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Latest Maastrichtian foraminiferal assemblages from the Husów region (Skole Nappe, Outer Carpathians, Poland)

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Abstract: The Ropianka Formation (also known as the Inoceramian Beds) in the marginal part of the Skole Nappe (Husów region, the Gaj section) contains abundant, diverse and well preserved assemblages of Maastrichtian planktonic and benthic foraminiferids, assigned to the middle-upper part of the Gansserina gansseri Zone and to the Abathomphalus mayaroensis Zone. The composition of the assemblages indicates fluctuations of organic matter flux to the marginal part of the Skole Basin floor in the studied interval. The studied taxa are typical of the "transitional zone" between the Tethyan and the Boreal domains. The disappearance of planktonic foraminifers in the uppermost part of the section and appearance of some agglutinated taxa (*Rzehakina fissistomata*; abundant *Conglophragmium irregularis* and *Glomospira charoides*) points to a Paleocene age.

Key words: Maastrichtian, flysch, transitional zone, paleoecology, biostratigraphy, foraminiferids.

Introduction

Terminal Maastrichtian foraminiferal assemblages in the Flysch Carpathians are represented by mostly poorly diagnostic benthic agglutinated taxa. The foraminiferal zones based on them (Geroch & Nowak 1984; Olszewska 1997) are broad in duration. As a consequence a precise stratigraphy of this interval is very difficult, and determination of the K/T boundary is imprecise. Exceptionally, some taxa of the youngest Cretaceous planktonic foraminiferal Abathomphalus mayaroensis Zone have been found in a few sections of the Subsilesian Unit (Gasiński et al. 1999, 2001) and the Skole Nappe (see chapter **Micropaleontological analysis**).

Very rich assemblages of planktonic and benthic foraminifers of youngest Maastrichtian age occur in flysch sediments of the marginal thrust sheet in the Skole Nappe, SE of Rzeszów in the Husów region (Fig. 1). Their description and interpretation are the main aim of the paper.

The biostratigraphy of the Cretaceous in the study area is so far poorly recognized, without modern micropaleontological research. Such abundant, very diverse and well preserved Maastrichtian planktonic foraminiferal assemblages are very rarely found in the Polish Flysch Carpathians (Gasiński et al. 1999, 2001, 2003). Commonly, only some index taxa are listed but not illustrated. For the first time in the Skole Unit, the planktonic foraminiferal assemblage allow the recognition of recently proposed latest Cretaceous biozones. Moreover, the microfauna of the Skole Unit contributes to our understanding of migration "gates" between the Boreal and Tethyan biogeoprovinces (Gasiński 1997, 1998; Marcinowski & Gasiński 2002). The marginal part of the Skole Unit of the Polish Carpathians was located near the Boreal-Transitional domain (Kollmann & Zapfe 1992) in proximity to the so-called Lviv Gate (Marcinowski & Gasiński 2002). Therefore, micropaleontological data from this area are very important for reconstructions of the Late Cretaceous plankton paleobiogeography.

Geological setting

The Skole Nappe SE of Rzeszów has been studied since the 19th century. Tietze (1883) distinguished the Ropianka Beds in the vicinity of Albigowa and ascribed all the flysch deposits SE of Rzeszów to the "older Tertiary", and Hilber (1885) assigned them to the Neocomian. Friedberg (1900) also distinguished the Ropianka Beds at Albigowa and Husów. Wdowiarz (1936, 1949) characterized the lithostratigraphy and tectonics of the Cretaceous and younger deposits of this area. He recognized the Inoceramian Beds (formerly known as the Ropianka Beds), subdivided them into the lower, middle and upper levels, estimated their thickness at 500 m, and dated them to the Senonian–Paleocene by analogy to other areas. They are overlain by the Eocene Variegated Shale. For a comprehensive history of research on the Ropianka Beds (latter Ropianka Formation or Inoceramian Beds) in the Skole Nappe see Kotlarczyk (1978). Bromowicz (1974) described the lithology and distinguished four lithological complexes in the Inoceramian Beds in the area SE of Rzeszów, the total thickness of which was estimated at about 400 m. Bromowicz determined that their sediments were transported from the NW. West of the study area, Malata (2001) distinguished the Fucoid Marl Member, Leszczyny Sandstone Member (Maastrichtian) and the Makówka Slump Debris (Late Maastrichtian) within the Ropianka Formation which was renamed as the Rybotycze Formation.

At first in the 19th century, the studied deposits of the Skole Nappe were named the Ropianka Beds, which were originally distinguished in the Magura Nappe (Paul 1869). Later, these deposits were called the Inoceramian Beds (Uhlig 1888;

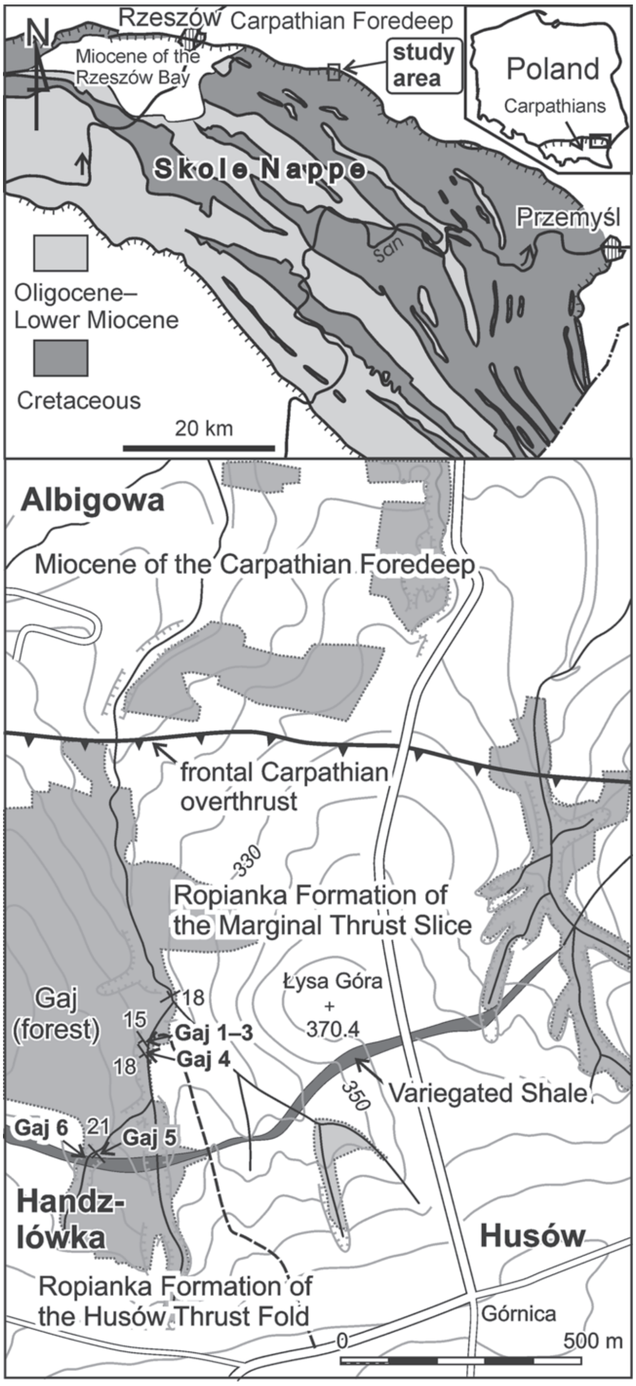

Fig. 1. Location map. Tectonic unit designation, Carpathian margin and range of the Variegated Shale after Wdowiarz (1949). Location of samples (Gaj 1, etc.) indicated.

