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Early Sarmatian biota in the northern part of the Danube Basin (Slovakia)

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Abstract: Lower Sarmatian molluscan (gastropod, bivalve), foraminiferal, ostracod, bryozoan and algal taphocenotic associations occur in northern part of the Danube Basin in SW Slovakia. Bryozoan associations are dominated by stenohaline forms such as *Hippopleurifera* cf. *semicristata* (Reuss), *Hippadenella regularis* (Reuss) and *Celleporina* sp. Their occurrence along with other paleoecological and isotopical indicators gives ground for inferring a local persistence of full-marine conditions in this part of the Lower Sarmatian Central Paratethys.

Key words: Early Sarmatian, Central Paratethys, stratigraphy, paleoenvironmental reconstruction, Mollusca, Foraminifera, Ostracoda, Bryozoa.

Introduction

During Miocene times the Danube Basin was a part of the Central Paratethys. From the Late Badenian to Early Sarmatian the sea level dropped rapidly in the whole Paratethys and the area lost connection with the open sea (Rögl & Steininger 1983). This isolation resulted in reduction of salinity, causing extinction of stenohaline organisms, corals, radiolarians and many species of molluscs, foraminifers, ostracods and calcareous nannoplankton. New paleoecological and isotopic studies (Latal et al. 2004; Piller & Harzhauser 2005) indicate that the isolation of the basin did not result in decrease of salinity everywhere. A new transgression started at the beginning of the Sarmatian and formed a large epicontinental basin situated between the Alps in the west and the Aral Sea in the east (Paramonova 1994). The basin was characterized by high alkaline waters oversaturated with carbonate (Pisera 1996), by uniform environmental conditions (Rögl 1998), and by episodic connections with the Mediterranean (Paramonova 1994).

In the West Carpathian basins (both the Vienna and Danube Basins), the regression at the boundary between the Late Badenian and Early Sarmatian formed a freshwater to brackish lake and Badenian sediments were eroded (Hudáčková & Kováč 1993). During Early Sarmatian transgression, the sedimentation started with shallow water deposits (Kováč 2000) characterized by occurrence of large foraminifers of the *Elphidium reginum* Biozone in the sense of Grill (1941).

Characteristics of Sarmatian sediments of the northern part of the Danube Basin

The basal member of the Vráble Formation (Priechodská in Harčár et al. 1988) of Early Sarmatian age starts with freshwater gravels and sands containing redeposited Badenian marine foraminifers.

These sediments are passing both laterally and vertically into variegated pelitic sediments without fossils. They are overlain by fine-grained sands and sandy clays with abundant carbonized parts of plants, and higher up, by greenish-grey calcareous clays with rich assemblages of molluscs, in which *Mohrensternia* cf. *inflata* (M. Hoernes), *M. styriaca* Hilber, *M.* cf. *sarmatica* Friedbberg, *M. banatica* Jekelius, *Pseudamnicola sarmatica sarmatica* Jekelius, *Acteocina lajonkaireana lajonkaireana* (Basterot), *Hydrobia stagnalis andrusovi* Hilber dominate, and with associations of foraminifers consisting of *Elphidium reginum* (d'Orbigny), *E. crispum* (Linné), *E.* cf. *josephinum* (d'Orbigny), *E. aculeatum* (d'Orbigny) and *Nonion* cf. *bogdanowiczi* Voloshinova (Mořkovský 1960).

Middle Sarmatian sediments of the *Elphidium haueri-num* Biozone (Grill 1941) in the Vráble Formation are represented by basinal pelites and marginally by sand. Basinal sediment includes greyish, greenish to grey and blue-greenish clays. Locally, the clays are rusty in colour, typically without any microfauna. Only a few foraminifers have been determined: *Elphidium* cf. *hauerinum* (d'Orbigny), *E. crispum* (Linné), *Ammonia beccarii* (Linné) and *Nonion* cf. *bogdanowiczi* Voloshinova (Dlugi & Svoboda 1958; Mořkovský 1960). The marginal development is characterized by a layer of gravels to coarse-grained sands about 5 m thick, but thinning out towards the margin of the basin (Mořkovský l.c.).

