, fig. 1.
2013 *Euxinocythere naca* (Méhes) – ter Borgh et al., fig. 8/10.

Dimensions: L= 470–510 µm, H= 235–260 µm, L/H= 1.88–1.95.

Stratigraphic range and geographic distribution: Sarmatian: Vienna and Danube basins, Austria and Slovakia (Cernajsek 1974, Zelenka 1990); Moldavian Plateau, Romania (Ionesi & Chintăuan 1975, 1985); Carpathian Foredeep, Poland (Szczechura 2000); Volhynian: Moesian Plate, Northern Bulgaria (Stancheva 1990); Zsámbék Basin, Hungary (Tóth 2008, 2009); Pannonian-Pontian: Pannonian Basin, Hungary and Serbia (Krstić 1973, Méhes 1908, Széles 1982, Krstić & Stancheva 1989; ter Borgh et al. 2013); North-Croatian Basin, Croatia (Sokač 1967, 1972, 1989); Transylvanian Basin, Romania (Olteanu 2011); Pontian: Dacian Basin, Romania (Olteanu 1989); South Caspian Basin, Azerbaijan (Agalarova 1967).

Euxinocythere (Euxinocythere) praebosqueti (Suzin, 1956)
Plate II, figs 4–6

1956 *Leptocythere praebosqueti* n. sp. Suzin, p. 83, pl. 3, figs 2–4.
2008 *Euxinocythere (Euxinocythere) praebosqueti* (Suzin) – Tóth, p. 114, pl. 3, figs 2–5. (cum syn.)
2013 *Euxinocythere (Euxinocythere) praebosqueti* (Suzin) – Van Baak et al., fig. 4/13.

Dimensions: L= 490–510 µm, H= 200–260 µm, L/H= 1.9–2.1.

Stratigraphic range and geographic distribution: Sarmatian: Moesian Plate, Northern Bulgaria (STANCHEVA 1972, 1990); Upper Sarmatian: Zsámbék Basin, Hungary (TÓTH 2008); Bessarabian: Caucasus, Russia (SUZIN 1956); Plio-Pleistocene: South Caspian Basin, Azerbaijan (VAN BAAK et al. 2013).

Family Loxoconchidae SARS, 1925
Subfamily Loxoconchinae SARS, 1925
Genus *Loxoconcha* SARS, 1866

Loxoconcha kochi MÉHES, 1908
Plate II, figs 14–15

1908 *Loxoconcha kochi* n. sp. MÉHES, pp. 543–544, pl. 9, figs 5–9.
2005 *Loxoconcha kochi* MÉHES – FILIPESCU et al., pl. 3, fig. 6.
2006 *Loxoconcha kochi*? MÉHES – GROSS & PILLER, pp. 112–113, pl. 40, figs 1–7,9.
2008 *Loxoconcha kochi* MÉHES – TÓTH, p. 124, pl. 9, fig. 6. (cum syn.)
2013 *Loxoconcha kochi* MÉHES – TER BORGH et al., fig. 8/24–25.
2014 *Loxoconcha kochi* MÉHES - TER BORGH et al., fig. 7/23.
2014 *Loxoconcha kochi* MÉHES – FILIPESCU et al., fig.8/15.
2018 *Loxoconcha kochi* MÉHES – HARZHAUSER et al., fig.7/12.

Dimensions: L= 640–835 µm, H= 400–520 µm, L/H= 1.6–1.75.

Stratigraphic range and geographic distribution: Upper Badenian: Vienna Basin, Austria (GROSS & PILLER 2006); Dacian Basin, Romania (TER BORGH et al. 2014); Sarmatian: Vienna Basin, Austria (CERNAJSEK 1974, GROSS & PILLER 2006, HARZHAUSER et al. 2018); easternmost Pannonian and Transylvanian basins, Blacks Sea Depression, Romania (IONESI & CHINTĂUAN 1985; FILIPESCU et al. 2005, 2014); Upper Sarmatian: Zsámbék Basin, Hungary (TÓTH 2008); Pannonian Basin, Serbia (TER BORGH et al. 2013); Lower Pannonian (?): Pannonian Basin, Hungary (MÉHES 1908); Messinian and Pliocene (?): Rhône Valley, France (CARBONNEL 1978).

Loxoconcha laeta STANCHEVA, 1963
Plate II, fig. 16

1963 *Loxoconcha laeta* n.sp. STANCHEVA, pp. 34–35, pl.6, fig 9.
1990 *Loxoconcha laeta* STANCHEVA – STANCHEVA, pp. 88–89, pl. 31, figs 5–6.
2009 *Loxoconcha laeta* STANCHEVA – TÓTH, pp. 91–92, pl. 7, fig. 12.