Wdowiarz 1949). Kotlarczyk (1978) applied the oldest name to the Inoceramian Beds of the Skole Nappe and established the Ropianka Formation with its neostratotype in the Przemyśl area, which he (see also Kotlarczyk 1979, 1985) subdivided into the Cisowa Member (Turonian–Lower Campanian), Wiar Member (Lower Campanian–Lower Maastrichtian), Leszczyny Member (Lower Maastrichtian–Lower Paleocene) and Wola Korzeniecka Member (Paleocene) (Fig. 2). This lithostratigraphic scheme was a matter of controversies (Haczewski 1986; Ślączka & Miziołek 1995; Malata 1996, 2001) but new propositions, if present (Malata 1996, 2001), are also problematic. These problems require clarification that is beyond the scope of this study.

The oldest biostratigraphic data in the studied area come from the 19th century. Hilber in Uhlig (1883) and Grzybowski (1903) found inoceramid bivalve fragments at Husów (their Hussow) pointing to the Cretaceous. Friedberg (1901, 1903) determined the foraminifers *Dendrophrya excelsa* Grzybowski, *D. robusta* Grzybowski and *D. robusta* var. *maxima* from intercalations of sandstones and shales at Albigowa, probably from the Inoceramian Beds. Friedberg (1908) determined *Inoceramus salisburgensis* Fugger & Kastner from Husów.

The studied section occurs along the Gajowy stream, in the Gaj forest between the territories of the villages of

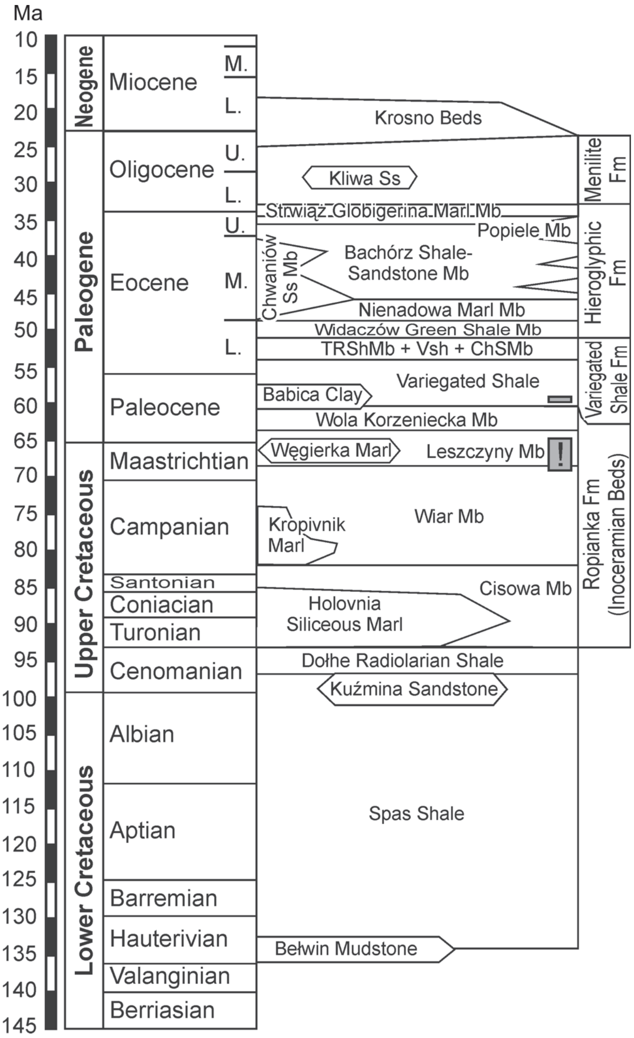

Fig. 2. Stratigraphic scheme of the Skole Nappe. Based on Kotlarczyk (1988), Rajchel (1990), Rajchel & Uchman (1998), Ślączka & Kaminski (1998), with further corrections based on further data by Gedl (1999) and Kotlarczyk et al. (2007). The investigated interval indicated by "!". The time scale is after Gradstein et al. (2004). **TRShMb** — Trójca Red Shale Member, **VSh** — Variegated Shale, **ChSMb** — Chmielnik Striped Sandstone Member.

Husów, Handzlówka and Albigowa (Fig. 1). The outcrops are small and isolated (sections A–D in Fig. 3), but the consequent strikes and dips of beds suggest a limb of a regular anticline with its axis dipping to the west. The anticline is a part of the Marginal Thrust Sheet, the structure of which is more complex to the NW (Wdowiarz 1949). The Marginal Thrust Sheet is overthrust to the NE onto the Miocene of the Stebnik Unit (or Zgłobice Unit according to Kotlarczyk 1988) or on the autochthonous Miocene of the Carpathian Foredeep. To the SE, the Ropianka Formation of the Marginal Thrust Sheet is bound by a belt of Eocene Variegated Shale, which also belongs to the Marginal Thrust Sheet. Further to the South, the Husów Thrust Sheet is present, which is overthrust onto the Marginal Thrust Sheet (Wdowiarz 1949).

The studied outcrops are composed of turbiditic deposits with a great contribution of marls and marly shales intercalated with fine- to medium-grained calcareous sandstones (Fig. 3). The lower part of the studied sequence (sections A and B) contains more sandstones, with beds up to 30 cm thick. The upper part (sections C, D) contains less sandstones, with thinner beds. These deposits contain the trace fossils *Ophiomorpha rudis* (especially in thicker beds), *Chondrites targionii*, and rarely *Nereites irregularis* and *Phycosiphon incertum*. Stratigraphically, the studied deposits are an equivalent of the Leszczyny Member and possibly of the uppermost part of the Wiar Member of the Ropianka Formation *sensu* Kotlarczyk (1978, 1988) (Fig. 2). The lithology of the Leszczyny Member is very variable and includes marl-rich olistostromes. It is not clear whether the Wiar Member or the Leszczyny Member can be distinguished in the study area, however a general fining-up section is one of the typical features of the Leszczyny Member (Kotlarczyk 1978) and these members are recognized west of the study area (J. Kotlarczyk, personal communication, 2008). The divisions recognized by Malata (2001) in the same tectonic units, namely the Leszczyny Sandstone Member (thick-bedded sandstones at least 100 m thick) and the Makówka Slump Debris Member, which can be expected to occur in the studied section because of their stratigraphic position, are not recognized here.