The Upper Sarmatian part of the Vráble Formation comprises pale greenish to greyish clays, frequently with rusty mottled calcareous portions in their basal parts and fine-grained to medium-grained sand, which often passes to rudaceous sand to gravel at the top. The following fauna has been determined from Upper Sarmatian sediments: foraminifers *Nonion granosum* (d'Orbigny), *N. bogdanowiczi* Voloshinova, *Ammonia beccarii* (Linné), *Elphidium* ex gr.

macellum (Fichtel et Moll), ostracods *Hemicytheria lörenthey* (Méhes), gastropods *Pirenella* and *Hydrobia,* and bivalves *Cardium* (Čermák 1969; Lunga 1964; Mořkovský 1960).

In the deeper part of the basin, a regressive trend may be indicated in Upper Sarmatian sediments with coaliferous clays and wooden lignite (Mořkovský l.c.).

The Dubová section

A very instructive and fossiliferous section near Dubová village was excavated during construction works for dump place below the eastern slopes of the Malé Karpaty Mts about 10 km north of the town of Pezinok (Fig. 1). Grey to greenish clays of the Vráble Formation contain thin tempestite intercalations of molluscan shell debris.

Abundant fauna of molluscs (gastropods, bivalves), foraminifers, ostracods, bryozoans and calcareous cysts of algae *Chalmasia morelleti* Pokorný has been found in these shell beds.

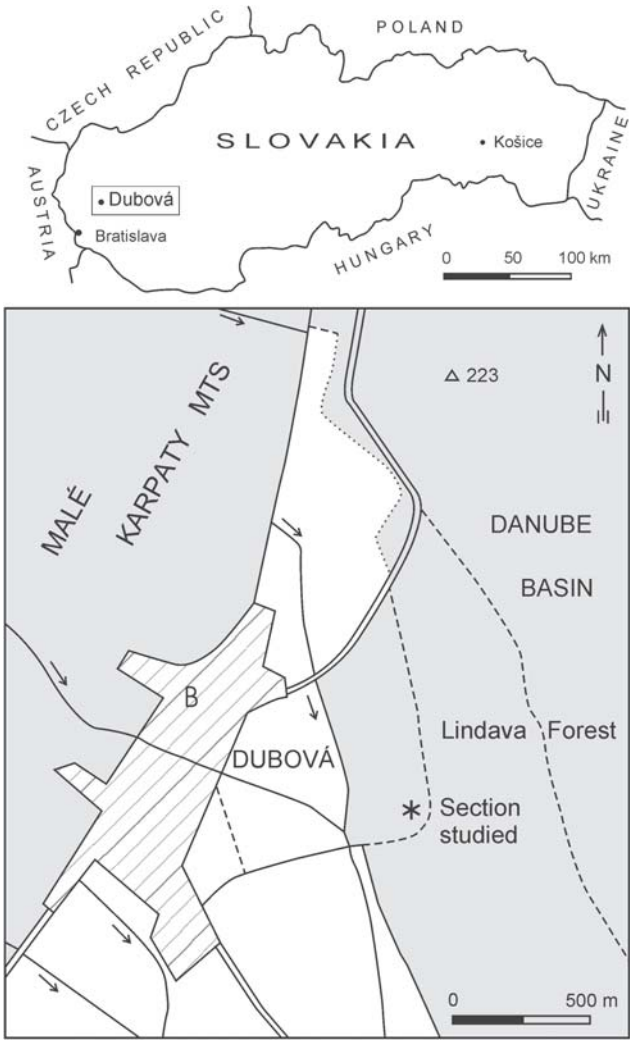

Fig. 1. Geographical sketch map of the Dubová locality.

Table 1: Fauna determined from the Dubová locality.

List of species found

Gastropoda

Actecina lajonkaireana lajonkaireana (Basterot)
Calliostoma angulata spirocarinata Papp
Hydrobia stagnalis (Basterot)
Mohrensternia pseudoangulata pseudoangulata Hilber
Mohrensternia pseudoangulata politioanei Jekelius
Mohrensternia inflata (M. Hoernes)
Mohrensternia banatica Jekelius
Mohrensternia styriaca Hilber
Ocinebrina sublavata sublavata (Basterot)
Pirenella soceni Jekelius
Pseudamanicola immunata (M. Hoernes)

Bivalvia

Cardium procarpatinum spinosum (Jekelius)
Ervilia dissita dissita Eichwald
Inaequicostata politioanei suessiformis (Jekelius)
Musculus sarmaticus (Gatujev)
Obsoletiforma obsoleta ghergutai (Jekelius)

