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Middle Miocene (Badenian) ostracods and green algae (Chlorophyta) from Kamienica Nawojowska, Nowy Sącz Basin (Western Carpathians, Poland)

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Abstract: The paper documents Middle Miocene (Badenian) ostracods of the Polish part of the Western Carpathians for the first time. The material has been collected at the outcrop in the Kamienica Nawojowska locality, in the Nowy Sącz Basin. The ostracods allowed the identification of 42 species, referred to 26 genera and representing 15 families. Among them, a few species (e.g. *Neonesidea* cf. *corpulenta* (G.W. Müller, 1894), *Pokornyella* cf. *devians* Bonaduce, Ruggieri et Russo, 1986) and the genus *Jonicythere* Mostafawi, 1986, appear to be recorded from the Middle Miocene of the Central Paratethys for the first time. Some species show uncommonly high variability. Besides the ostracods, the associated remnants of green algae (Chlorophyta), assigned to three genera, are also preliminarily identified and illustrated. The taxonomic composition of ostracods, as well as their preservation state, and the associated green algae suggest their marine, shallow-water (inner neritic), rather highly dynamic and unstable environment. The close similarity of the recognized ostracod assemblage to those known from the Middle Miocene deposits of the others parts of the Central Paratethys (including the Carpathian Foredeep), Mediterranean areas, and the Atlantic border of Europe seems to be important. It suggests intensive exchange of fauna within these bioprovinces.

Key words: Middle Miocene, Badenian, Western Carpathians, Nowy Sącz Basin, Chlorophyta, Ostracoda.

Introduction

The previous elaborations of the marine Miocene ostracods from Poland were mostly limited to those from the Carpathian Foredeep and its southeastern prolongation, namely the Roztocze Upland (the western part of the Lublin Upland). A notable exception was the ostracods listed by Schiller (1976) from the parautochthonous Lower Badenian peri-Carpathian deposits outcropping in Benczyn. Thus, the presented study of ostracods from the Kamienica Nawojowska outcrop near Nowy Sącz, within the Nowy Sącz Basin, is the first one concerning this group of microfauna from the Neogene deposits from the Polish part of the flysch Carpathians. It is undertaken in parallel with studies on the foraminifers from that site (Gonera subm.).

The microfossils, mostly foraminifers, but also other groups, including the green algae (Chlorophyta) mentioned herein, from the marine Miocene deposits outcropping or pierced by boreholes in the Nowy Sącz Basin, were described in numerous studies (Gonera subm.). They also prompted many speculations concerning both their age and the depositional conditions. They were referred to the Lower Badenian (corresponding to the Langhian) up to the Sarmatian (corresponding to the Serravallian).

Considering the existing opinions concerning the age and the depositional conditions of the Miocene strata from the Nowy Sącz Basin, sometimes differing even from the same locality (cf. Oszczypko et al. 1991, 1992; Gonera subm.), the attempt at the research on microfossils from the Kamienica Nawojowska outcrop seemed particularly justified and interesting. The main reason for this work was to recognize the ostracod assemblages and the co-occurring remnants of flora from the Kamienica Nawojowska outcrop, then to establish their supposed age and environmental conditions.

The studied material is housed in the Institute of Paleobiology, Polish Academy of Sciences, Warszawa (abbreviated ZPAL).

Material and geological setting

The samples were taken from a geological section, nearly 4 meters thick and about 50 meters long, outcropping as dark grey, indistinctly stratified and somewhat inclined sandy-silty deposits, dipping about 35° to the south, on the left bank of the Kamienica Nawojowska River, at the southern boundary of the town Nowy Sącz (Fig. 1). The studied section is situated just above the water surface, and is overlain by about 1.5 m thick Quaternary deposits (Gonera & Styczynski 2002; Bitner & Kaim 2004).

This outcrop was exposed in 2001, after a flood, and is one of few outcrops of the transgressive Miocene sediments, infilling intramountainous depressions, including the Nowy Sącz Basin, within the flysch Carpathians, and overlying the Cretaceous-Paleogene flysch deposits of the Magura Nappe (Fig. 1). The rather complex sedimentological and tectonic situation, as well as various faunistic contents of the deposits within the Nowy Sącz Basin, obscure their lithostratigraphy and biostratigraphy (cf. e.g.

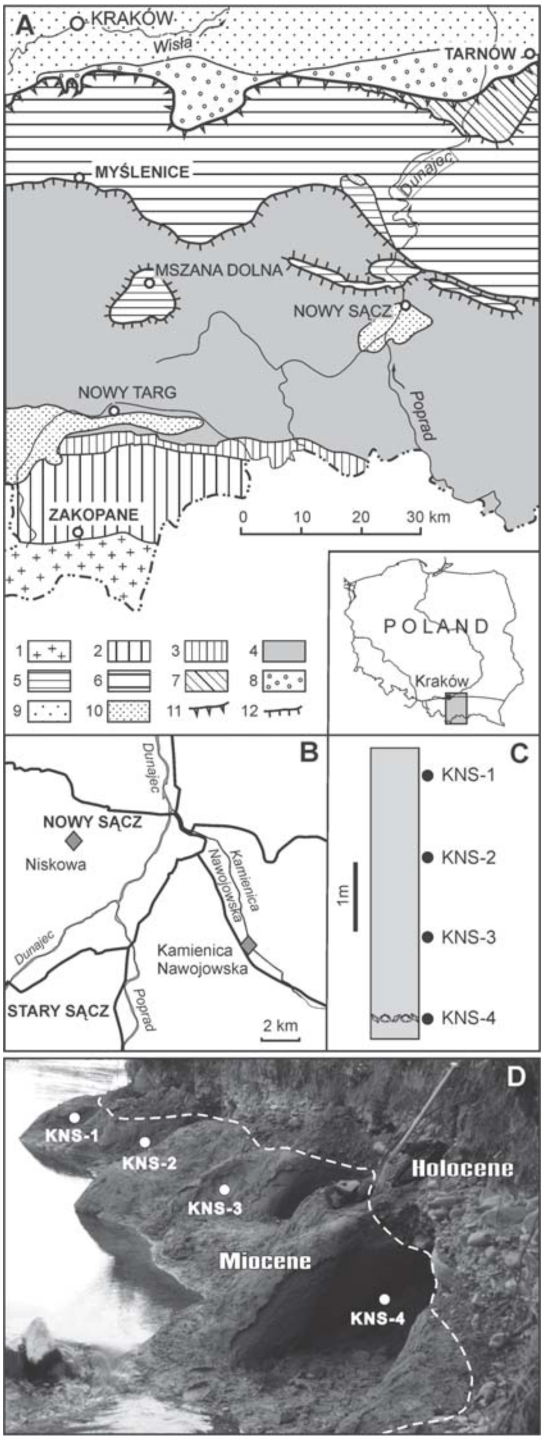

Fig. 1. The sketch maps indicating the location of sampled section at Kamienica Nawojowska. **A** — structural sketch map of the Polish Carpathians, middle part: 1 — Tatra units, 2 — Podhale flysch, 3 — Pieniny Klippen Belt, 4 — Magura Nappe, 5 — Dukla and Fore-Magura units, 6 — Silesian and Subsilesian units, 7 — Skole unit, 8 — folded Miocene deposits, 9 — autochthonous Miocene deposits in the Carpathian Foredeep, 10 — Miocene deposits transgressive on the Carpathians, 11 — Carpathian frontal overthrust, 12 — subordinate thrust (after Oszczypko et al. (somewhat simplified) 1992). **B** — Nowy Sącz region with locality Kamienica Nawojowska. **C** — sampled part of the Kamienica Nawojowska section. **D** — general view of the section at Kamienica Nawojowska (B–D after Bitner & Kaim 2004).

Oszczypko 1973; Oszczypko et al. 1991, 1992; Gonera subm.). In general, fresh-water facies (sandy clays with lignite and coal) occur at the bottom of the section, and are overlain by marine sediments (mostly sands and marly silts) and the brackish-water intercalations. The Miocene deposits of the Nowy Sącz Basin are slightly deformed and they distinctly dip from the south-west to the east. Oszczypko et al. (1992), working on microfauna (foraminifers) and the calcareous nannoplankton from the Neogene marine deposits from boreholes and outcrops from the Nowy Sącz Basin, have distinguished two formations there: the Iwkowa and Niskowa Formations, of which the Iwkowa Formation consists mostly of clayey mudstones (350–470 m thick sequence), and is referred to the Upper Badenian and/or Lower Sarmatian, while overlying it the Niskowa Formation, represented by sandy-silty deposits (about 50 m thick), is referred to the Lower Sarmatian.

Gonera (subm.), on the basis of foraminifers (mostly calcareous benthic forms) from one sample from the Kamienica Nawojowska outcrop, assigned it to the Lower Badenian (Moravian), a substage not recognized by Oszczypko et al. (1992) within the distinguished formations of the Nowy Sącz Basin, and she compared the studied foraminiferal assemblage to that from Niskowa. According to Bitner & Kaim (2004), who studied brachiopods (2 species of *Argyrotheca*) from samples from Kamienica Nawojowska, they indicate (although tentatively) a Badenian age of the strata. Ostracods, so far unknown from the Nowy Sącz Basin, do not allow correlation of the studied deposits from Kamienica Nawojowska with those known from this basin, but they contain biostratigraphic markers suggesting their Late Badenian age.

For the present study I used one sample collected by Malgorzata Gonera just above the water level for her foraminiferal studies (Gonera subm.), and four samples (about 30 kg each), collected by Andrzej Kaim for examination of molluscs as well as brachiopods (see Bitner & Kaim 2004) from the entire section at Kamienica Nawojowska.

These latter samples were divided into smaller ones to obtain possibly homogeneous samples for micropaleontological examination and to avoid mixing of the material. Samples were washed in hot water with some powder (generally used) (e.g. 5 % nonionic surfactans, soap, polycarboxylates, 5–15 % zeolites, anionic surfactans) for washing and then sieved with 0.1 mm and 0.3 mm mesh sieves.

Since a close similarity of the taxonomic structure of ostracods from the studied samples was found, they were all referred to a single ostracod assemblage. This assemblage appears to be of rather uniform origin, when consider its age and environment.

From the entire residuum of the above mentioned samples, several thousands of specimens of ostracods (including fragments) were obtained, of which only the larger (identifiable) fragments were picked up. They represent valves and complete carapaces, mostly of adults, and mostly of the large-sized forms (species). The specimens are generally badly preserved, since they have been abraded, crushed or compressed, often covered or infilled with quartz grains; sometimes they are covered by salt crystals

(Fig. 8.1). It seems probable, that the studied ostracod assemblage is biased, as a result of being selected mechanically by the dynamic hydrological conditions of their environment.

The green algae (Chlorophyta) (Fig. 11) in the studied samples from Kamienica Nawojowska are rather rare and occur generally as poorly preserved fragments of thalli (?) or gametangia.