Micropaleontological analysis

Biostratigraphy

Twenty five samples from the section studied area have been analysed (see: Figs. 3, 4). Some of these contain well

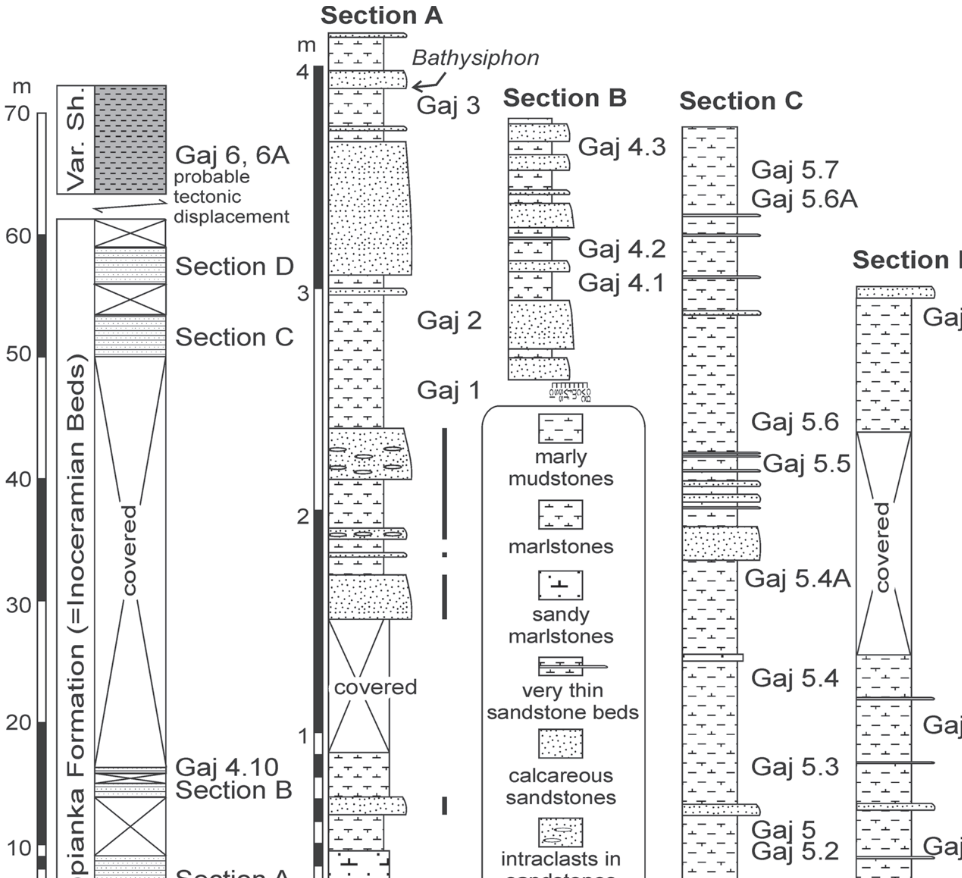

Fig. 3. Lithological column with location of the samples.

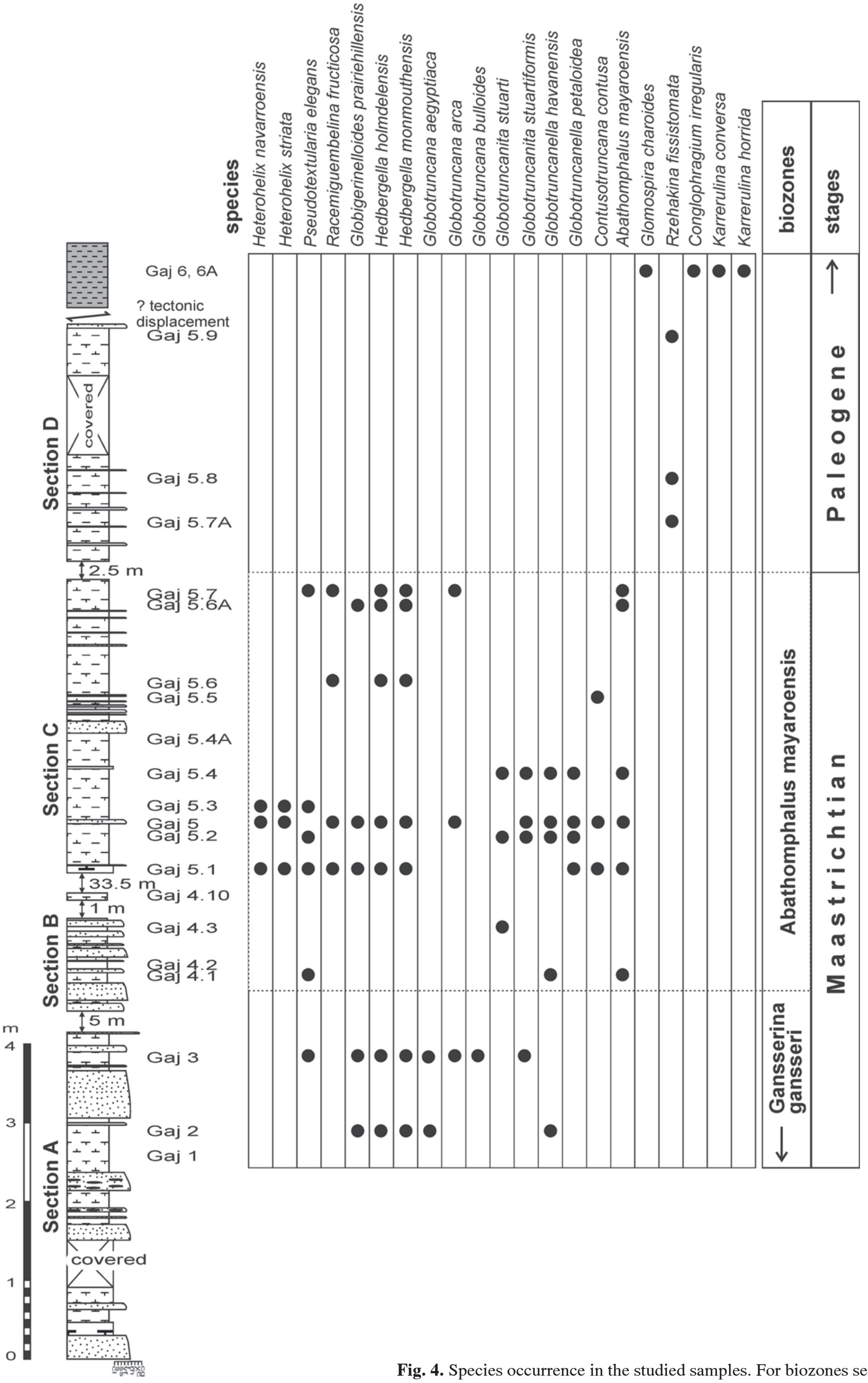

Fig. 4. Species occurrence in the studied samples. For biozones see Fig. 5.