Foraminifera

Ammonia beccarii (Linné)
Articulina articulinoides Gerke et Issaeva
Articulina problema Bogdanowicz
Bulimina schischkinskayae (Samoylova)
Cycloforina contorta (d'Orbigny)
Cycloforina sp.
Elphidium aculeatum (d'Orbigny)
Elphidium crispum (Linné)
Elphidium fichtelianum (d'Orbigny)
Elphidium josephinum (d'Orbigny)
Elphidium macellum (F.-M.)
Elphidium reginum (d'Orbigny)
Nonion bogdanowiczi Voloshinova
Porosononion granosum (d'Orbigny)
Porosononion cf. *martkobi* (Bogdanowicz)
Quinqueloculina akneriana d'Orbigny
Quinqueloculina badenensis (d'Orbigny)
Quinqueloculina boueana d'Orbigny
Quinqueloculina hauerina (d'Orbigny)
Rosalina obtusa d'Orbigny
Schackoinella imperatoria (d'Orbigny)
Porosononion granosum (d'Orbigny)

Ostracoda

Aurila mehesi (Zalányi)
Cytheridea hungarica (Zalányi)
Hemicytheria omphalodes omphalodes (Reuss)
Leptocythere tenuis (Reuss)
Loxoconcha schmidi Cernajsek
Xestoleberis glaberescens (Reuss)

Bryozoa

Tubulipora cumulus (Sinzow)
Schizoporella tetragona (Reuss)
Hippopleurifera cf. *semicristata* (Reuss)
Hippadenella regularis (Reuss)
Celleporina sp.

Mollusca

Eleven species of gastropods and five species of bivalves have been found in the sediment from Dubová (Table 1).

Mohrensternia is the dominant species among the gastropods, *Ervilia dissita dissita* Eichwald dominates among bivalves (Table 1). According to Papp (1954), such an association of molluscs is characteristic of the Rissoa Beds of the Early Sarmatian age (Fig. 2).

Foraminifera

Elphidium dominate among the studied foraminifers (Table 1). This foraminiferal association found at Dubová is typical of the Early Sarmatian *Elphidium reginum* Biozone sensu Grill (1941).

Ostracoda

Cytheridea hungarica (Zalányi) is the dominant ostracod species, but an additional five species were also determined (Table 1).

According to the presence of ostracods *Cytheridea hungarica* (Zalányi) and *Aurila mehesi* (Zalányi), the fauna belongs to the Early Sarmatian biozone of *Cytheridea hungarica–Aurila mehesi* (Fig. 2), which is well correlable around the entire Paratethys Basin (Jiříček 1983; Stancheva 1990; Zelenka 1990).

Bryozoa

No Sarmatian bryozoans have been previously described from Slovakia. Our new study has led to the recognition of five species of Bryozoa (Table 1). Large colonies of celleporid cheilostome of *Celleporina* sp., along with colonies of the cyclostome *Tubulipora cumulus* (Sinzow, 1892) as described by Ghiurca & Stancu (1974) dominate the studied association.

Material and methods

The samples for detailed study were taken from thin layers intercalated within the clay, with macroscopically visible fragments of molluscs. The samples were dried and subsequently moistened in water several times until their disintegration and than they were washed on sieve with 0.025 mm mesh diameter. The washed residues were studied