Results

Considerations on the taxonomy of ostracods

Since the studied material is rather badly preserved, it seems probable, that the thin-shelled and small-sized specimens (species) have been mechanically selected and thus the preserved assemblage is not identical with the original biocenosis. The afore-mentioned state of preservation of the ostracod remnants from the Kamienica Nawojowska do not favour their identifications. Moreover, there exists large intraspecific variability among some of the recognized species, especially those assigned to *Grinioneis haidingeri* (Reuss, 1850) and *Pokornyella deformis* (Reuss, 1850). This polymorphism concerns the size as well as the morphology of specimens and is particularly distinct among the adult forms.

However, 42 species, belonging to 26 genera and 15 families have been identified among the studied ostracods (Figs. 2–10). The most common are representatives of the genera *Aurila*, *Tenedocythere*, *Pokornyella*, *Cytheridea*, *Grinioneis*, *Nonurocythereis* and ?*Ghardaglaia*, while only singular specimens belong to the genera *Flexus*, *Parakrithe*, *Triebelina*, *Pontocypris* and *Carinocythereis*. As it was stated above, probable secondary composition of the studied assemblage caused rarity of the small-sized and thin-shelled forms (species), mostly *Callistocythere*, *Jonicythere* and *Loxoconcha* representatives.

In the available elaborations of even the recent ostracods, the specimens most probably belonging to the same species, since they have similar morphology, are sometimes variously named. At the same time, specimens referred by various authors to the same species, often differ more or less distinctly from each other. This seemingly stems from common neglect of intraspecies variability, and not acknowledging the actual range of features of a given species.

An example is provided by the ostracod fauna from Kamienica Nawojowska, especially by some species discussed below. One of them is the species assigned to *Grinioneis* gr. *haidingeri* (Reuss, 1850) (Fig. 8.8,10–13). It was described by Reuss (l.c.) (among others) from the Lower Badenian of Nussdorf, Vienna Basin, but is broadly known from the Tertiary deposits of numerous parts of Europe (more details see Gross 2002). It has distinct and continuous variability concerning its size as well as morphology and ornamentation, which are only partly presented here. Its different representatives may be assigned at least to *Grinioneis pirata* (Ruggieri, 1960), *G. haidingeri minor* (Ruggieri, 1962) and *G. haidingeri rectangularis* (Ruggieri, 1962) (the two last also regarded as separate species), all from the Neogene of the Mediterranean areas, or to *Hermanites* sp. 2 (Cernajsek, 1974) from the Sarmatian of Austria; Barra & Bonaduce (2001) identify *G. pirata* with *G. rectangularis.* Interestingly, a similar dilemma concerning the taxonomy of specimens close to *G. haidingeri* was discussed by Babinot (2002), working on the Miocene ostracods from Turkey, as well as by Gross (2002, p. 95), studying the Middle Miocene ostracods of Austria.

Similar polymorphism, concerning the size, shape and ornamentation of the adult forms also exists in the here recognized *Pokornyella deformis* (Reuss, 1850) (Fig. 6. ?8,9,?10,11–14), described by Reuss (l.c.) from (among others) the Lower Badenian of Nussdorf. Some specimens seem to correspond to those, known as *P. deformis minor* (Moyes, 1965) from Miocene of the Aquitanian Basin and Turkey (Bassiouni 1979), *P. italica* Ruggieri, Russo et Bossio, 1992 from the Upper Miocene of Italy, *P.* aff. *galeata* (Reuss, 1850), sensu Ducasse & Coustillas (1981), from the Oligocene of the Aquitanian Basin; there are also specimens “transitory” to the here distinguished *Pokornyella* sp. (Fig. 6.1–7), which seems comparable to *P. limbata* (Bosquet, 1852), sensu Ducasse & Coustillas (1981), also from the Oligocene of the Aquitanian Basin. It seems worth mentioning, that also Ducasse & Coustillas (1981), working on the Tertiary ostracods of the Aquitanian Basin, observed conspicuous variability among the recognized species belonging to the genus *Pokornyella*, and they distinguished there various morphs, changing both in time as well as within one sample.

Another example of the polymorphism among the here examined ostracods is presented by *Tenedocythere sulcatopunctata* (Reuss, 1850) (Fig. 5.1–9), also being described by Reuss (l.c.) from the Lower Badenian of Nussdorf. Some of its representatives are very similar, either conspecific or closely related, as with *T. cruciata* Bonaduce, Ruggieri et Russo, 1984 from the Miocene of the Mediterranean areas, or *T. perplexa* Bonaduce, Ruggieri et Russo, 1984. This latter species is described from the Lower Badenian of Nussdorf, and their authors assigned to this species *T. sulcatopunctata* Reuss, 1850, figured by Brestenská & Jiříček (1978) from the Badenian of Hungary; according to these authors (l.c.) the specimen figured by Brestenská & Jiříček (1978) only tentatively may correspond to the specimen established by Reuss (1850) as *Cypridina* (recte *Tenedocythere*) *sulcatopunctata.* Regarding the variability among *T. sulcatopunctata* from Kamienica Nawojowska, *T. cruciata* described by Babinot (2002) from the Miocene of Turkey appears to be conspecific with this first one. It is noteworthy that *Procythereis sulcatopunctatus* (Reuss, 1850) is known from the Middle Miocene of Turkey (Bassiouni 1979). Considerable confusion in determinations of species within the genus *Tenedocythere* are to some extent presented by Mostafawi (2002), who revised some ostracod species from Uliczny’s (1969) collection.

A similar but more troublesome problem results from the taxonomic studies of the smooth-shelled specimens, espe-

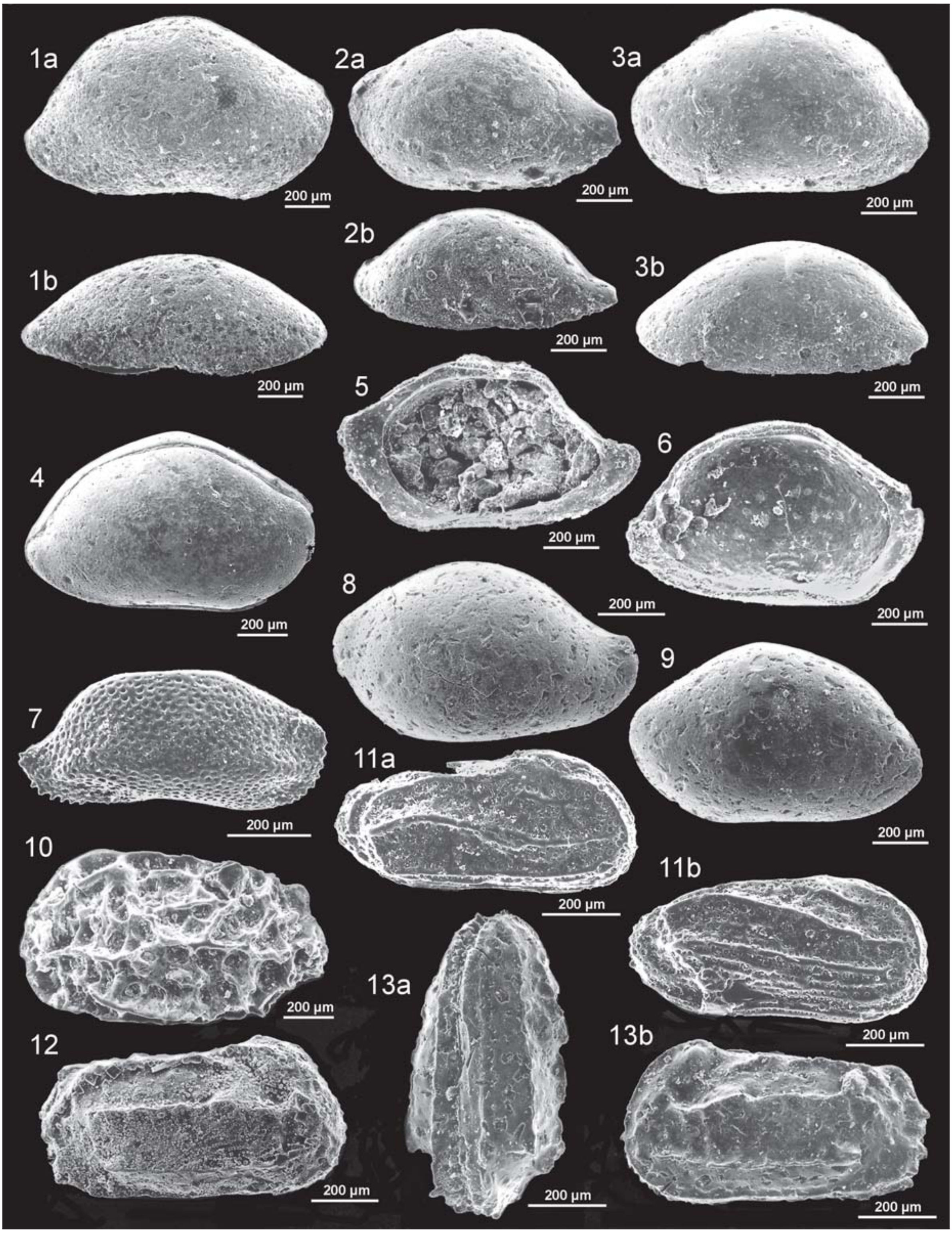

Fig. 2. All pictures (in all following figures) represent external views except where stated. ***Abbreviations:*** C — carapace, RV — right valve, LV — left valve. **1, 4** — *Neonesidea* cf. *subdeltoidea* (Münster, 1830); 1 RV, a — lateral view, b — ventral view, ZPAL O. 54/311; 4 C, right side, ZPAL O. 54/104. **2, 5, 8** — *Neonesidea* cf. *corpulenta* (G.W. Müller, 1894); 2 LV, a — lateral view, b — ventral view, ZPAL O. 54/315; 5 RV, seen from inside, ZPAL O. 54/313; 8 LV, ZPAL O. 54/262. **3, 6, 9** — *Neonesidea* cf. *mediterranea* (G.W. Müller, 1894); 3 LV, a — lateral view, b — ventral view, ZPAL O. 54/79; 6 LV, seen from inside, ZPAL O. 54/309; 9 LV, ZPAL O. 54/258. **7** — *Triebelina raripila* (G.W. Müller, 1894), RV, ZPAL O. 54/81. **10** — *Cnestocythere lamellicosta* Triebel, 1950; LV, ZPAL 0. 54/195. **11** — *Flexus reussianus* Ruggieri, 1992, C, a — right side, b — oblique ventral view, ZPAL O. 54/127. **12, 13** — *Carinocythereis galilea* Ruggieri, 1972 *jiriceki* Aiello et Szczechura, 2001; 12 C, right side, ZPAL O. 54/265; 13 C, a — ventral side, b — left side, ZPAL O. 54/130.