and very well preserved planktonic and benthic foraminiferids (Figs. 4, 5). The stratigraphic ranges of the index taxa point to a Maastrichtian age. The middle to upper part of the Gansserina gansseri to Abathomphalus mayaroensis standard zones were distinguished according to the zonation published by Caron (1985), Robaszynski & Caron (1995; Fig. 5). These zones have been recognized on the basis of index planktonic foraminiferids as well as characteristic foraminiferal assemblages. The Abtahomphalus mayaroensis Zone is a Taxon Range Zone. It was recognized between sample Gaj 4.1, where the first appearance (FO) of *A. mayaroensis* (Bolli) is noted, and sample Gaj 5.7, where its last occurrence (LO) is observed (Fig. 5). *Gansserina gansseri* (Bolli) is not present in the analysed material, probably due to its more Tethyan paleobiogeographic preferences. Nevertheless, the stratigraphic ranges of other planktonic species, such as: *Pseudotextularia elegans* (Rzehak), *Globigerinelloides prairiehillensis* Pessagno, *Hedbergella holmdelensis* Olsson, *Globotruncana aegyptiaca* Nakkady, *G. bulloides* Vogler and *G. stuartiformis* (Dalbiez), and the absence of *Abathomphalus mayaroensis* (Bolli) in sample Gaj 1 to Gaj 4 (below its FO) points to the underlying Gansserina gansseri Zone (Fig. 4).

Abathomphalus mayaroensis is rarely noted from the turbiditic sequences of the Outer Carpathians (e.g. Liszkowa & Morgiel 1981; Gasiński et al. 2001). However, this species is never abundant and occurs in assemblages together with other planktonic species, such as *Heterohelix navarroensis* Ehrenberg, *H. striata* (Ehrenberg), *Pseudotextularia elegans* (Rzehak), *Racemiguembelina fructicosa* (Egger), *Globigerinelloides prairiehillensis* Pessagno, *Hedbergella holmdelensis* Olsson, *H. monmouthensis* (Olsson), *Globotruncana aegyptiaca* Nakkady, *G. arca* (Cushman), *G. bulloides* Vogler, *Globotruncanita stuarti* (de Lapparent), *G. stuartiformis* (Dalbiez), *Globotruncanella havanensis* (Voorvijk), *G. petaloidea* (Gandolfi), or *Contusotruncana contusa* (Cushman) (Fig. 4). All the diagnostic species as well as some taxa which are typical of the studied foraminiferal assemblages are illustrated in Figures 7–9. Their stratigraphic ranges are reported after Robaszynski et al. (1984), Caron (1985), Robaszynski & Caron (1995), Premoli-Silva & Rettori (2002) and Premoli-Silva & Verga (2004).

Foraminiferal assemblages from sample Gaj 5.7A to sample Gaj 6A (Fig. 4) are composed mainly of agglutinated taxa, with a small admixture of calcareous benthic forms. They do not contain any planktonic taxa. Therefore, it is impossible to determine their precise biostratigraphical position to a particular biozone, however some suggestions based on composition of the agglutinated foraminiferal assemblages can be made. Samples Gaj 5.7A, 5.8 and 5.9 contain among others the agglutinated index species *Rzehakina fissistomata* (Grzybowski), which ranges from the ?Maastrichtian to the Paleocene (Kaminski & Gradstein 2005). Liszkowa & Morgiel (1981) have dated an agglutinated foraminiferal assemblage with *Rzehakina fissistomata* from the Krasice section of the Skole Unit as Paleocene. Sample Gaj 6 does not contain index taxa, but the increased abundance of *Conglophragmium irregularis* (White) and *Glomospira charoides* (Parker & Jones) points to the Paleogene. The same concerns sample Gaj 6A, which additionally contains *Karrerulina conversa* (Grzybowski) and *K. horrida* (Mjatliuk). The higher abundance of shales in this part of the section (Figs. 3, 4) suggests a change in depositional conditions.

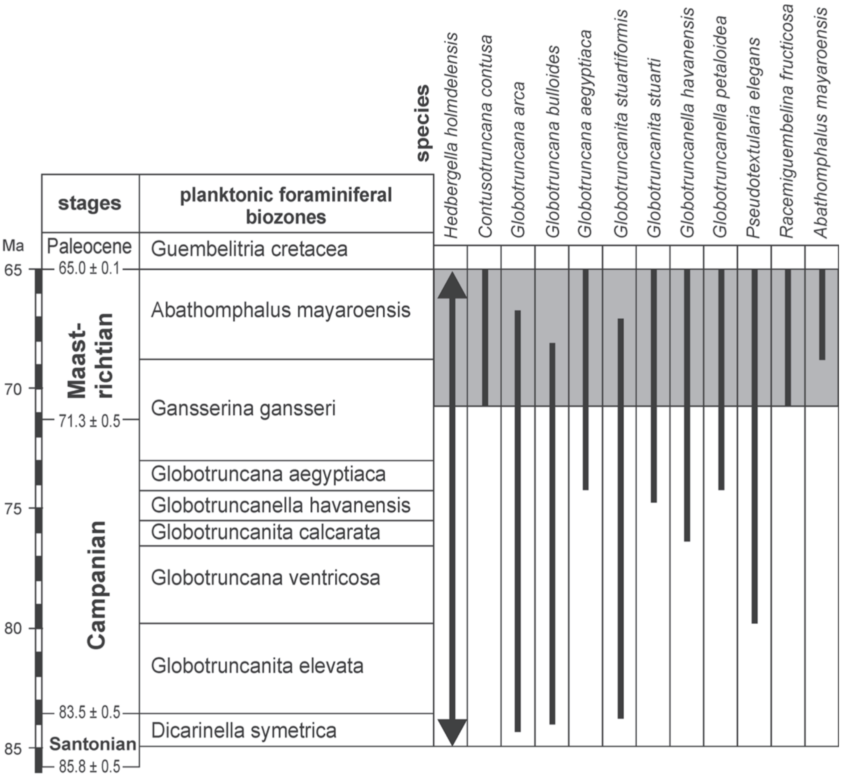

Fig. 5. Biostratigraphical ranges of the studied planktonic index taxa. Ranges of species and biozones plotted (combined) after Robaszynski et al. (1984), Caron (1985), Robaszynski & Caron (1995), Premoli-Silva & Rettori (2002) and Premoli-Silva & Verga (2004). The grey area indicates biozones recognized in the studied material.