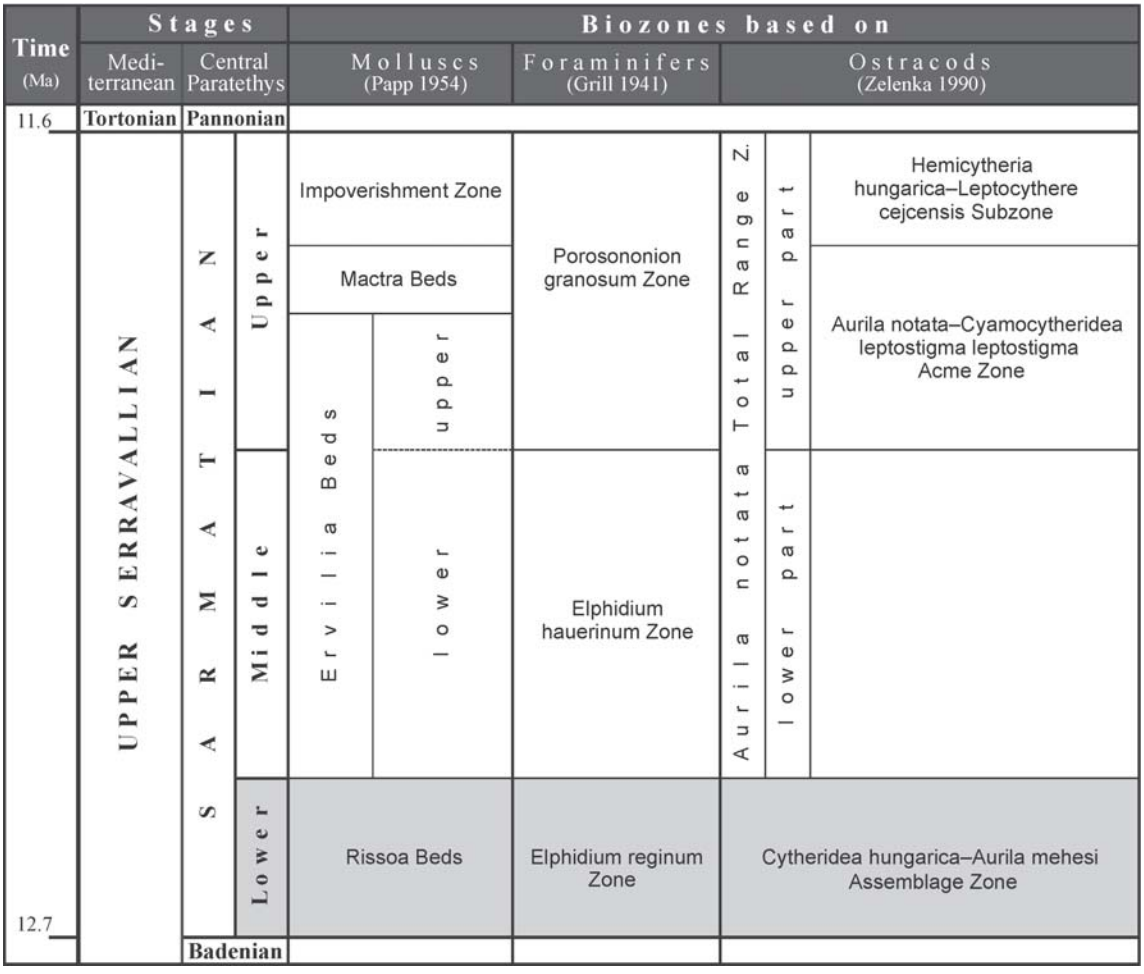

Fig. 2. Biozonation of the Sarmatian based on foraminifers, molluscs and ostracods.