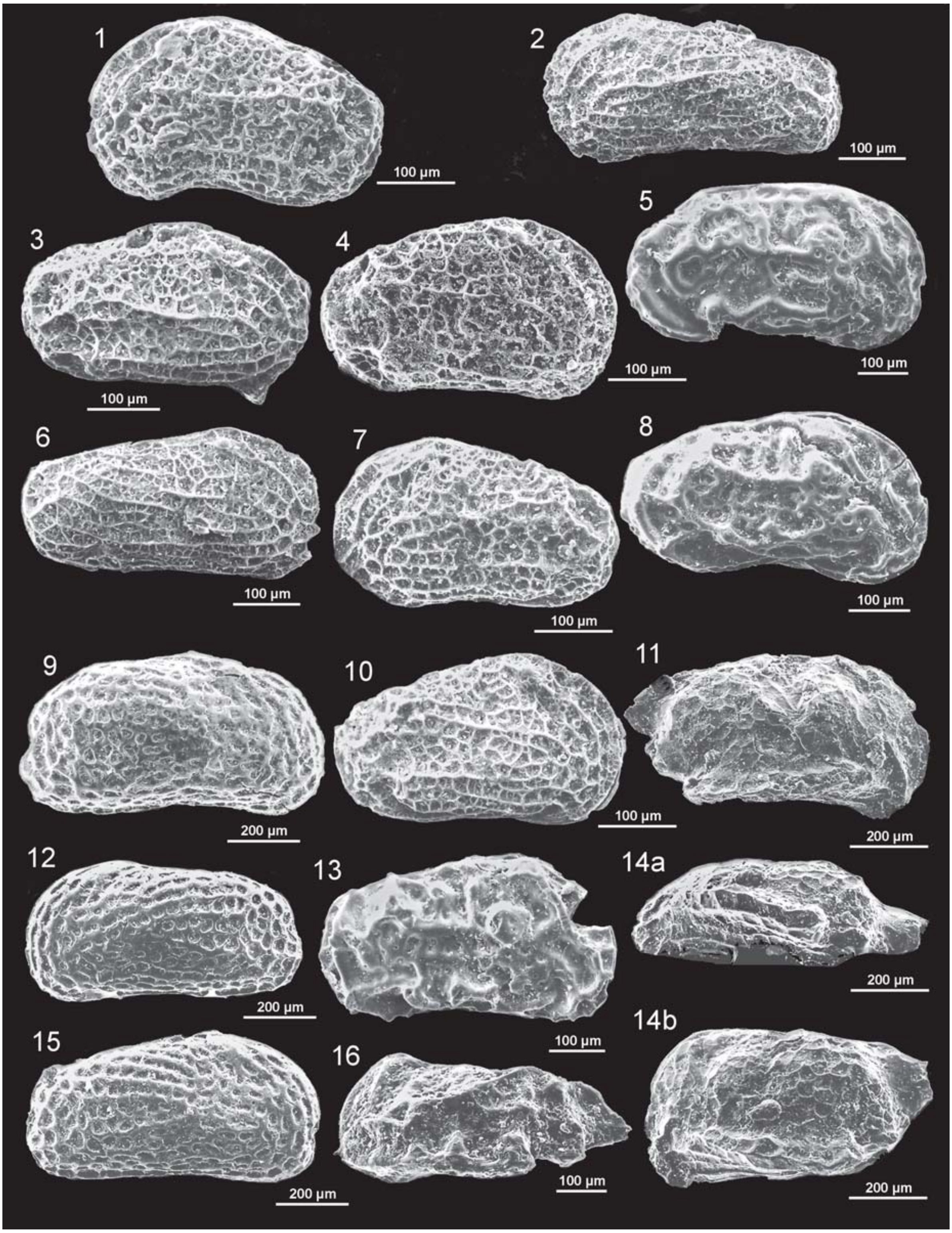

Fig. 3. 1–4, 6, 7, 10 — *Jonicythere* cf. *tribrachys* (Bonaduce, Ruggieri, Russo et Bismuth, 1992); 1 C, left side, ZPAL O. 54/213; 2 C, left side, ZAL O. 54/234; 3 C, right side, ZPAL O. 54/223; 4 C, right side, ZPAL O. 54/224; 6 C, right side, ZPAL O. 54/235; 7 C, left side, ZPAL O. 54/225; 10 RV, ZPAL O. 54/222. **5** — *Callistocythere* sp. 1, RV, ZPAL O. 54/232. **8** — *Callistocythere* sp. 2, RV, ZPAL O. 54/230. **9, 12, 15** — *Nonurocythereis seminulum* (Sequenza, 1880); 9 RV, ZPAL O. 54/192; 12 C, left side, ZPAL O. 54/194; 15 C, right side, ZPAL O. 54/193. **11, 14** — *Pseudocytherura* cf. *calcarata* (Sequenza, 1880); 11 RV, ZPAL O. 54/246; 14 LV, a — oblique ventral view, b — lateral view, ZPAL O. 54/252. **13** — *Callistocythere* cf. *pallida* (G.W. Müller, 1894), RV, ZPAL O. 54/231. **16** — *Paracytheridea triquetra* (Reuss, 1850), LV, ZPAL O. 54/257.

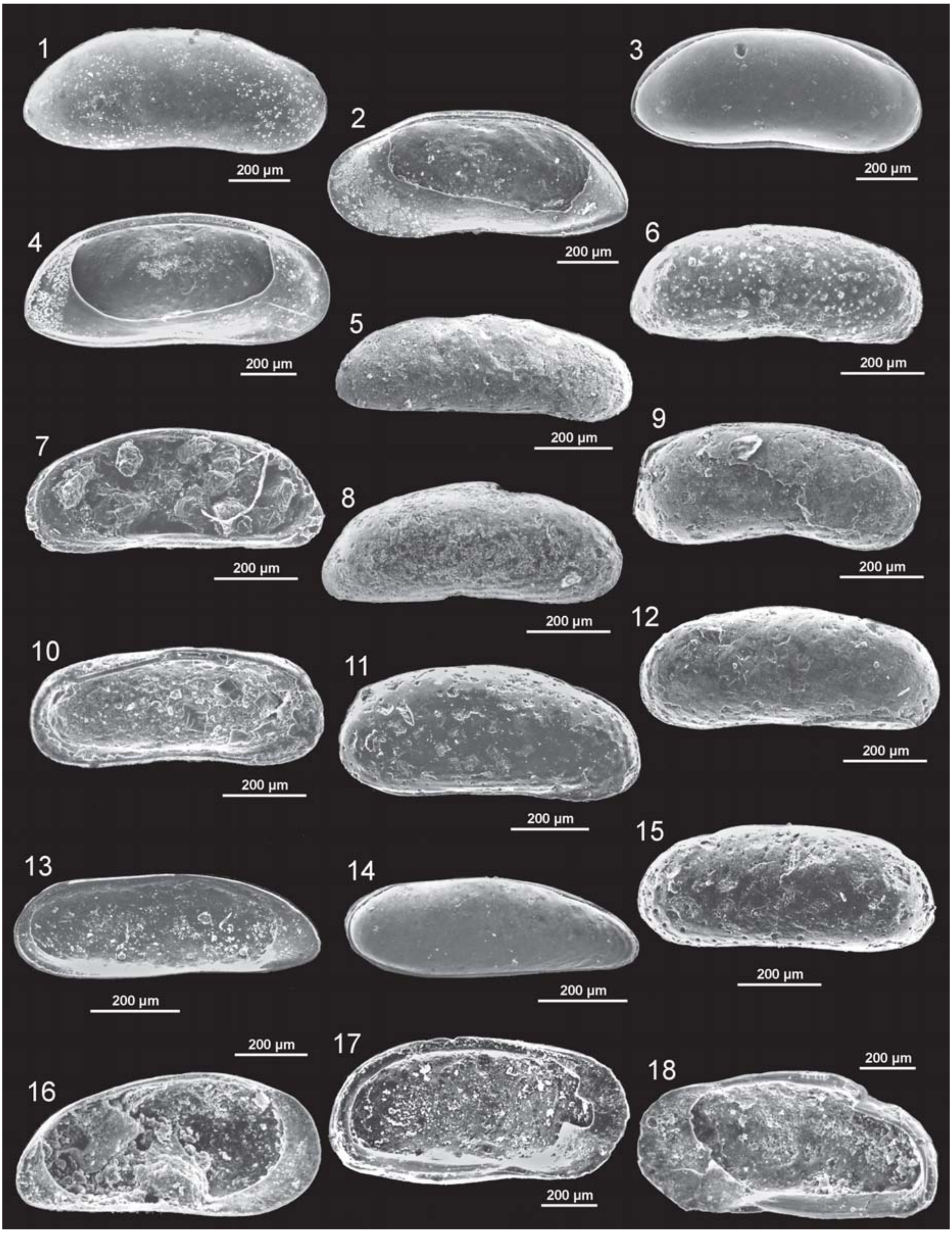

Fig. 4. 1–4 — ?*Ghardaglaia* cf. *pectinata* (Hejjas, 1894); 1 RV, ZPAL O. 54/116; 2 RV, seen from inside, ZPAL O. 54/115; 3 C, right side, ZPAL O. 54/100; 4 LV, seen from inside, ZPAL O. 54/311. **5, ?6, 7, 8** — *Pontocythere* cf. *curvata* (Bosquet, 1852); 5 RV, ZPAL O. 54/239; 6 RV, ZPAL O. 54/304; 7 RV, seen from inside, ZPAL O. 54/134; 8 RV, ZPAL O. 54/302. **9–12, 15** — *Pontocythere* cf. *elongata* (Brady, 1868); 9 C, right side, ZPAL O. 54/135; 10 LV, seen from inside, ZPAL O. 54/303; 11 C, right side, ZPAL O. 54/245; 12 LV, ZPAL O. 54/136; 15 LV, ZPAL O. 54/239. **13, 14** — N*eocytherideis* gr. *subulata* (Brady, 1868); 13 LV, seen from inside, ZPAL O. 54/243; 14 C, right side, ZPAL O. 54/226. **16** — *Pontocypris* sp., LV, seen from inside, ZPAL O. 54/306. **17, 18** — *Parakrithe* sp.; 17 LV, seen from inside, ZPAL O. 54/322; 18 RV, seen from inside, ZPAL O. 54/316.

cially belonging to the genera *Neonesidea*, *Neocytherideis*, *Pontocythere* and *Xestoleberis.* The so far distinguished species of these genera, are sometimes not sufficiently described with regard to their external and internal features, resulting in confusion concerning the taxonomy of representatives of this (mentioned above) ostracod group, the uncertainty additionally reinforced by the lack of knowledge about the variability of extinct species. As is known, for example, in the case of Upper Oligocene–Lower Miocene populations of ostracod species, referred to *Neocytherideis* (including *Neocytherideis linearis* (Roemer, 1838) from the Aquitanian Basin (Ducasse 1994)), a distinct polymorphism occurs concerning the size as well as the shape and ornamentation of the valves; the recognizable "morphs" co-exist and/or change in time; *N. linearis*, similar to that determined here as *N.* gr. *subulata* is reported by Zorn (1998) among Early Miocene ostracods of Lower Austria. Similarly variable is *Pontocythere elongata*, sometimes identified with *P. turbida* (G.W. Müller, 1894), which according to Wouters (1976) represents the Cenozoic evolutionary lineage *Cushmanidea* (recte *Pontocythere*) *lithomoides* (Bosquet, 1852)–*P. elongata* (Brady, 1868). The actual taxonomic position of ?*Pontocythere longa*, described by Reuss (1850) from the Middle Miocene of Austria (Molasse Zone) as *Cytherina longa*, close to that occurring in Kamienica Nawojowska, at least in their external appearance, needs additional studies.