Abathomphalus mayaroensis *(Bolli)* *in the Skole Nappe*

Abathomphalus mayaroensis (Bolli) (formerly *Globotruncana mayaroensis* Bolli) has been recognized by Bukowy & Geroch (1957) in the K. Wójcik collection of foraminiferids from the exotic conglomerates at Kruhel Wielki near Przemyśl. Morgiel (1959) and Szymakowska (1961) mentioned the occurrence of this species in the Babica Clay. The Babica Clay is composed mostly of debris flow deposits and is dated to the Paleocene (Bukowy 1956, 1957; Geroch & Kotlarczyk 1963). It seems that *A. mayaroensis* in this unit is redeposited from Maastrichtian sediments.

Other findings of *Abathomphalus mayaroensis* come from the Ropianka Formation of the Skole Nappe but these observations are rarely supplemented by detailed localization. Morgiel & Żgiet (1961) mentioned *G. mayaroensis* in samples from the borehole at Dydnia (their Inoceramian Beds of the Subsilesian and Skole Units transitional zone). *Globotruncana mayaroensis* is listed among the foraminiferal assemblages of the Ropianka Formation (Inoceramian Beds) as well as those of the Węgierka Marls (upper part of the Ropianka Formation) (Gucik 1962, 1987; Gucik & Wójcik 1982; Kotlarczyk 1988). It was also listed by Bieda et al. (1963) from the Węglówka Marl and the Żegocina Marl of the Subsilesian Unit. Vialov et al. (1967) and Zhurakovsky (1971) reported findings of *G. mayaroensis* in the Ukrainian part of the Skole Nappe. Morgiel in Wdowiarz et al. (1974) mentioned it from the Cisowa IG-1 borehole. Morgiel & Liszkowa (1981) informed about relatively numerous specimens of *A. mayaroensis* within foraminiferal assemblages of the Frydek Marl-type sediments of the Subsilesian Unit as well as from the so-called Baculites Marls (an equivalent of the Węgierka Marls in the Skole Nappe).

Abathomphalus mayaroensis and associated planktonic and benthic foraminifers have also been found in the Leszczyny Member in the Przemyśl area (Kotlarczyk 1988, p. 44). Morgiel in Żytko & Zimnal (1997) noted *A. mayaroensis* from the foraminiferal association of the Smorż stream section.

Paleoecology

On the basis of washed residues of the collected samples, a quantitative analysis has been performed (Fig. 6). All specimens, including those with broken tests, were counted. For the planktonic assemblages, the parameters: planktonic/benthic ratio and epipelagic/bathypelagic ratio are considered as indicators of paleobathymetry and offshore distance (cf. Sliter 1972; Sliter & Baker 1972; Olsson & Nyong 1984; and others). Within the benthic associations, the agglutinated/calcareous benthic taxa ratio and the suspension-feeders (tubular forms such as *Rhabdammina* or *Nothia*)/other agglutinated taxa ratio were counted. These results point to the organic flux (OF) to the basin floor by turbiditic currents and to its quantitative aspect (cf. Kaminski & Kuhnt 1995; Gasiński 1998). A distinct negative correlation between an increase in planktonic and especially epipelagic species and a reduction in suspension feeders is noted (Fig. 6). Only in sample Gaj 5.4A does this relation change rapidly; planktonic species became very scarce, whereas suspension feeders dominate. This could reflect an increase in OF, which may have been caused by increased productivity or redeposition of organic matter from the shallower part of the basin due to a relative sea-level fall. However, the latter possibility is not marked by any sedimentological change, such as coarsening of sediments. The relative increase in abundance of the suspension feeder morphological group in relation to relatively scarce epipelagic taxa is observed in sample Gaj 1. Another rapid increase in suspension feeder abundance and diminishing abundance of epipelagic planktonic taxa is noted in sample Gaj 5.5. Such rapid changes among foraminiferal assemblages of samples Gaj 5.4A and Gaj 5.5 can be interpreted as an episode of rapid increase in sea-surface productivity (especially distinct in sample Gaj 5.4A). The increased availability of organic matter caused the rapid appearance of tubular agglutinated taxa (for the feeding strategy of foraminiferal suspension feeders see: Jones & Charnock 1985; Nagy 1992; Kaminski & Kuhnt 1995; Gasiński 1998). It should be stressed that from sample Gaj 6 (Fig. 6) agglutinated foraminiferids dominate, which indicates a drastic change in environmental conditions resulting in a change of composition of foraminiferal assemblages toward decreasing planktonic taxa. Of course, the activity of turbiditic currents taking place in the studied part of the Skole Basin strongly influenced such processes.

Discussion

Biostratigraphy

The chronostratigraphy of the Abathomphalus mayaroensis and Gansserina gansseri Zones has been provided by Robaszynski & Caron (1995). In their scheme, the Maastrichtian comprises the whole of the A. mayaroensis Zone and the upper part of the G. gansseri Zone. Robaszynski et al. (1984) and Caron (1985) proposed a different scheme, in which the underlying G. aegyptiaca and the G. helvetica Zones are also included into the Maastrichtian. According to the subsequent schemes by Robaszynski & Caron (1995) and Premoli-Silva & Rettori (2002), these zones belong into the upper Campanian. In the current Cretaceous Time Scale, Gradstein et al. (2004) proposed a Racemiguembelina fructicosa Zone situated between the A. mayaroensis and G. gansseri Zones. *Racemiguembelina fructicosa* (Egger) is present in the studied material (Fig. 8.3–6), however its occurrence together with *A. mayaroensis* (Fig. 4) does not allow us to separate the Racemiguembelina fructicosa Zone. *Racemiguembelina fructicosa* is rarely noted in foraminiferal assemblages of the Tethyan domain (cf. Nederbragt 1991).

It should be mentioned that the Cretaceous/Paleocene boundary (traditionally named K/T) is placed between the last occurrence of *Abathomphalus mayaroensis* (Bolli) and first abundant appearance of *Guembelitria cretacea* Cushman, which constitutes the Partial Range P0 Zone *sensu* Olsson et al. (1999) and Gradstein et al. (2004). It is located between the samples Gaj 5.7 amd Gaj 5.7A of the studied section (Fig. 3), which are 3 m apart. So far, this is the most precise location of the K/T boundary in the Polish Carpathians.

Provenience of the studied planktonic assemblage

The Maastrichtian foraminiferal assemblages analysed from the Husów area (this study) and those from the Węgierka Marls of the Skole Unit (Kotlarczyk 1978; Geroch et al. 1979) display a distinct similarity. The Kropiwnik Fucoid Marl in the Wiar Member (Kotlarczyk 1978, 1985, 1988) also contains some similar species of foraminiferids, among them a few index species such as: *Globotruncana arca*, *Globotruncanita stuarti*, *Globotruncanella havanensis*, and *Contusotruncana contusa*.