Dimensions: L= 720–750 µm, H= 390–410 µm, L/H= 1.8–1.83.

Stratigraphic range and geographic distribution: Lower Sarmatian: Moesian Plate, Bulgaria (STANCHEVA 1963, 1990); Upper Sarmatian: Zsámbék Basin, Hungary (TÓTH 2009).

Loxoconcha porosa MÉHES, 1908
Plate II, fig. 17

1908 *Loxoconcha porosa* n. sp. MÉHES, pp. 542–543, pl. 8, figs 10–14.
2008 *Loxoconcha porosa* MÉHES – TÓTH, pp. 124–125, pl. 9, figs 3–5. (cum syn.)

Dimensions: L= 620–700 µm, H= 420–470 µm, L/H= 1.45–1.55.

Stratigraphic range and geographic distribution: Sarmatian: Pannonian Basin, Serbia (KRSTIĆ 1972); Black Sea Depression, Romania (IONESI & CHINTĂUAN 1985); Upper Sarmatian: Vienna Basin, Slovakia (ZELENKA 1990); Zsámbék Basin, Hungary (TÓTH 2008); Pannonian: Pannonian Basin, Hungary and Croatia (MÉHES 1908, SOKAČ 1972).

Loxoconcha punctatella (REUSS, 1850)
Plate I, fig. 5

1850 *Cypridina punctatella* n. sp. REUSS, pp. 65–66, pl. 9, fig. 15 a–b.
1978 *Loxoconcha punctatella* (REUSS) – BRESTENSKÁ & JIŘIČEK, pl. 2, figs 12–13.
1985 *Loxoconcha punctatella* (REUSS) – ZELENKA, pl. 3, figs 10–11.
2004 *Loxoconcha* ex. gr. *punctatella* (REUSS) – TÓTH, pp. 140–141, pl. 6, figs 1–2.
2006 *Loxoconcha punctatella* (REUSS) – GROSS & PILLER, pp. 73–74, pl. 40, figs 8,11, pl. 41, figs 1–10. (cum syn.)
2006 *Loxocorniculum* cf. *punctatella* (REUSS) – SZCZECHURA, fig. 10/3.
2008 *Loxoconcha* ex. gr. *punctatella* (REUSS) – TÓTH, p. 125, pl. 10, figs 1–2.
2011 *Loxoconcha punctatella* (REUSS) – HAJEK-TADESSE & PRTOLJAN, fig. 4/16.
2012 *Loxoconcha punctatella* (REUSS) – SEKO et al., fig. 8/D.
2013 *Loxoconcha punctatella* (REUSS) – TER BORGH et al., fig. 6/28.
2019 *Loxoconcha punctatella* (REUSS) – BRINKMANN et al., fig. 8/N–O.

Dimensions: L= 540–670 µm, H= 400–450 µm, L/H= 1.4–1.54.

Stratigraphic range and geographic distribution: Burdigalian: Molasse Basin, Austria (BRINKMANN et al. 2019); Karpatian: Molasse Basin, Austria (ZORN 1998); Badenian: Danube Basin and Vienna Basin, Slovakia (BRESTENSKÁ & JIŘIČEK 1978, ZELENKA 1985); Molasse Basin, Austria (ZORN 2004); Carpathian Foredeep, Czech Republic and Poland (PARUCH-KULCZYCKA 1992, SZCZECHURA 2006, SEKO et al. 2012); North-Croatian Basin, Croatia (HAJEK-TADESSE & PRTOLJAN 2011); Badenian to Sarmatian: Vienna Basin, Austria (GROSS & PILLER 2006); Lower Sarmatian: Zsámbék Basin, Hungary (TÓTH 2004, 2008); Pannonian Basin, Serbia (TER BORGH et al. 2013).

Genus *Loxocorniculum* BENSON & COLEMAN, 1963

Loxocorniculum hastatum (REUSS, 1850)
Plate II, figs 19–20

1850 *Cytherina hastata* REUSS sensu CERNAJSEK – REUSS, pl. 9, fig. 26.
2008 *Loxocorniculum hastatum* (REUSS) – TÓTH, pp.125–126, pl. 9, figs 1–2. (cum syn.)
2012 *Loxocorniculum hastatum* (REUSS) – SEKO et al., fig. 8/F.
2014 *Loxocorniculum hastatum* (REUSS) – TER BORGH et al., fig.7/22.
2017 *Loxocorniculum hastatum* (REUSS) – DUMITRIU et al., fig. 13/I–J.
2019 *Loxocorniculum hastatum* (REUSS) – BRINKMANN et al., p. 84, fig. 8/M.