However, even this preliminary analysis of the collected ostracods from the Kamienica Nawojowska allows us to state that they are similar to those known from the Miocene, especially the Middle Miocene of the Central Paratethys, in particular, for example the Polish part of the Carpathian Foredeep as well as its eastern prolongation, Roztocze Upland (see Szczechura & Pisera 1986; Paruch-Kulczycka & Szczechura 1996; Szczechura 1998; Aiello & Szczechura 2001) and the peri-Carpathian area (Schiller 1976), Austria (Huber-Mahdi 1984; Zorn 1999, 2003; Gross 2002), Czech Republic and/or Slovakia (Brestenská & Jiříček 1978; Říha 1983; Říha & Odehnal 1988; Zelenka 1985; Holcová et al. 1996), northwestern and northcentral Bulgaria (Stancheva 1962; Tzankov et al. 1965), former Yugoslavia (Bosnia and Serbia) (e.g. Rundić 1992; Rundić & Mitrović 1995; Knežević & Krstić 1996; Rundić et al. 2000) and in southwestern Romania (Olteanu 1971).

Significant exceptions in this assemblage seem to be represented by *Neonesidea* cf. *corpulenta* (G.W. Müller, 1894) (Fig. 2.2,5,8), *Jonicythere* cf. *tribrachys* (Bonaduce, Ruggieri, Russo et Bismuth, 1992) (Fig. 3.1–4,6,7,10), *Pokornyella* cf. *devians* Bonaduce, Ruggieri et Russo, 1985 (Fig. 8.2–7,9), *Pontocypris* sp. (Fig. 4.16), *Aurila* sp. 2 (Fig. 8.14–16) and *Pokornyella* sp. (Fig. 6.1–7) (the two last species probably new ones). These taxa were not recorded so far from the Miocene of the Central Paratethys. Among them the representatives of *Jonicythere* Bassiouni, 1986, were unknown up to now from Miocene deposits of the above discussed area. Interestingly, some of them, such as *Neonesidea* cf. *corpulenta* and *Pokornyella* cf. *devians* occur in the Upper Badenian deposits in the Węglin outcrop, in the Roztocze region (newest author's observations).

Considerations on the taxonomy of green algae

Among the collected fragments of green algae (Fig. 11.1–13) from the Kamienica Nawojowska, the most common belong to the genus *Acicularia* d'Archiac, 1843. A single fragment (a segment of thallus) represents *Cymopolia* Lamoroux, 1816, while a few of them are referred to *Halicoryne* Harvey, 1859. The poor state of preservation as well as insufficient amount of the studied fossils precluded any detailed taxonomic identification; they are assigned to *Cymopolia* sp., *Acicularia* sp. and *Halicoryne* (formerly *Chalmasia*) cf. *morelleti* (Pokorný, 1948). All these genera, as well as *H. morelleti* are known from the Middle Miocene of the Central Paratethys, including Poland, both from the Carpathian Foredeep as well as from the Carpathians (Malecki 1970; Stancu & Tautu 1974; Bucur et al. 1993; Paruch-Kulczycka 1994).

Biostratigraphic significance of ostracods and green algae

As was indicated above, the Middle Miocene ostracods are broadly distributed in the Cenral Paratethys and they are quite well recognized. At the same time, their biostratigraphic significance was proposed by various authors (e.g. Jiříček 1975, 1983; Brestenská & Jiříček 1978; Jiříček & Říha 1991). Unfortunately, these propositions, concerning ostracod-based stratigraphic zonation of the Middle Miocene deposits, generally do not consider the dependence of their distribution on their environmental conditions and therefore are barely useful in this discussion on the age of ostracods from the Kamienica Nawojowska deposits, representing a shallow-water and unstable environment.

Among ostracods from Kamienica Nawojowska, a significant majority of species (in sum more than 75 %) occur in the Badenian (especially in the Early Badenian) of Austria (both in the Molasse Basin as well as in the Vienna Basin) (Huber-Mahdi 1984; Gross 2002; Zorn 2003, 2004), in the Badenian of the Polish part of the Carpathian Foredeep (e.g. in the Korytnica Basin) and in the Roztocze region (Szczechura & Pisera 1986, newest author's observations). However, some of them appeared earlier in the Central Paratethys, for example in the Karpatian of the Korneuburg Basin (Austria) (Zorn 1998). As results of the stratigraphic extent of the ostracod species known from the Vienna Basin and other areas of the Central Paratethys, established by Gross (2002), and recognized in the studied material, at least the following species indicate its Badenian (not later and not earlier) age: *Aurila angulata*, *A. cicatricosa*, *A. haueri*, *Cnestocythere lamellicosta*, *Cytheridea acuminata*, *Flexus reussianus*, *Senesia cinctella*, *S. trigonella* and *Tenedocythere sulcatopunctata.*

The Badenian age of the studied materal also seems to be confirmed by the occurrence of *Triebelina raripila* and *Carinocythereis galilea jiriceki* (Szczechura 1998; Aiello & Szczechura 2001), the species so far known from the Central Paratethys from the Badenian deposits only. At the same time, *C. galilea jiriceki* is regarded as the Upper Bad-

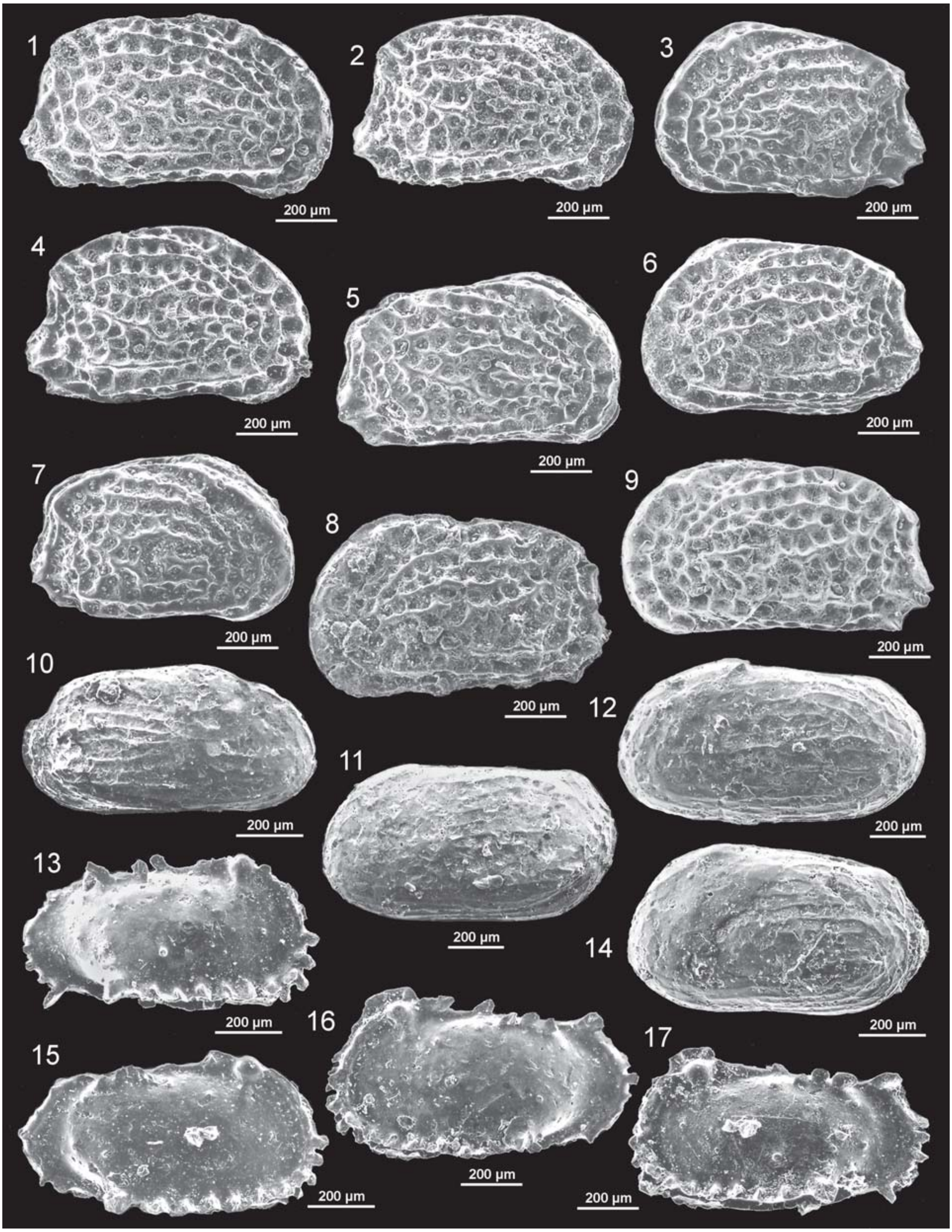

Fig. 5. 1–9 — *Tenedocythere sulcatopunctata* (Reuss, 1850); 1 RV, ZPAL O. 54/180; 2 RV, ZPAL O. 54/183; 3 C, left side, ZPAL O. 54/99; 4 RV, ZPAL O. 54/181; 5 RV, ZPAL O. 54/7; 6 C, right side, ZPAL O. 54/186; 7 C, right side, ZPAL O. 54/96; 8 LV, ZPAL O. 54/9; 9 LV, ZPAL O. 54/185. **10–12, 14** — *Cytheretta ornata* (Hejjas, 1894) *semiornata* (Brestenská, 1978); 10 RV, ZPAL O. 54/157; 11 LV, ZPAL O. 54/158; 12 LV, ZPAL O. 54/105; 14 LV, ZPAL O. 54/264. **13, 15–17** — *Pterygocythereis jonesii* (Baird, 1850); 13 RV, ZPAL O. 54/260; 15 RV, ZPAL O. 54/152; 16 LV, ZPAL O. 54/141; 17 LV, ZPAL O. 54/257.