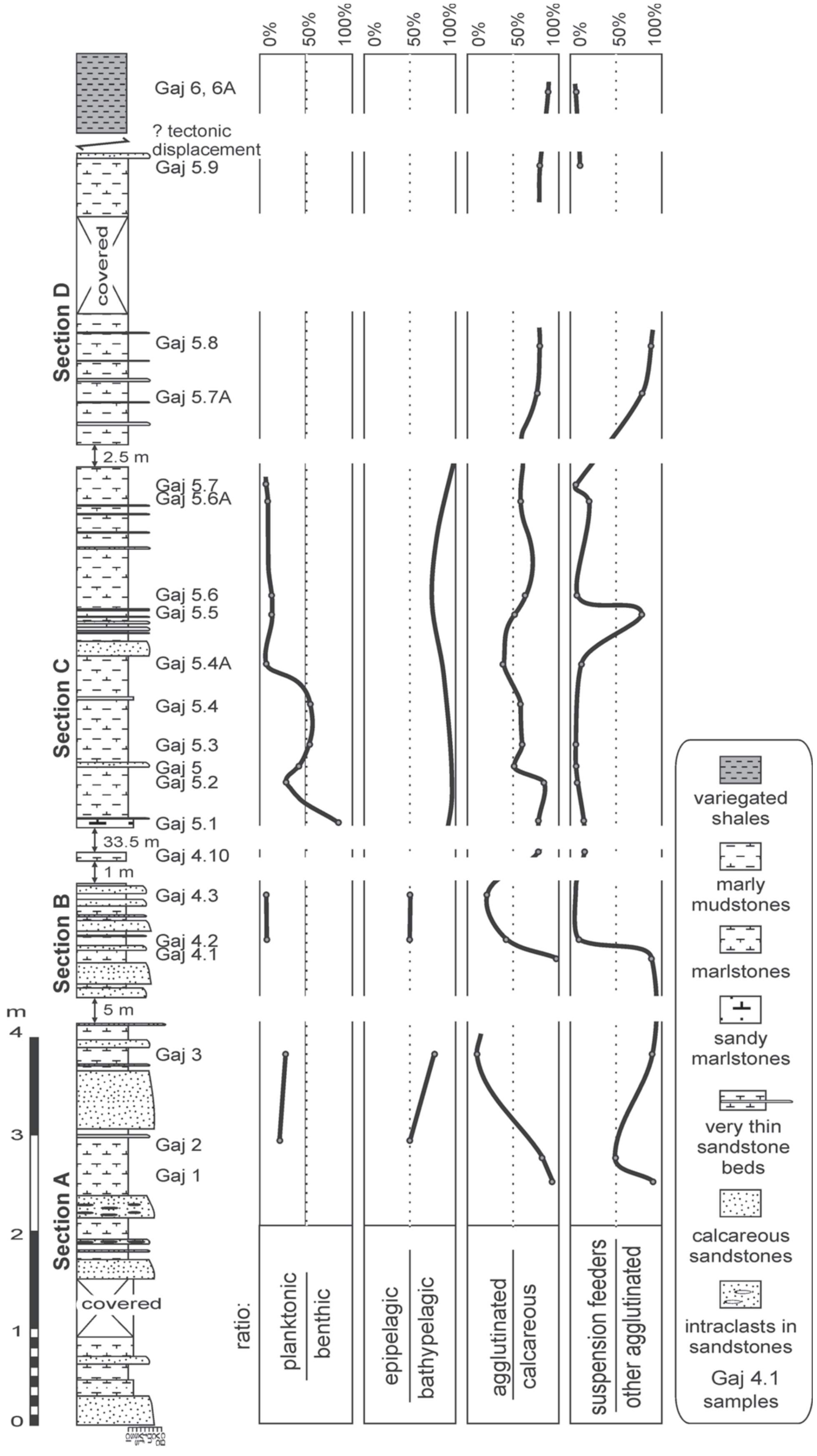

Fig. 6. Quantitative analysis of the studied foraminiferal assemblages.