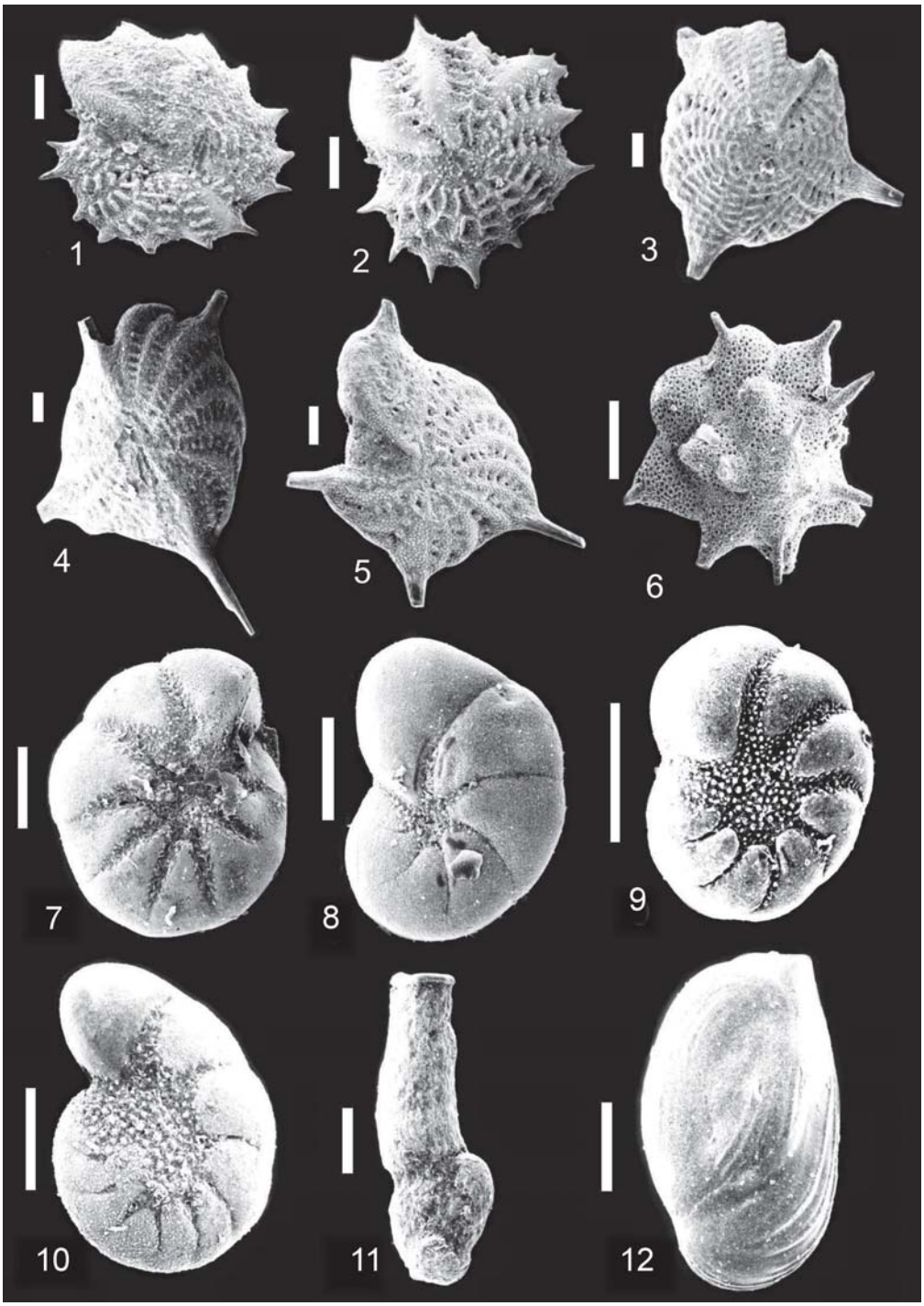

Fig. 3. Foraminifera. **1** — *Elphidium aculeatum* (d'Orbigny). **2** — *Elphidium josephinum* (d'Orbigny). **3–5** — *Elphidium reginum* (d'Orbigny). **6** — *Schackoinella imperatoria* (d'Orbigny). **7** — *Ammonia beccarii* (Linné), **8** — *Nonion bogdanowiczi* Voloshinova. **9–10** — *Porosononion* cf. *martkobi* (Bogdanowicz). **11** — *Articulina articulinoides* Gerke et Issaeva. **12** — *Cycloforina* sp. All pictures were made on a SEM JSM-840 in the Geological Survey of the Slovak Republic by I. Holický. Scale bar 100 μm.

under binocular microscope and fragments of molluscs, foraminifers, ostracods and bryozoans were selected.

Bryozoans were, before detailed taxonomic study, macerated in Quaternary "O"™ for about 2–3 days. The samples with Quaternary "O"™ could be heated for a better effect of cleaning in a water bath to 80–100 °C. All the specimens were cleaned in an ultrasonic cleaner before taking any photos (details see Zágoršek & Vávra 2000).

Foraminiferal and ostracod assemblages were studied by JSM-840 SEM in the Geological Survey of the Slovak Republic, photos were taken by I. Holický. The described specimens of molluscs, foraminifers and ostracods are de-