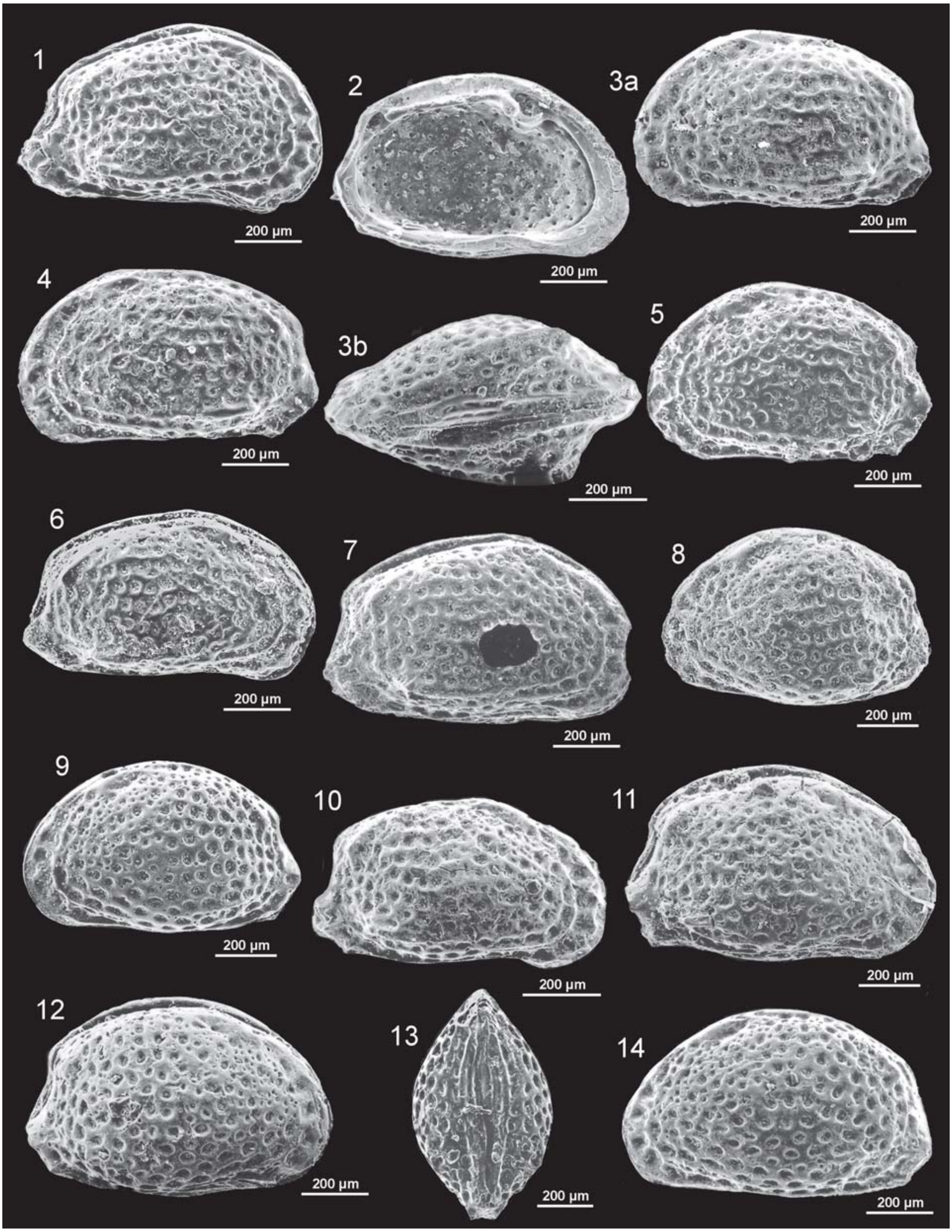

Fig. 6. 1–7 — *Pokornyella* sp. (? sp. n.); 1 C, right side, ZPAL O. 54/286; 2 LV, seen from inside, ZPAL O. 54/269; 3 C, a — left side, b — ventral side, ZPAL O. 54/2; 4 LV, ZPAL O. 54/24; 5 LV, ZPAL O. 54/25; 6 C, right side, ZPAL O. 54/89; 7 C, right side, ZPAL O. 54/188. **?8, 9, ?10, 11–14** — *Pokornyella deformis* (Reuss, 1850); 8 LV, ZPAL O. 54/121; 9 LV, ZPAL O. 54/119; 10 RV, ZPAL O. 54/255; 11 C, right side, ZPAL O. 54/290; 12 C, right side, ZPAL O. 54/279; 13 C, ventral side, ZPAL O. 54/270; 14 LV, ZPAL O. 54/271.

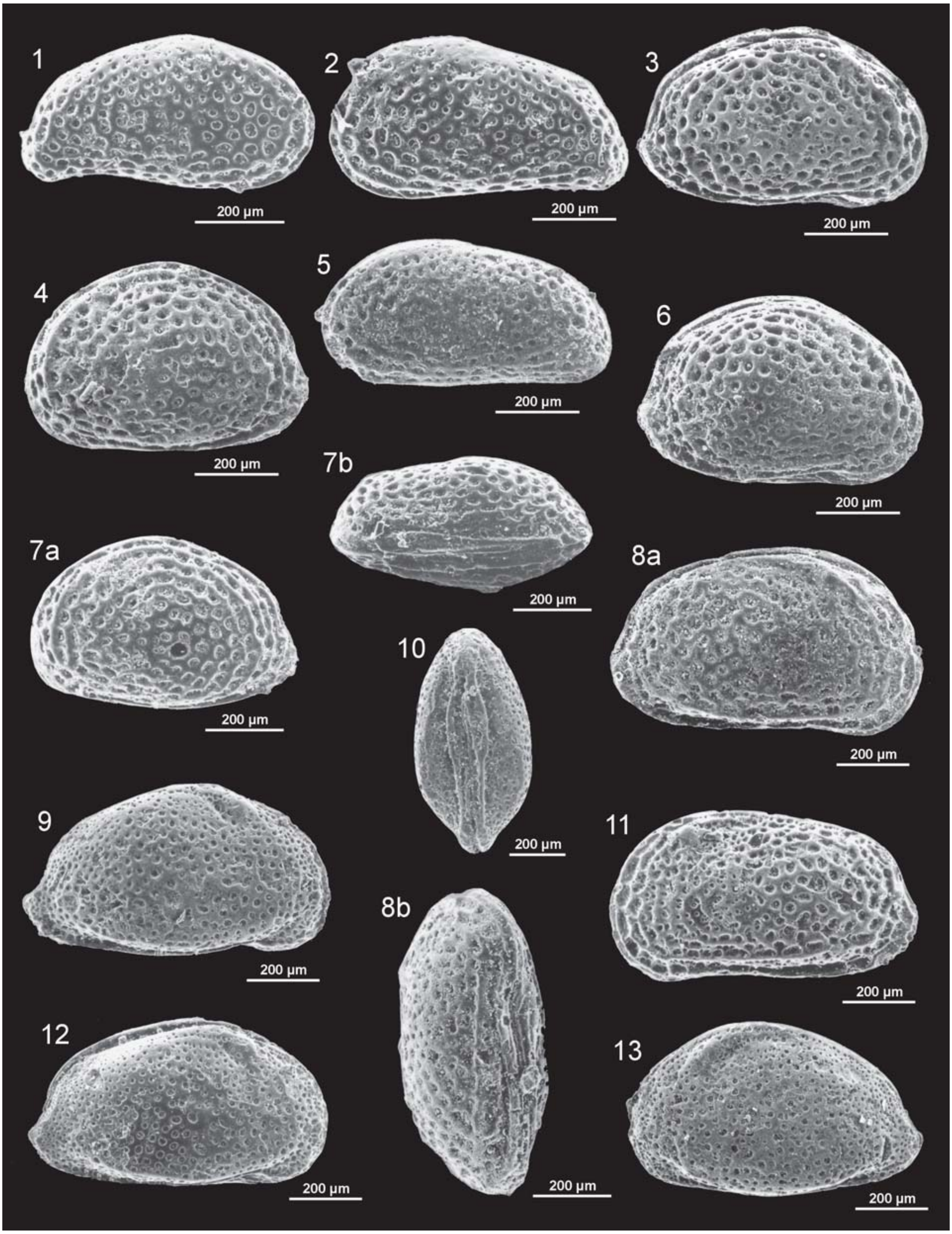

Fig. 7. 1, 2, 5 — *Cytheridea acuminata* Bosquet, 1852; 1 RV, ZPAL O. 54/137; 2 LV, ZPAL O. 54/83; 5 LV, ZPAL O. 54/133. **3, 4, 6, 7** — *Aurila* sp. 1; 3 C, right side, ZPAL O. 54/148; 4 LV, ZPAL O. 54/149; 6 C, right side, ZPAL O. 54/150; 7 C, a — left side, b — oblique ventral view, ZPAL O. 54/83. **8, 11** — *Aurila angulata* (Reuss, 1850); 8 C, a — right side, b — oblique ventral view, ZPAL O. 54/151; 11 LV, ZPAL O. 54/256. **9, 10, 12, 13** — *Senesia trigonella* **(**Reuss, 1850); 9 RV, ZPAL O. 54/146; 10 C, ventral side, ZPAL O. 54/144; 12 C, right side, ZPAL O. 54/145; 13 LV, ZPAL O. 54/147.

enian biostratigraphic marker (Szczechura 1998; Aiello & Szczechura 2001). Notably, the discussed ostracod assemblage from Kamienica Nawojowska does not contain species characteristic for the Sarmatian of the Central Paratethys (cf. e.g. Cernajsek 1974; Jiříček 1974; Szczechura 2000).

Considering the stratigraphic significance of the ostracod species found in Kamienica Nawojowska but so far unknown from the Central Paratethys — the species *Neonesidea corpulenta* is living now in the Mediterranean region, where it is known, at least since the Lower Miocene, but is mentioned (among others) from the Langhian of the Tejo Bay (Portugal) (Nascimento 1988) and from the Antakya area (southern Turkey) (Şafak 1993). It seems probable that *N.* cf. *corpulenta* from Kamienica Nawojowska is conspecific with specimens from the Badenian of Austria assigned by Huber-Mahdi (1984) to *Bairdoppilata* (?) *succinata* (Deltel, 1963).

Jonicythere tribrachys was described from the Upper Miocene of Tunisia, however, according to Bonaduce et al. (1992) it is conspecific with specimens from the Langhian of Portugal assigned by Nascimento (1988) to *Cytheromorpha zinndorfi* (Lienenklaus, 1905); *C. zinndorfi*, unfortunately not figured, is also mentioned by Bassiouni & Elewa (2000) from the late Middle Miocene of the Western Desert of Egypt. Since *C. zinndorfi*, typical of the Oligocene of Europe, prefers brackish conditions (salinity <16‰) (Keen 1978), specimens referred to *C. zinndorfi* and co-occurring with normal marine ostracod species in Egypt may in fact represent the genus *Jonicythere*. Possibly, basal representatives of this genus (and maybe the species) existed already in the Paleogene of the Tethys (cf. *Cytheromorpha zinndorfi* from the molasse Oligocene of Switzerland (Oertli 1956–58)).

Pokornyella devians is known from the Upper Miocene of Italy (Sicily) (Bonaduce et al. 1985) and Tunisia (Bonaduce et al. 1992), while very similar forms, determined as *Pokornyella*? sp. and *Procythereis*? sp., are described from the Miocene (Serravallian–Messinian) of southern Turkey (Babinot 2002). Thus, also these two last species, namely *Jonicythere* cf. *tribrachys* and *Pokornyella* cf. *devians* suggest a Middle Miocene (Badenian) age of the discussed meiofauna from Kamienica Nawojowska.

It should be added, that both *Neonesidea* cf. *corpulenta* and *Pokornyella* cf. *devians* (together with, among others, *C. galilea jiriceki*) occur in the Upper Badenian deposits of the Roztocze region, in the Węglin outcrop (newest author's observations). Interestingly, also brachiopods from Kamienica Nawojowska, elaborated by Bitner & Kaim (2004), co-occurring there with the here described ostracods, are similar to those present in the Upper Badenian of the Roztocze region.