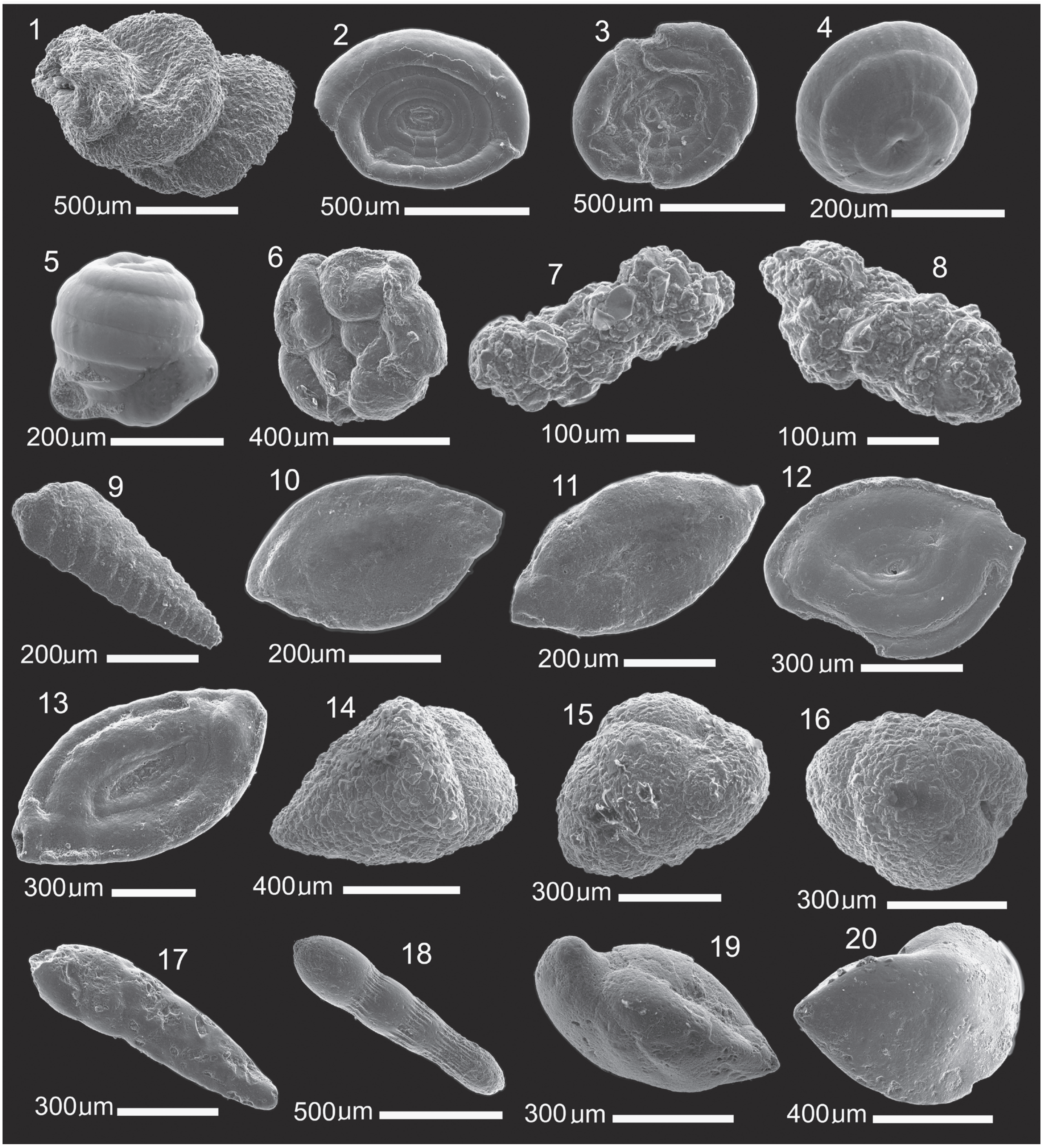

Fig. 7. Benthic foraminiferids from the Gaj section. **1** — *Hormosina velascoensis* (Cushman), sample Gaj 5.8. **2, 3** — *Ammodiscus* sp., 2 — sample Gaj 5.3, 3 — sample Gaj 6. **4, 5** — *Glomospira charoides* (Parker & Jones), 4 — sample Gaj 5.3, 5 — sample Gaj 6. **6** — *Conglophragmium irregularis* (White), sample Gaj 6. **7** — *Karrerulina horrida* (Mjatliuk), sample Gaj 6A. **8** — *Karrerulina conversa* (Grzybowski), sample Gaj 6A. **9** — *Spiroplectammina spectabilis* (Grzybowski), sample Gaj 5.4. **10, 11** — *Rzehakina epigona* (Grzybowski), sample Gaj 5.2. **12, 13** — *Rzehakina fissistomata* (Grzybowski), sample Gaj 5.9. **14** — *Dorothia oxycona,* sample Gaj 5.8. **15, 16** — *Arenobulimina dorbignyi* (Reuss), sample Gaj 5.6A. **17** — *Coryphostoma* cf. *plaita* (Carsey), sample Gaj 5. **18** — *Nodosaria* sp., sample Gaj 5.3. **19** — *Saracenaria* cf. *triangularis* (d'Orbigny), sample Gaj 5.4. **20** — *Lenticulina* sp., sample Gaj 5.4A.

According to the results of cluster analysis of significant Campanian–Maastrichtian foraminiferal associations (Gasiński 1998), the considered associations fit within the "transitional zone" between the Boreal and Tethyan provinces (cf. Gasiński 1997, 1998; Marcinowski & Gasiński 2002). In comparison to the Maastrichtian foraminiferal assemblages from the Andrychów Klippen marls regarded as typical "transitional" biota between Boreal and Tethyan domains (cf. Gasiński 1998), the described assemblages do not contain some planktonic genera (e.g. *Rugoglobigerina*), that are diagnostic of the Boreal province (cf. Scheibnerova 1971; Sliter 1972, 1977; Gasiński 1997). According to Olsson & Wise (1987), *Contusotruncana*