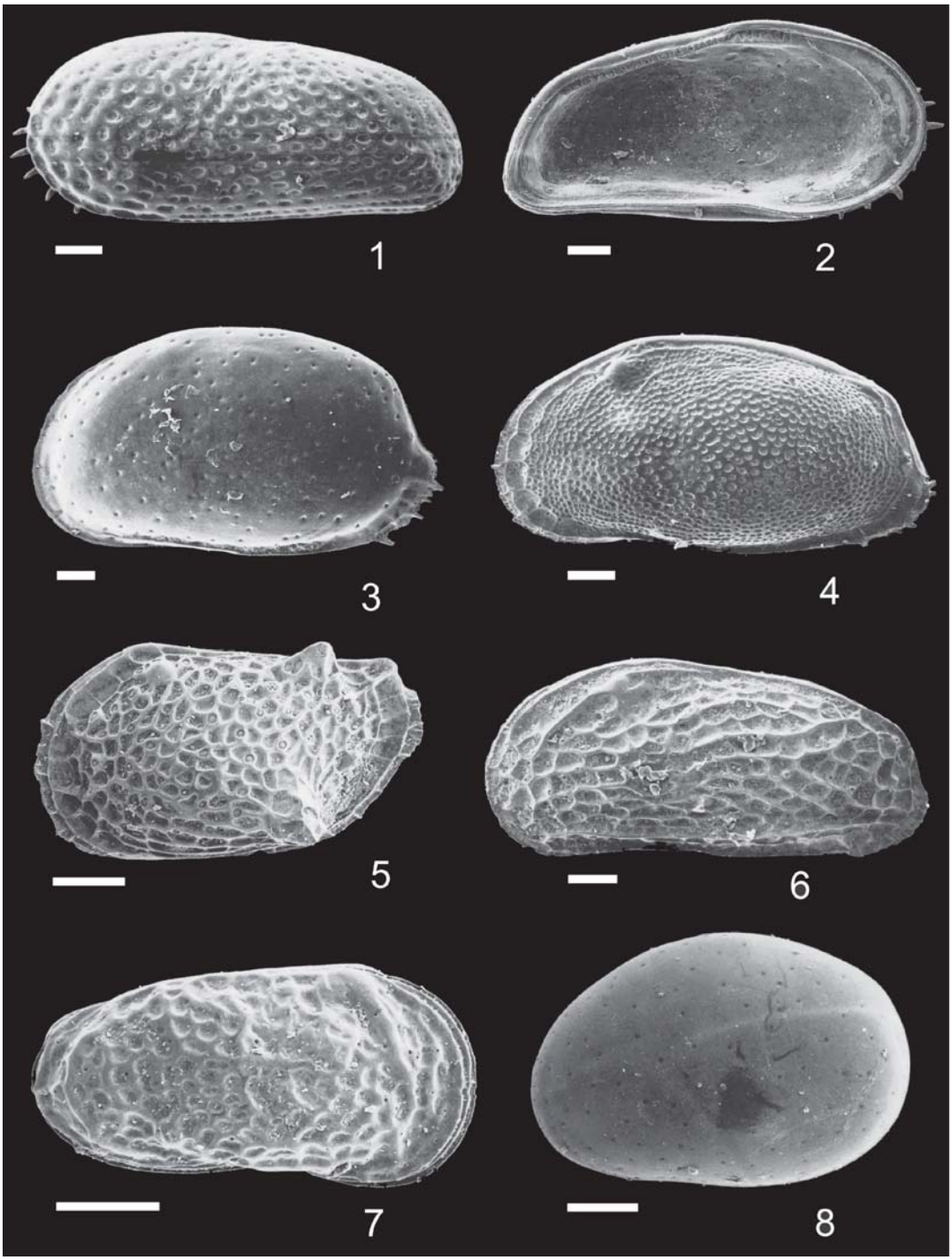

Fig. 4. Ostracoda. **1–2** — *Cytheridea hungarica* (Zalányi). **3** — *Aurila mehesi* (Zalányi). **4** — *Aurila merita* (Zalányi). **5** — *Loxoconcha schmidi* Cernajsek. **6** — *Hemicytheria omphalodes omphalodes* (Reuss). **7** — *Callistocythere* sp. **8** — *Xestoleberis glaberescens* (Reuss). All pictures were made on a SEM JSM-840 in the Geological Survey of the Slovak Republic by I. Holický. Scale bar 100 μm.

posited in the Geological Survey of the Slovak Republic in Bratislava.

Bryozoans were studied and documented by K. Zágoršek by use of the Jeol type JSM-6400 SEM in the Paleontological Department of Vienna University. The specimens described are deposited in the National Museum in Prague.

Ecological needs of found species

Mohrensternia and *Hydrobia* (gastropods) occurred in the littoral to sublittoral zone at depths up to 30 m, in well aerated water, with abundant vegetation and salinity levels between 0.9 and 1.8 % (Remane 1958; Švagrovský