These latest observations complicate, to some degree, the estimation of the age of biota from Kamienica Nawojowska, especially given the opinion of Gonera (subm.). Gonera (l.c.), working on foraminifers from Kamienica Nawojowska, because of the lack of planktonic forms, used the ecostratigraphic signal of the collected calcareous benthic forms, in particular the presence of the warm-water taxons, characteristic for the Lower Badenian (Moravian substage) for example *Borelis* representatives. The strong dependence of distribution of fauna (especially foraminifers) and flora on temperature (mostly reflecting climate) is obvious, however, the changes of the environmental conditions (including temperature) in the Middle Miocene of the Polish part of the Carpathian Foredeep and the adjoining areas seems to need additional study.

More detailed determination of the age of the Kamienica Nawojowska sediments on the basis of ostracods is presently impossible, however, in general it agrees with those by Gonera (subm.) and Bitner & Kaim (2004).

The genera present among the recognized green algae (Chlorophyta) from Kamienica Nawojowska, i.e. *Acicularia*, *Cymopolia* and *Halicoryne* (including *Halicoryne morelleti*) are known from the Badenian as well as the Sarmatian of the Central Paratethys (Stancu & Tautu 1974), thus this group of fossils is not helpful in estimating of age of sediments from Kamienica Nawojowska. They are described mostly from the Sarmatian deposits, however *H. morelleti* occurs in the Upper Badenian deposits from the Roztocze region (e.g. in Węglin) (author's observations). Various species of these algae, known from the Miocene of the Central Paratethys, have broad stratigraphic and paleogeographical distributions (Stancu & Tautu 1974) and seem to be important mostly as paleoecological markers.

Paleoecological significance of microfossils from Kamienica Nawojowska

The taxonomic composition of the studied ostracods, on the generic level, especially the presence of *Triebelina*, *Grinioneis*, *Callistocythere*, *Cytheridea*, *Pontocythere*, *Neocytherideis, Cytheretta, Aurila, Pokornyella*, *Paracytheridea, Pseudocytherura* and *Carinocythereis* rather explicitly indicate their normal marine and shallow-water (upper part of the epineritic zone, inner littoral) depositional environment, while *Xestoleberis* and *Loxoconcha* are more bathymetrically tolerant (Morkhoven 1963). In the opinion of Maddocks (1969) *Neonesidea* represents ostracods living in the shallow-marine environment, rich in bottom vegetation (algae, grasses) and associated with detrital accumulations, while *Triebelina* is restricted to very shallow waters, with reefs and a high wave-energy level. Although this latter genus is known as thermophilic, some rare species, including *T. raripila*, occur in temperate latitudes.

According to Athersuch (1979) both *Aurila* and *Xestoleberis* represent phytophilous forms, while Ducasse & Bekaert (1996) stated that also *Callistocythere*, *Loxoconcha*, *Neocytherideis* and *Pontocythere* represent forms preferring phytal environment, that is they live in pericoastal areas with bottom vegetation. At the same time, the coexisting and quite common *Grinioneis* (e.g. *G. haidingeri*) and *Nonurocythereis* (e.g. *N. seminulum*) are often found in Miocene and younger ostracod assemblages, representing shallow-water biotopes, sometimes connected with various kinds of plants (Moyes 1965; Peypouquet 1977;

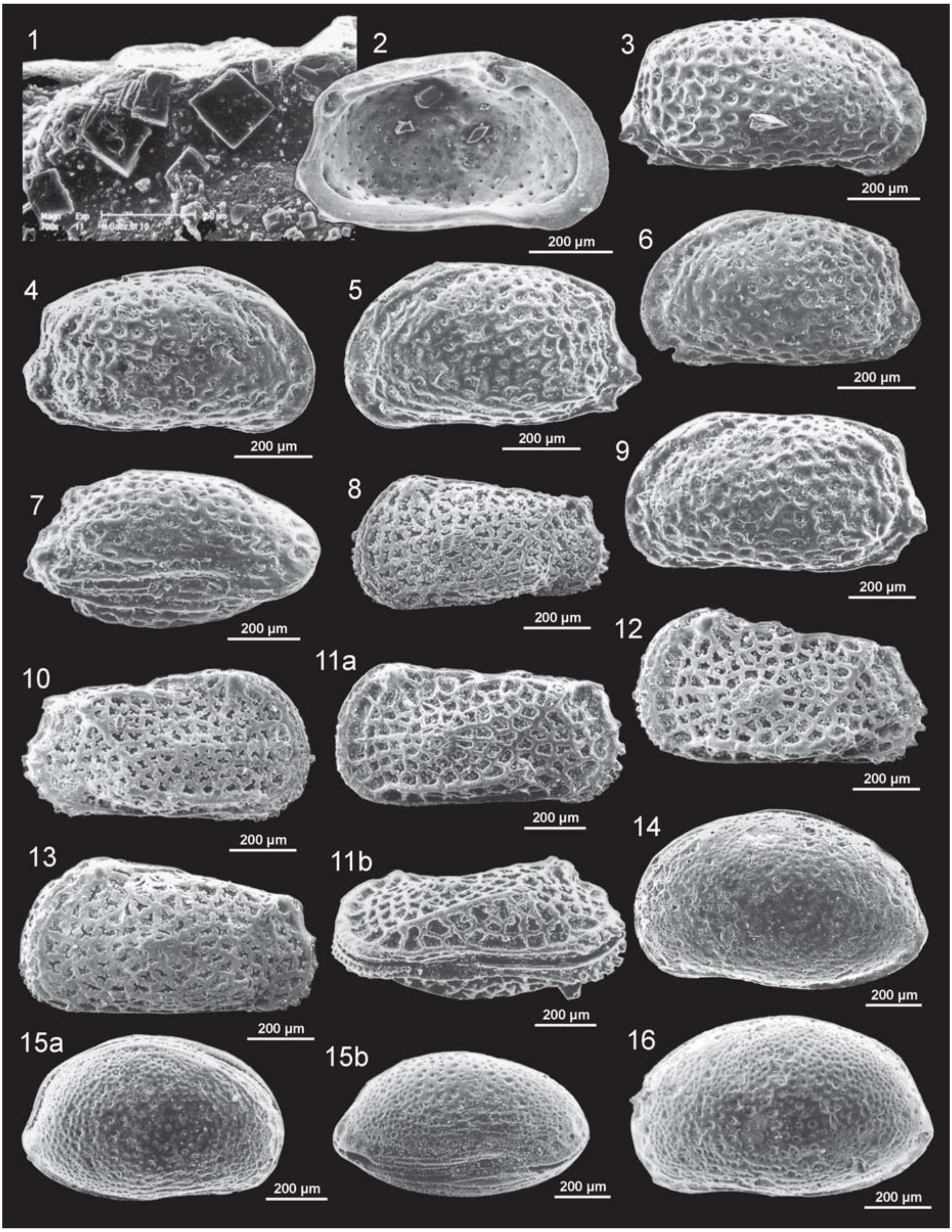

Fig. 8. 1 — Halite crystals infilling (covering) ostracod valve, ZPAL O. 54/265. **2–7, 9** — *Pokornyella* cf. *devians* Bonaduce, Ruggieri et Russo, 1986; 2 LV, seen from inside, ZPAL O. 54/275; 3 RV, ZPAL O. 54/254; 4 RV, ZPAL O. 54/255; 5 C, left side, ZPAL O. 54/81; 6 C, left side, ZPAL O. 54/20; 7 C, oblique ventral view, ZPAL O. 54/80; 9 LV, ZPAL O. 54/251. **8, 10–13** — *Grinioneis* gr. *haidingeri* (Reuss, 1850) [10 — form close to *G. pirata* (Ruggieri, 1960)]; 8 C, left side, ZPAL O. 54/177; 10 C, right side, ZPAL O. 54/18; 11 C, a — left side, b —oblique ventral view, ZPAL O. 54/170; 12 C, left side, ZPAL O. 54/4; 13 C, left side, ZPAL O. 54/17. **14–16** — *Aurila* sp. 2; 14 C, left side, ZPAL O. 54/111; 15 C, a —right side, b — oblique ventral view, ZPAL O. 54/109; 16 LV, ZPAL O. 54/276.

Yassini 1979a; Aranki 1987; Nascimento 1988; Ducasse & Cahuzac 1996; Conesa & Babinot 1999; Babinot 2002; Gross 2002).

Recent forms living especially in the northern and/or southern borders of the Mediterranean Sea and in the adjacent seas are relatively numerous among the studied and recognized ostracod species, or are close to them. They include *Callistocythere pallida*, *Loxoconcha tumida*, *L. rhomboidea*, *Neonesidea corpulenta, N. mediterranea*, *Neocytherideis subulata*, *Pontocythere elongata, P. curvata, Pterygocythereis jonesii*, *Pseudocytherura calcarata* and *Triebelina raripila* (e.g. Puri et al. 1964; Bonaduce & Masoli 1968; Masoli 1968; Barbeito-Gonzalez 1971; Uffenorde 1972; Bonaduce et al. 1975; Yassini 1979b; Lachenal 1989; Ruiz-Munoz et al. 1996; Barra 1997; Ruiz et al. 1997, 2000, 2003; Şafak 1999), thus their environmental preferences are well known and corroborate the above expressed suggestions.

Only a few species among the distinguished ones, for example *Pontocythere elongata*, *Neocytherideis subulata* and *Loxoconcha rhomboidea*, are known to live also in the southwestern and northern pericoastal areas of Europe, e.g. in the Arcachon Bay (Yassini 1969), the Bay of Seine (Chait et al. 1998) and the coastal parts of England (Athersuch et al. 1989); according to Chait et al. (1998) they represent species with large latitudinal distribution, in contrast to the "northern" species which do not cross the Bay of Seine in their southward extent. In the modern pericoastal, marine waters of England *P. elongata* and *N. subulata* prefer sandy substrate, while *L. rhomboidea* represents a phytal species, showing different environmental preferences (Athersuch et al. 1989); they coexist, however, on the sandy bottom in the Bay of Seine (Chait et al. 1998).

It is worth reminding here, that the distribution of ostracods depends not only on the physical and chemical features of water in their habitats, but also (as indicated above) on the bottom character, especially the type of sediment, and the kind as well as availability of food; among the phytophilous forms various species prefer different groups of plants. According to Ruiz et al. (1997), studying ostracods from a shallow-water estuary on the coast of southwestern Spain (Cadiz Gulf), and Uffenorde (1972), working on ostracods from the Limsky Canal on the Adriatic Sea coast, their regional and bathymetric distributions depend on seasons and on local hydrographic and hydrodynamic conditions. So the ostracod assemblage from Kamienica Nawojowska may represent a different paleobiocenosis, but probably all from the shallow-water environment.