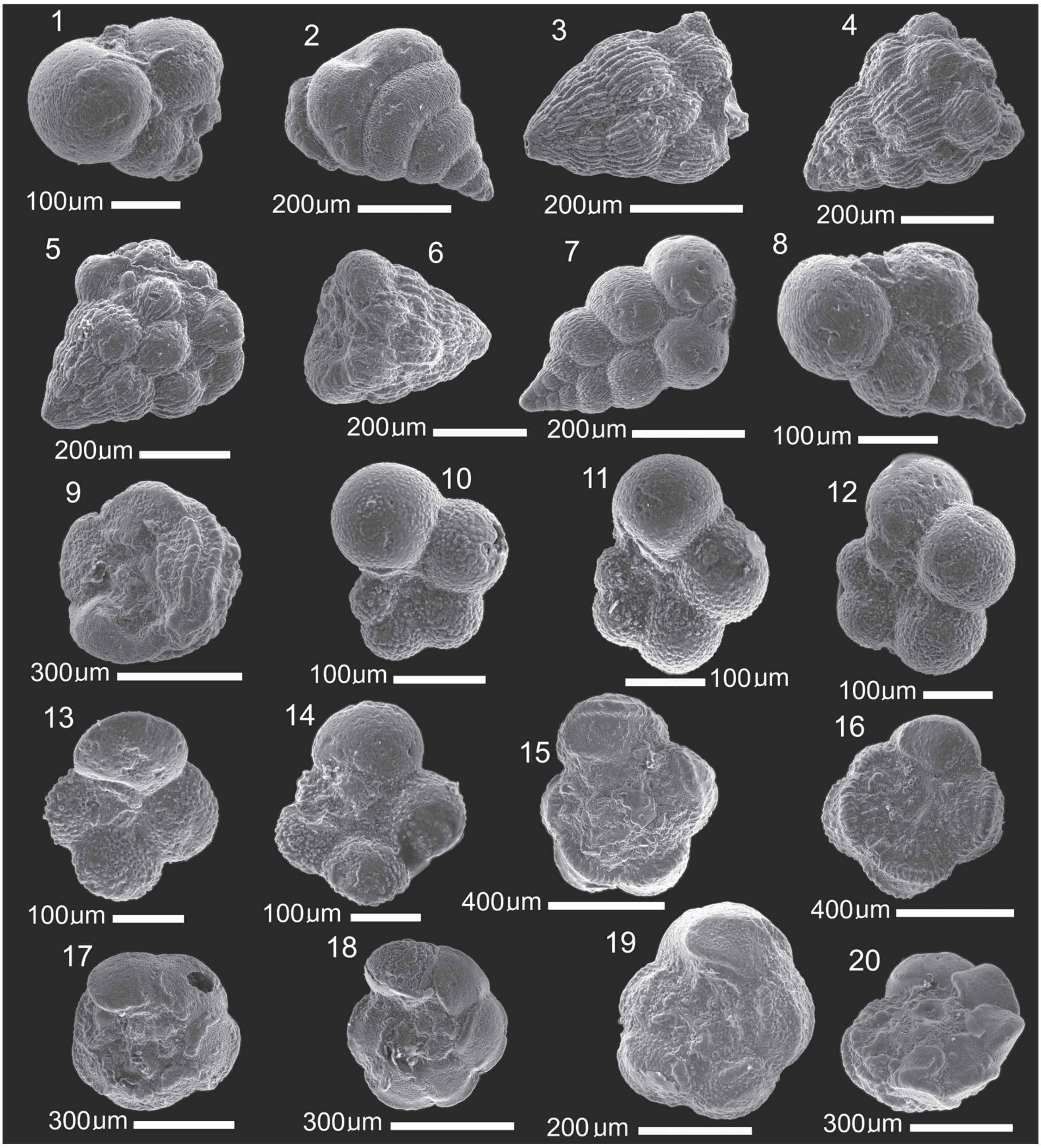

Fig. 8. Planktonic foraminiferids from the Gaj section. **1, 7** — *Heterohelix striata* (Ehrenberg), sample Gaj 5. **2** — *Pseudotextularia elegans* (Rzehak), sample Gaj 5. **3–6** — *Racemiguembelina fructicosa* (Egger), sample Gaj 5. **8** — *Heterohelix navarroensis* Ehrenberg, sample Gaj 5. **9** — *Contusotruncana contusa* (Cushman), sample Gaj 5. **10** — *Hedbergella monmouthensis* (Olsson), sample Gaj 5. **11–12** — *Hedbergella holmdelensis* Olsson, sample Gaj 5. **13** — *Globotruncanella havanensis* (Voorwijk), sample Gaj 5. **14** — *Globotruncanella petaloidea* (Gandolfi), sample Gaj 5. **15, 16** — *Abathomphalus mayaroensis* (Bolli), 15 — sample Gaj 5, 16 — sample Gaj 5.4. **17** — *Globotruncanita stuarti* (de Lapparent), sample Gaj 5.4. **18**, **20** — *Globotruncana bulloides* Vogler, sample Gaj 3. **19** — *Globotruncana arca* Cushman, sample Gaj 5.7.

contusa and *Globotruncana arca* (species noted in the studied assemblages) are characteristic of the transitional domain. Malmgren (1991) stated that *Abathomphalus mayaroensis*, *Pseudotextularia elegans* and *Globotruncana arca* characterize the so-called “warm transitional subassemblage”. However, Malmgren also mentioned rugoglobigerinids among this “subassemblage”, but they are absent in the studied material. The compositions of the benthic foraminiferal assemblages are also different than those of the Boreal province. For instance, *Stensioeina* and *Bolivinoides*, genera characteristic for the transitional zone are absent in the studied material. Kotlarczyk (1978, 1985) listed such genera from the Wiar and

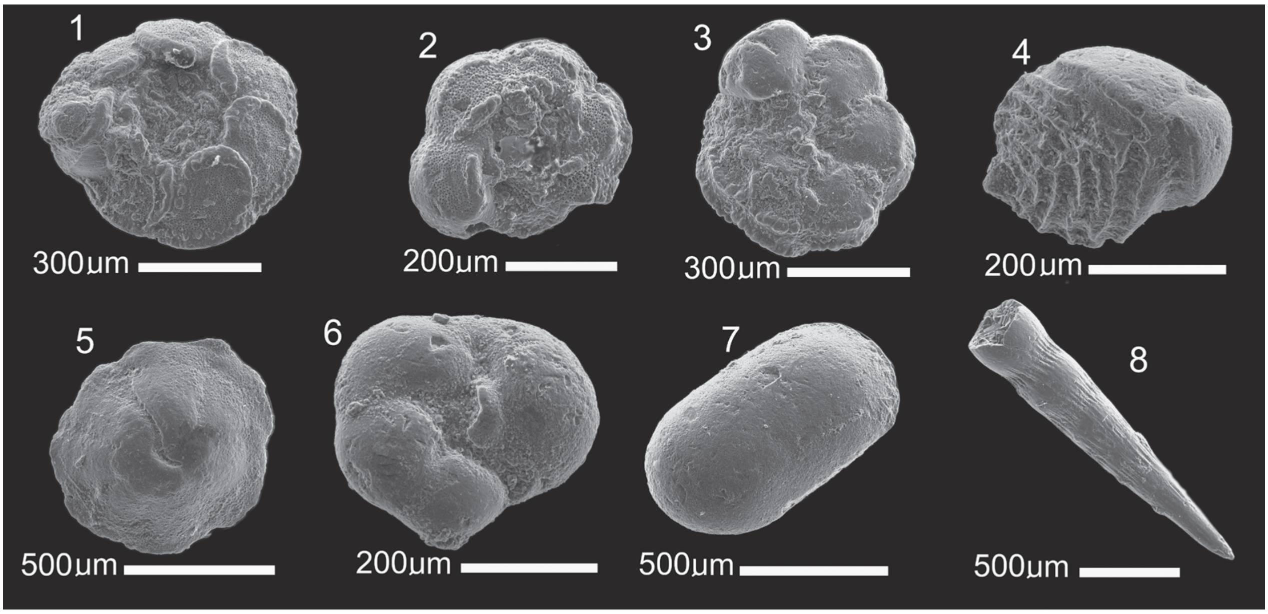

Fig. 9. Other microfossils from the Gaj section. **1** — *Globotruncanita stuartiformis* Dalbiez, sample Gaj 5.2. **2** — *Globotruncana linneiana* (de Lapparent), sample Gaj 3. **3** — *Globotruncana arca* Cushman, sample Gaj 5. **4** — *Aragonia ouezzensis* (Rey), sample Gaj 5. **5** — *Cibicides* sp., sample Gaj 5.4. **6** — *Quadrimorphina allomorphinoides* (Reuss), sample Gaj 5.4. **7** — Ostracoda, sample Gaj 5.4. **8** — ?*Nodosaria* sp., sample Gaj 5.4A.

Leszczyny Members. However, the problem of migration processes of microfauna between Tethyan Carpathian basins and Boreal domain is still unsolved.

The connection between the Skole Basin and the adjacent epicontinental sea has been suggested for quite some time. Wawryk (1939) noted a similarity of the more or less coeval sediments of the so-called Łopuszka Marls and Węgierka Marls (about 20 km E of the studied section) to the marls exposed near Lviv (the so-called Lviv Opoka). Kotlarczyk (1988) mentioned that the Leszczyny Member marls resemble the Upper Cretaceous marls from the Eastern European Platform. These suggestions are confirmed by the studied foraminiferal assemblage composition.

The possible migration gates of biota between the Boreal and Tethyan provinces during the Late Cretaceous have been discussed by Hanzliková (1972), Fuchs & Wessely (1996), Gasiński (1998) and Marcinowski & Gasiński (2002). The processes of migration and strategies of foraminiferal "migrants" have been suggested by Gasiński (1997, 1998) and Marcinowski & Gasiński (2002). In the later publication the so-called "Lviv Gate" is suggested as the migration pathway to the Carpathian basins from the North (Marcinowski & Gasiński 1992, p. 109).

Conclusions

1. The studied deposits of the Ropianka Formation in the Gaj section are here correlated with the Maastrichtian (part of the Gansserina gansseri Zone and the Abathomphalus mayaroensis Zone). The uppermost part of the section is dated to the Paleocene. The K/T boundary is located within a 3 m thick part of the Gaj section.

2. Foraminiferal assemblage composition indicates fluctuations in organic matter flux to the marginal part of the Skole Basin floor in the studied interval.

3. The studied foraminiferal assemblages are typical of the "transitional zone" between the Tethyan and the Boreal domains.

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