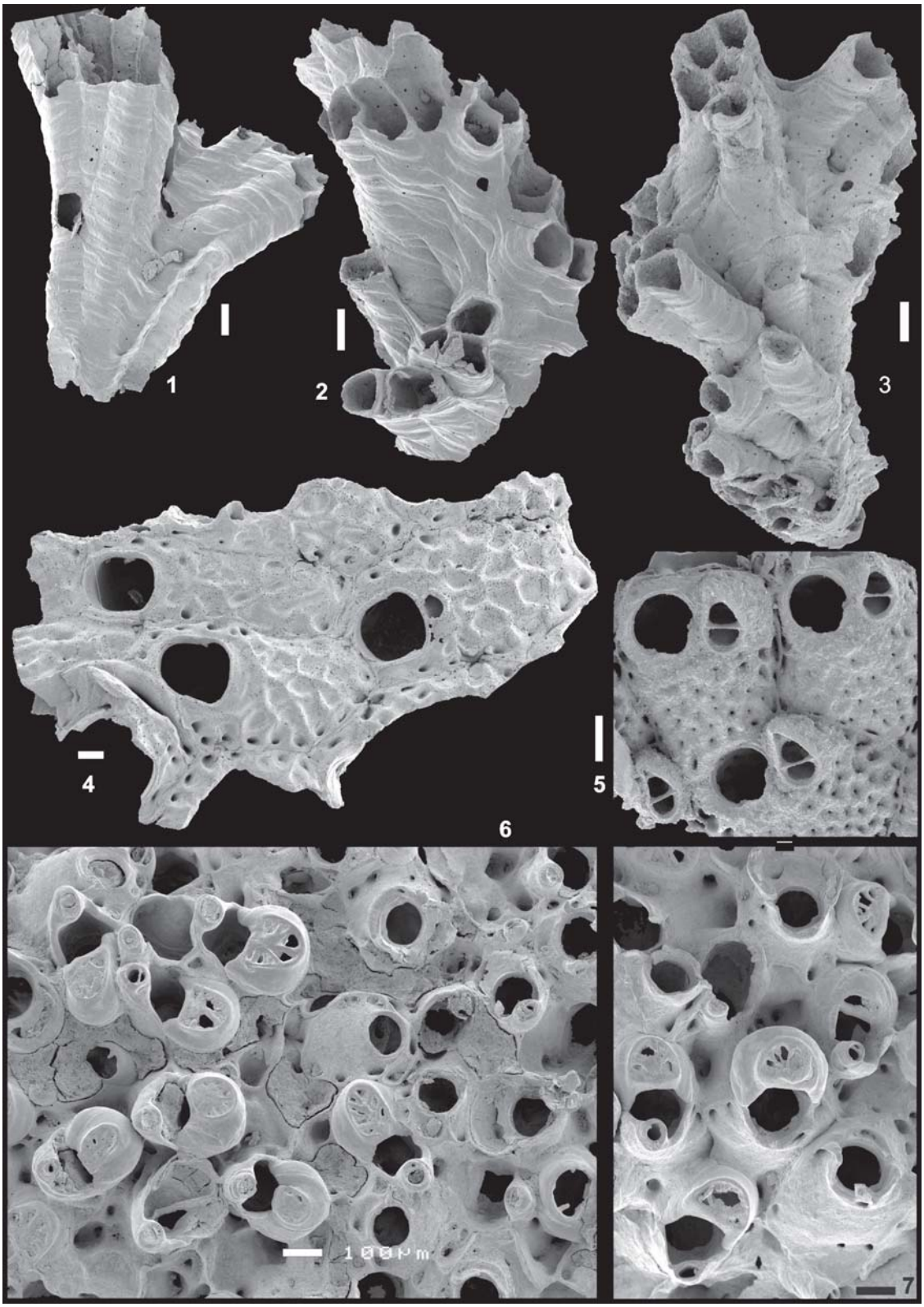

Fig. 5. Bryozoa. **1–3** — *Tubulipora cumulus* (Sinzow, 1892); note marked concentric growth lines, apertures arranged in fascicles and porous frontal walls. **4** — *Hippadenella regularis* (Reuss, 1874); general view showing wide apertures with characteristic key-shaped suboral avicularium (visible on right zooecium). **5** — *Schizoporella tetragona* (Reuss, 1848); detail of a few zooecia with visible characteristic aperture with wide sinus and large oral avicularia with prominent pivotal bar. **6–7** — *Celleporina* sp.; general view showing small suboral avicularia, lateral areolar pores and ovicells with semicircular windows. All pictures were made in the Paleontological Institute of Vienna University in SEM Jeol type JSM-6400 by K. Zágoršek. Scale bar 100 μm.

1960; Iljina 1966). *Mohrensternia* preferred quiet water environments (Kowalke & Harzhauser 2004).

The presence of bivalve *Ervilia dissita dissita* Eichwald indicates shallow water with a sandy bottom, *Obsoletiforma* lived on sandy to sandy-clay bottoms, and *Inaequicostata* sandy-clay to clay bottoms (Paramonova 1994). The occurrence of *Chalmasia morelleti* Pokorný through the whole profile indicates a warm climate and shallow water during deposition of the studied sediments (Pokorný 1948).