The generally poor preservation of this fauna as well as the predominance of the large-sized, adult carapaces suggests a highly energetic (at least periodically agitated) environment and rapid sedimentation, while a considerable amount of the thick-shelled species may indicates its good saturation with $CaCO_3$. Moreover, the presence of the phytophilous forms indicates that the ostracods lived in well oxygenated waters, well illuminated by the sun, as expected of the shallow-water conditions. Bitner & Kaim (2004) do not exclude, however, the redeposition of fauna from Kamienica Nawojowska, involving its transportation basinward.

According to Puri (1971), the thick, heavy, large carapaces, containing representatives of *Cytheridea*, *Mutilus* (here *Aurila*) and *Carinocythereis* "characterize near-shore, coarse-grained sediments" (l.c. p. 165).

The distinct intraspecific variability among ostracods from Kamienica Nawojowska is, most probably, the result of the variability of the environment, which is ecophenotypic in character and may reflect seasonal fluctuations involving various hydrological factors: temperature, salinity, amount of $CaCO_3$, dissolved O_2, food supply, run off water masses (cf. e.g. Szczechura 1971; Keen 1982; Ikeya & Ueda 1988; Peypouquet et al. 1988; Babinot et al. 1991; Ducasse 1994). According to Babinot et al. (1991), the presence of numerous ostracod morphs in one sample may result from the seasonal fluctuation of the environment.

Since the ostracode assemblage from Kamienica Nawojowska is only indistinctly diversified along the studied section, it is regarded, in general, as living in rather a similar environment considering the entire studied depositional sequence. However, the sporadic occurrence of species preferring deeper waters, such as *Pterygocythereis jonesii* and *Parakrithe* sp., and greater diversity of ostracods in the lower part of the section, may indicate indistinct changes in the sea level, towards shallowing, and/or weakening of influence of the open sea during the deposition of sediments in the upper part of the section. Brachiopods are also more frequent in the lowermost sample (Bitner & Kaim 2004).

The shallow-water environment, well illuminated by the sun (high photic zone) and with bottom vegetation, indicated by ostracods from Kamienica Nawojowska, is confirmed by the coexistence of the calcareous green algae (Chlorophyta): the representatives of *Acicularia, Halicoryne* and *Cymopolia* (Fig. 11), nb. known (among others) from the Middle Miocene deposits (assigned to the Sarmatian) of the other areas of the Nowy Sącz Basin (e.g. from Niskowa) (Malecki 1970). According to Paruch-Kulczycka (1994), working on the marine algae (including *H. morelleti*) from the Sarmatian of the Carpathian Foredeep, they lived in "mainly shallow (5–30 m deep), tropical and subtropical waters with normal or increased salinity and low turbulence typical for coastal lagoons" (l.c. p. 572). Also according to Bucur et al. (1993), reporting on the Sarmatian algal microflora from Romania, they needed almost normal marine and subtropical-tropical (23–30 °C) waters.

Paleobiogeographic significance of the studied microfossils from Kamienica Nawojowska

Ostracods — As said above, the notable majority of the ostracod species from Kamienica Nawojowska is largerly known from the Badenian deposits of the other parts of the Central Paratethys. They are also known from the Middle Miocene sediments from the areas outside the Central Paratethys, mainly from the Mediterranean bioprovince, including its central part as well as the northern and southern adjacent parts, such as Italy (Bonaduce & Russo 1984; Dall'Antonia & Bossio 2001), southern Turkey (Bassiouni

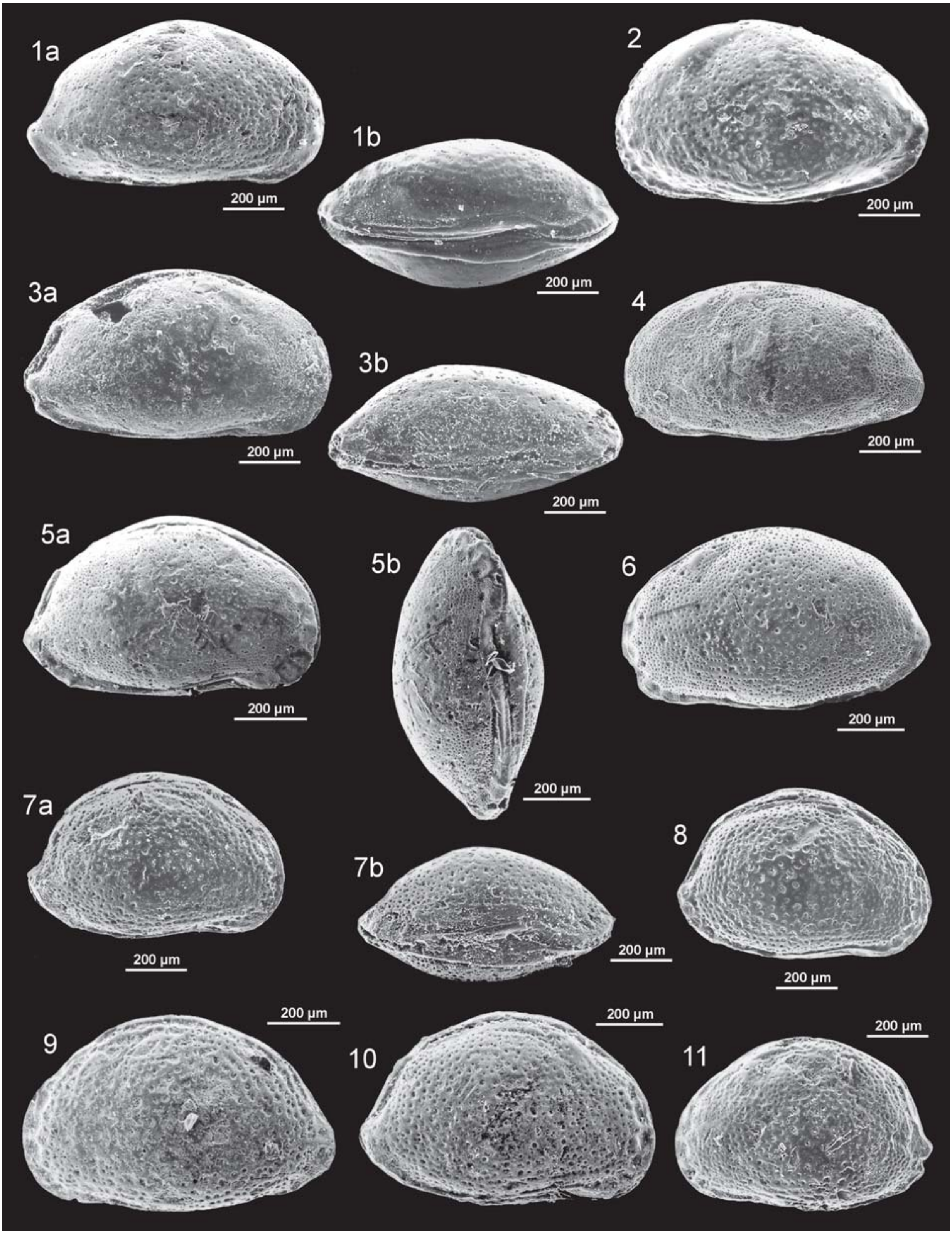

Fig. 9. 1, 2 — *Senesia cinctella* (Reuss, 1850); 1 C, a — right side, b — ventral side, ZPAL O. 54/106; 2 LV, ZPAL O. 54/277. **3, 4** — *Aurila haueri* (Reuss, 1850); 3 C, a — right side, b — ventral side, ZPAL O. 54/102; 4 LV, ZPAL O. 54/268. **5, 6** — *A.* cf. *opaca* (Reuss, 1850); 5 C, a — right side, b — oblique ventral side, ZPAL O. 54/266; 6 LV, ZPAL O. 54/284. **7, 8, 11** — *A.* sp. 3; 7 C, a — right side, b — ventral side, ZPAL O. 54/112; 8 C, right side, ZPAL O. 54/113; 11 C, left side, ZPAL O. 54/117. **9, 10** — *Aurila cicatricosa* (Reuss, 1850); 9 LV, ZPAL O. 54/104; 10 C, right side, ZPAL O. 54/124.