Dimensions: L= 620–630 μm, H= 390–410 μm, L/H= 1.5–1.6.

Stratigraphic range and geographic distribution: Oligocene to Miocene (Aquitanian, Burdigalian, Langhian): Aquitaine Basin, France (DUCASSE et al. 1991, BEKAERT et al. 1991, DUCASSE & CAHUZAC 1996); Burdigalian: Molasse Basin, Austria (BRINKMANN et al. 2019); Rhône Basin, France (CARBONNEL 1969); Eggenburgian: Molasse Basin, Austria (KOLLMANN 1971); Karpatian: Vienna Basin, Czech Republic (KHEIL 1967); Molasse Basin, Austria (ZORN 1998, 2003, 2004); Badenian: Molasse Basin, Austria (ZORN 1998, 2004); Carpathian Foredeep, Poland and Czech Republic (PARUCH-KULCZYCKA 1992, SZCZECHURA 2006, SEKO et al. 2012); Vienna Basin, Austria and Czech Republic (CERNAJSEK 1974, BRESTENSKÁ & JIŘIČEK 1978, JANZ & VENNEMANN 2005, ZELENKA 1985); Moesian Platform, Bulgaria (STANCHEVA 1962); Dacian Basin, Romania (TER BORGH et al. 2014); Carpathian Foredeep, Poland (AIELLO & SZCZECHURA 2004); Sarmatian: Mecsek Mts and Zsámbék Basin, Hungary (SZUROMI-KORECZ & SZEGŐ 2001, TÓTH 2008); Carpathian Foredeep, Poland (DUMITRIU et al. 2017).

Family Xestoleberididae SARS, 1928
Genus *Xestoleberis* SARS, 1866

Xestoleberis dispar MUELLER, 1894
Plate I, fig. 8

1894 *Xestoleberis dispar* n. sp. MÜLLER, p. 334, pl. 25, figs 2, 3, 9, 35.
1982 *Xestoleberis dispar* MÜLLER – FARANDA et al., pl. 2, figs 16–17.
1986 *Xestoleberis* sp. – MOSTAFAWI, pl. 3, fig. 33.
2006 *Xestoleberis* aff. *dispar* MÜLLER – GROSS & PILLER, pp. 137–138, pl. 2, fig. 4.
2008 *Xestoleberis dispar* MÜLLER – KOEHN-ZANINETTI & TÉTARD, fig. 4/10.
2014 *Xestoleberis dispar* (MUELLER) – TER BORGH et al., fig.7/26–27.
2015 *Xestoleberis dispar* MUELLER – SCIUTO et al., pl. 2, fig. 6.
2016 *Xestoleberis dispar* MUELLER – PARLAK & NAZIK, pl. 3, fig. 14.
2017 *Xestoleberis fuscata* SCHNEIDER – DUMITRIU et al., fig. 13/H.

Dimensions: L= 660–665 μm, H= 350–370 μm, L/H= 1.80–1.88.

Stratigraphic range and geographic distribution: Badenian: Dacian Basin, Romania (TER BORGH et al. 2014); upper Badenian to lower Sarmatian: Vienna Basin, Austria (GROSS & PILLER 2006); lower Sarmatian: Carpathian Foredeep, Poland (DUMITRIU et al. 2017); Tortonian, Pleistocene: Mediterranean Sea, Greece (FARANDA et al. 2008, MOSTAFAWI 1986); Recently widely distributed in the Mediterranean Sea.

Xestoleberis tumida (REUSS, 1850)
Plate I, fig. 7

1850 *Cytherina tumida* n. sp. REUSS, pp. 57–58, pl.8, fig. 29.
2006 *Xestoleberis tumida* (REUSS) – GROSS & PILLER, pp. 134–137. pl. 48, figs 1–10, pl. 49, figs 1–5, pl. 51, fig. 7. (cum syn.)
2006 *Xestoleberis* cf. *tumida* (REUSS) – SZCZECHURA, fig. 10/2,4.

Dimensions: L= 510–540 μm, H= 320–330 μm, L/H= 1.6–1.8.

Stratigraphic range and geographic distribution: Karpatian: Molasse Basin, Austria (ZORN 1998); Badenian: Carpathian Foredeep, Poland (SZCZECHURA 2006); Austria (ZORN 1998; GROSS & PILLER 2006).