The presence of an *Elphidium–Quinqueloculina* foraminiferal assemblage proves brackish, shallow water. *Elphidium* is generally considered to indicate depths of less than 80–100 m (Walton 1964; Boltovskoy-Wright 1976; Poag 1981). According to Murray (1973) *Schackoinella imperatoria* (d'Orbigny) lived in the shallow neritic zone up to 50 m deep.

The presence of the ostracods *Cytheridea, Aurila, Hemicytheria, Loxoconcha, Leptocythere* and *Xestoleberis* indicates a shallow, brackish water paleoenvironment (Jiříček 1983).

Bryozoans from brackish environment were described very rarely. Bobies (1957) was the first (and last up to now), who mentioned Bryozoa from non-marine sediments. He described 10 Sarmatian species from Austria, from which only *Schizoporella tetragona* (Reuss, 1848) also occurs in the locality studied. Ghiurca & Stancu (1974) described *Tubulipora cumulus* (Sinzow, 1892) from brackish sediments of Romania. Pouyet (1973) pointed out, that *Celleporina* could also have survived in water with lower salinity, but it was never reported in the recent brackish environment. *Hippopleurifera* cf. *semicristata* (Reuss, 1848) and *Hippadenella regularis* (Reuss, 1874) are typical marine species, which indicate that the bryozoan association studied here could have lived in the full-marine environment.

Interpretation and reconstruction of the paleoenvironment of the Dubová locality

Based on ecological requirements of the species and genera of molluscs, foraminifers and ostracods identified in the studied association, we can infer that the Early Sarmatian paleoenvironment at Dubová was shallow littoral to sublittoral at depths of up to 30 m, with sandy to sandy-clay bottoms and well aerated water in a warm climate.

Small changes in the original paleoenvironment have been documented by the qualitative composition of the mollusc assemblages. During transgression at the beginning of the Early Sarmatian, the sandy sediments with *Ervilia dissita dissita* Eichwald were deposited near the shore in the zone of wave action (Paramonova 1994). Short stormy events caused deposition of thin layers containing fragments of this mollusc. Later, the depth increased slightly and fine-grained, pelitic sediments (clayey sand to clay) were deposited. This environment was suitable for the gastropods *Mohrensternia* and *Hydrobia* and for the bivalve *Inaequicostata*, which indicate well aerated, quiet water with a depth of less than 30 m, and a bottom overgrown by vegetation (Remane 1958; Švagrovský 1960; Iljina 1966; Kowalke & Paramonova 1994; Harzhauser 2004).

The presence of bryozoans *Hippopleurifera* cf. *semicristata* (Reuss), *Hippadenella regularis* (Reuss) and *Celleporina* sp. indicates a possible full-marine character of the Lower Sarmatian sea in the region of the northern part of Danube Basin.

On the basis of the presence and preservation of these fossils in clayey sediment, we can suppose, that the taphocoenosis was transported a short distance from a shallow, high energy environment (above wave base) with a sandy bottom, to deeper and quieter conditions on a clay bottom. The occurrence of the fossils in very thin layers as small fragments supports this hypothesis. The salinity in these two settings could be different; the shallow water association including bryozoans could have lived in almost normal salinity, while the association with the gastropods *Mohrensternia* and *Hydrobia* lived in deeper, quiet conditions with lower salinity. Normal salinity in shallow water environment could be explained by higher evaporation of brackish water in warm environment or as marine residues in a brackish basin.

Summary

In the northern part of the Danube Basin at the Dubová locality (Fig. 1) sediments containing rich assemblages of molluscs (gastropods, bivalves), foraminifers, ostracods, bryozoans and algae were found (Table 1). On the basis of individual groups of fossils the sediments were ranged biostratigraphically according to gastropods to the Rissoa Member (Papp 1954), to the *Elphidium reginum* Biozone (Grill 1941) on the basis of foraminifers and to the *Cytheridea hungarica–Aurila mehesi* Biozone (Zelenka 1990) on the basis of ostracods (Fig. 2). The occurrence of bryozoans at this locality represents their first find in Lower Sarmatian sediments of the northern part of the Danube Basin. On the basis of the paleoecological pretentions of individual species of the fossil groups mentioned it may be stated that sediments at the Dubová locality were deposited in shallow water environment during warmer climate period. The presence of bryozoans *Hippopleurifera* cf. *semicristata* (Reuss), *Hippadenella regularis* (Reuss) and *Celleporina* sp. pointed to the fact that character of the environment was probably marine during the Early Sarmatian as indicated by recent paleoecological and isotopic studies (Latal et al. 2004; Piller & Harzhauser 2005).

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