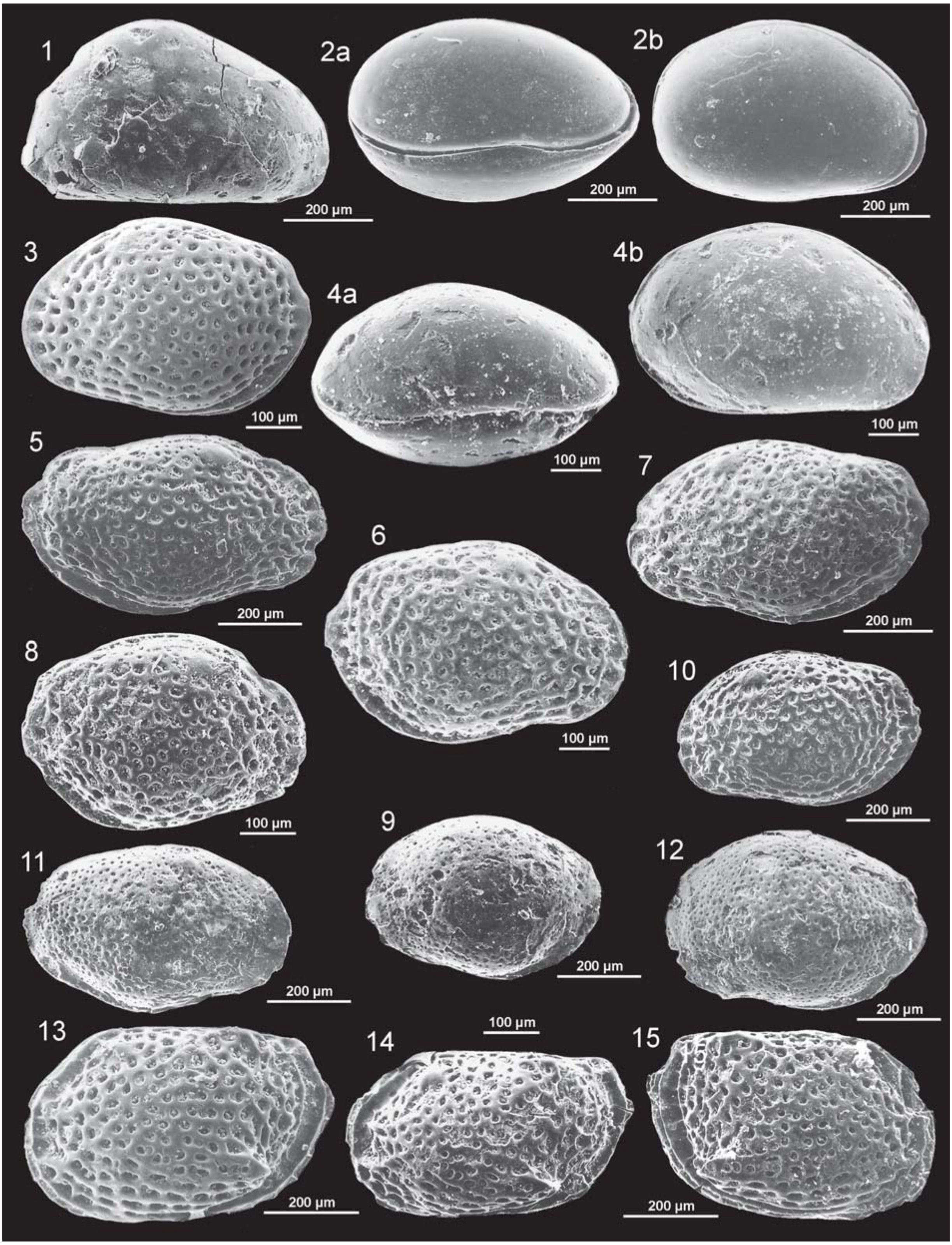

Fig. 10. 1 — *Xestoleberis* sp., RV, ZPAL O. 54/256. **2, 4** — *X.* cf. *tumida* (Reuss, 1850); 2 C, a — oblique ventral view, b — right side, ZPAL O. 54/215; 4 C, a — oblique ventral view, b — right side, ZPAL O. 54/319. **3** — *Loxoconcha* cf. *punctatella* (Reuss, 1850); LV, ZPAL O. 54/34. **5–8, 10** — *L.* cf. *tumida* (Brady, 1868); 5 RV, ZPAL O. 54/207; 6 RV, ZPAL O. 54/317; 7 LV, ZPAL O. 54/108; 8 C, right side, ZPAL O. 54/128; 10 LV, ZPAL O. 54/204. **9, 11, 12** — *L.* cf. *rhomboidea* (Fischer, 1855); 9 LV, ZPAL O. 54/216; 11 RV, ZPAL O. 54/205; 12 LV, ZPAL O. 54/217. **13–15** — *Loxocorniculum* cf. *hastatum* (Reuss, 1850); 13 LV, ZPAL O. 54/208; 14 LV, ZPAL O. 54/47; 15 RV, ZPAL O. 54/206.

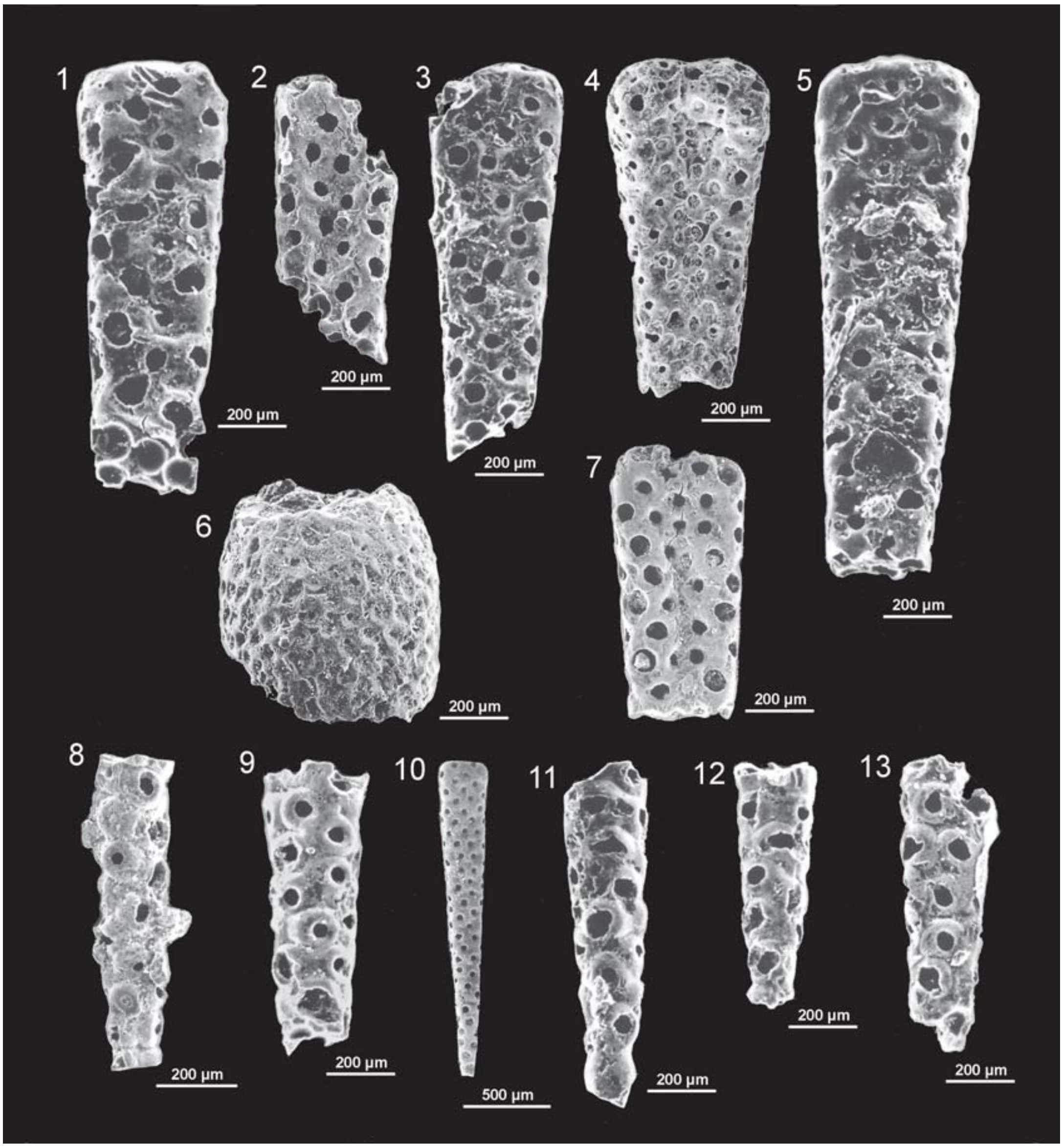

Fig. 11. 1–5, 7, 10 — *Acicularia* sp., ZPAL Al. 8/1–5, 7, 10. **6** — *Cymopolia* sp., ZPAL Al. 8/6. **8, 9, 11–13** — *Halicoryne* cf. *morelleti* (Pokorny, 1948); ZPAL Al. 8/8, 9, 11–13.

1979; Doruk 1979; Şafak 1993; Tunoğlu & Bilen 2001; Babinot 2002), northern Algeria (Carbonnel & Courme-Rault 1997). They are known, moreover, from that time, from the European peri-Atlantic parts (Atlantic bioprovince), especially the southwestern France (Aquitanian Basin) (Ducasse & Cahuzac 1996, 1997) and Portugal (Tejo Bay) (Nascimento 1988). Almost all these conclusions were presented earlier, when also other ostracod species from the discussed time and areas were compared (see e.g. Jiříček 1983; Szczechura 1994, 1998; Nascimento & Říha 1996; Zorn 1998; Gross 2002). The ostracod assemblages compared and mentioned here are more or less different with regard to their taxonomic composition probably mainly due to their more or less different environments.

The occurrence of the ostracod species in Kamienica Nawojowska so far unknown from the Middle Miocene of the Central Paratethys, but known from that time from the peri-Atlantic areas (e.g. *Jonicythere tribrachys* and *Neonesidea corpulenta*) (Nascimento 1988) and/or southern Turkey (e.g. *Pokornyella* sp. and associated forms) (Babinot 2002) additionally confirms the similarity of these faunas and indicates the sea connections and the existence of migratory routes. These Middle Miocene marine connections were suggested (among others) also by Studencka et al. (1998) and Rögl (2001).

Interestingly, the geographical range of the discussed ostracod species appears to be limited to the above mentioned areas. However, a species similar to this recognized here as *Pokornyella deformis*, is described from the Middle Miocene of the Caribbean region by van den Bold (1968, 1973), as *Procythereis* (recte *Pokornyella*) cf. *deformis*; it is associated with forms unknown from the Miocene of Europe. The shallow-water ostracod species from the Middle Miocene of the Caucasus, studied by Schneider (1949) as well as those listed by Pishchikova (1992) from the Middle Miocene of Crimea differ from those discussed here and represent mostly endemic forms, although *P. jonesii* is recorded from the Lower Miocene of both areas; the latter (late Middle Miocene deposits of Crimea) contain fresh-water elements. At the same time, however, the comprehensively figured and recognized ostracod assemblage presented by Schneider (l.c.), being poorly documented, seems worth additional studies, especially when considering its taxonomy and age, and so its paleobiogeographic importance.

Green algae — The reported green algae (especially *H. morelleti*), like the ostracods, are rather broadly distributed in the Middle Miocene deposits of Europe but mainly of the Central Paratethys; they are known, for example from the Carpathians and the Carpathian Foredeep, Vienna Basin, Serbia, Hungary and Romania (cf. Stancu & Tautu 1974; Bucur et al. 1993; Paruch-Kulczycka 1994).

Conclusions

The presented ostracods (Figs. 2–10) and green algae (Chlorophyta) (Fig. 11) have been studied in samples from an outcrop situated in the left bank of the Kamienica Nawojowska River, at the Kamienica Nawojowska locality, at the southern outskirts of the Nowy Sącz town, in the Nowy Sącz Basin, within the Outer Western Carpathians (Fig. 1). The outcropping marine deposits consist of dark grey sandy silts. Among the ostracods, attributed to 42 species (including 9 species left in the open nomenclature) and 26 genera, the representative of the genus *Jonicythere* Mostafawi, 1986 (*J.* cf. *tribrachys* (Bonaduce, Ruggieri, Russo et Bismuth, 1992)), so far unknown from the Miocene of the Central Paratethys seems to be particularly interesting. Also *Neonesidea* cf. *corpulenta* (G.W. Müller, 1894) and *Pokornyella* cf. *devians* Bonaduce, Ruggieri et Russo, 1986 are recorded for the first time from the Middle Miocene of the Central Paratethys.

The remnants of green algae are assigned to three genera and three species, of which two species are left in the open nomenclature.

The ostracods indicate that they lived in the pericoastal, shallow-water and normal marine environment, with bottom vegetation and high energy, but rather unstable conditions. These resulted in large, most probably ecophenotypic variability of some species, being characteristic for shallow-water ostracod faunas. These environmental conditions may be confirmed by the associated algal remnants as well as the coexisting foraminifers studied by Gonera (subm.).

The analysis of the spatiotemporal distribution of the studied ostracods allowed us to conclude that they are of Middle Miocene (Badenian) origin and have common elements with those known from sediments of this age from various areas of the Central Paratethys (including the Carpathian Foredeep) as well as the Mediterranean region and the peri-Atlantic areas of southwestern Europe; it means that in the Middle Miocene there were marine routes enabling their migrations. The algae, not helpful in determing the age, are more restricted regionally than ostracods; their distribution is rather limited to the Central Paratethys.

The supposed Middle Miocene (Badenian) age of the studied microfossils, mainly ostracods, from Kamienica Nawojowska is in agreement with that indicated by the coexisting foraminifers (Gonera subm.) and brachiopods (Bitner & Kaim 2004).

The exact age within the Badenian Stage of the studied microfossils from Kamienica Nawojowska is difficult to estimate. It might be possible after additional studies on the evolution of the Middle Miocene faunas in the Central Paratethys, mostly of its northern areas, and especially their environmental conditions.

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