Suborder Cypridocopina BAIRD, 1845
Superfamily Cypridoidea BAIRD, 1845
Family Cyprididae BAIRD, 1845
Subfamily Cyprinotinae BRONSHTEIN, 1947
Genus *Heterocypris* CLAUS, 1892

Heterocypris salina (BRADY, 1868)
Plate II, fig. 26

1868 *Cypris salina* n. sp. BRADY, p. 368; pl. 28, figs 8–13.
1980 *Heterocypris salina salina* (BRADY) – FREELS, p.28. pl. 3, figs 1–6. cum syn.
2000 *Heterocypris salina* (BRADY) – MEISCH, pp. 349–352, fig. 135.
2003 *Heterocypris salina* (BRADY) – MISCHKE et al., fig. 1/7.
2004 *Heterocypris salina* (BRADY) – PIPÍK, p.227, pl. 1, figs 6–7.
2005 *Heterocypris salina* (BRADY) – MATZKE-KARASZ, p. 126, pl. 3, fig. 4.
2005 *Heterocypris salina* (BRADY) – SCHARF et al., pl. 2, figs 17–20.
2008 *Heterocypris salina* (BRADY) – NAZIK et al., pl. 1, fig. 15.
2008 *Heterocypris salina* (BRADY) – POQUET et al., fig. 6/I.
2012 *Heterocypris salina* (BRADY) – MISCHKE et al., pl. 1, figs 7–10, 18.
2014 *Heterocypris salina* (BRADY) – SCHARF & MEISCH, fig. 3/I–K.
2014 *Heterocypris salina* (BRADY) – MISCHKE et al., fig. 7/2.
2016 *Heterocypris salina* (BRADY) – SALEL et al., pl. 4, figs 4–6.
2019 *Heterocypris salina* (BRADY) – TUNCER et al., pl. 1, figs 1–3.

Dimensions: L= 945–955 μm, H= 565–590 μm, L/H= 1.61–1.67.

Stratigraphic range and geographic distribution: Widely distributed in upper Miocene to Holocene freshwater to saline habitats (riverine pools and lakes) in Europe (MEISCH 2000) and recently over the world.

Suborder Darwinulocopina BRADY & NORMAN, 1889
Superfamily Darwinuloidea BRADY & NORMAN, 1889
Family Darwinulidae BRADY & NORMAN, 1889
Genus *Darwinula* BRADY & NORMAN, 1889

Darwinula stevensoni (BRADY & ROBERTSON, 1870)
Plate II, fig. 21

1870 *Polycheles stevensoni* m. BRADY & ROBERTSON, pp. 25–26, pl. 7, figs 1–7, pl. 10, figs 4–14.
2000 *Darwinula stevensoni* (BRADY & ROBERTSON) – MEISCH, p. 49, fig. 16/A–E.
2004 *Darwinula stevensoni* (BRADY & ROBERTSON) – PIPÍK et al., pl. 1, fig. 10.
2005 *Darwinula stevensoni* (BRADY & ROBERTSON) – CABRAL et al., pp. 53–55, pl. 1, figs 1–6. (cum syn.)
2012 *Darwinula stevensoni* (BRADY & ROBERTSON) – FUHRMANN, pl. 1, figs 1 a–f.

Dimensions: L= 670–680 μm, H= 420–425 μm, L/H= 1.59–1.6.

Stratigraphic range and geographic distribution: Widely distributed in Oligocene to Holocene lacustrine environments in Europe (MEISCH 2000) and recently over the world.

Genus *Vestalenula* ROSSETTI & MARTENS, 1998

Vestalenula pagliolii (PINTO & KOTZIAN, 1961)
Plate II, figs 22–23; Plate III, fig. 10 (thin-section)

1961 *Darwinula pagliolii* n. sp. PINTO & KOTZIAN, p. 27, pl. 1, figs 1–5, pl. 3, figs 1–4, pl. 5, figs 1–9, pl. 6, figs 1–9, pl. 9, figs 1–9.
2003 *Vestalenula pagliolii* (PINTO & KOTZIAN) – PIPÍK & BODERGAT, p. 348, pl. 1, figs 5–10, fig. 24. (cum syn.)
2004 *Vestalenula pagliolii* (PINTO & KOTZIAN) – PIPÍK et al., pl. 1, fig. 11.
2005 *Vestalenula pagliolii* (PINTO & KOTZIAN) – CABRAL et al., pp. 59–60, pl. 3, figs 5–16.

Dimensions: L= 455–470 μm, H= 210–220 μm, L/H= 2.16–2.18.

Stratigraphic range and geographic distribution: Widely distributed in Oligocene to Holocene freshwater to oligohaline habitats (riverine pools and lakes) in Europe (MEISCH 2000) and recently in Brazil (MARTENS et al. 1997).