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LATE ALBIAN AND CENOMANIAN REDEPOSITED FORAMINIFERA FROM LATE CRETACEOUS-PALEOCENE DEPOSITS OF THE RAČA SUBUNIT (MAGURA NAPPE, POLISH WESTERN CARPATHIANS) AND THEIR PALEOGEOGRAPHICAL SIGNIFICANCE

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Abstract: Late Albian abundant and diversified foraminifers and calcified radiolaria representing the Planomalina buxtorfi-Rotalipora appenninica Zone, and single Cenomanian planktonic foraminifers have been found as redeposited assemblages within lower-middle Campanian and Paleocene flysch deposits of the Rača Subunit, Magura Nappe, Polish Western Carpathians. The Late Albian foraminifers derived from the source area located at the NW margin of the Magura Basin, whereas the Cenomanian foraminifers derived from the SE periphery of the basin. The presence of such microfauna is interpreted as an occurrence of a submarine plateau with pelagic deposition, under lower neritic-upper bathyal depths in the marginal parts of the Magura Basin, during the Late Albian–Early Cenomanian. This assumption was used for reconstruction of the Late Albian-Early Cenomanian paleogeography of the Magura Basin.

Key words: Western Carpathians, Magura Nappe, Late Albian, Cenomanian, paleogeography, Foraminifera.

Introduction

The results of paleontological studies of Late Albian and Cenomanian redeposited foraminifers from the Campanian and Paleocene deposits of the Magura Nappe (Western Carpathians) within the Rača Subunit are discussed in this paper. These studies may give a better understanding of the early sedimentation history in the Polish part of the Magura Basin (a part of the Outer Carpathian realm), which is poorly documented.

The Magura Nappe was almost completely uprooted from its substratum during the overthrust movements, mostly along the ductile Upper Cretaceous rocks. For this reason, the Lower Cretaceous deposits are very scarce. Exposures with Lower Cretaceous deposits in this nappe were described from Southern Moravia (Bubík et al. 1993; Švabenická et al. 1997) and from Poland (Birkenmajer 1965, 1973; Cieszkowski & Sikora 1976; Burtan et al. 1976, 1978; Burtan & Łydka 1978).

Most stratigraphical data concerning the oldest deposits in the Polish part of the Magura Nappe were connected with the Grajcarek Unit (Birkenmajer 1965, 1973) — the southernmost tectonic-facies zone of the Magura Nappe, incorporated into the Pieniny Klippen Belt during the Laramian folding (Birkenmajer 1986). The oldest deposits of the Grajcarek Unit, represented by black turbidities, are ?Toarcian-Aalenian in age (e.g. Birkenmajer 1977). They were followed by deep-water, condensed sedimentation of Bajocian through Lower Cretaceous. The Albian and ?Cenomanian rocks were attributed to the Wronine and Hulina formations (Birkenmajer 1977), represented mostly by argillaceous, marly, siliceous, bituminous, black or dark-green shales with pyrite, siderite and ferruginous dolomite concretions (Wronine Fm.), and radiolarian cherts (Hulina Fm.).

The oldest deposits (green spotty shales) of the Krynica Subunit were described in the Obidowa IG-1 borehole (2453–2510 m; Cieszkowski & Sikora 1976). Their age was determined as the Cenomanian, however, no paleontological data was presented there. According to Birkenmajer & Oszczypko (1989), these deposits could be included as a part of the Hulina Formation (Albian–Cenomanian in the Grajcarek Unit; Birkenmajer 1977), based on lithofacies.

The oldest deposits in the Grybów Subunit and the Koninki thrust-sheet of the Magura Nappe are known from a few small exposures at the southern margin of the Mszana Dolna tectonic window (Burtan et al. 1976, 1978; Burtan & Łydka 1978). They include dark and green, spotty shales with manganesiferrous concretions (?Albian-Cenomanian) and dark shales with siliceous sandstones and benthonites (?Albian-Cenomanian). According to a recent investigation (Oszczypko et al. 1999), the Koninki thrust-slice could be assigned to the Rača Subunit. Birkenmajer & Oszczypko (1989) compared these deposits with the Hulina Formation (Albian-Cenomanian). The assemblage of small foraminifers, described from the green, spotty shales at Koninki village, consists of exclusively agglutinated taxa, corresponding to the Plectorecurvoides alternans Zone *sensu* Geroch & Nowak (1984). In the Polish Carpathians, this zone represents the Middle Albian–Early Cenomanian according to Geroch & Nowak (1984) and Bąk (in print), and the Middle–Late Albian according to Olszewska (1997).

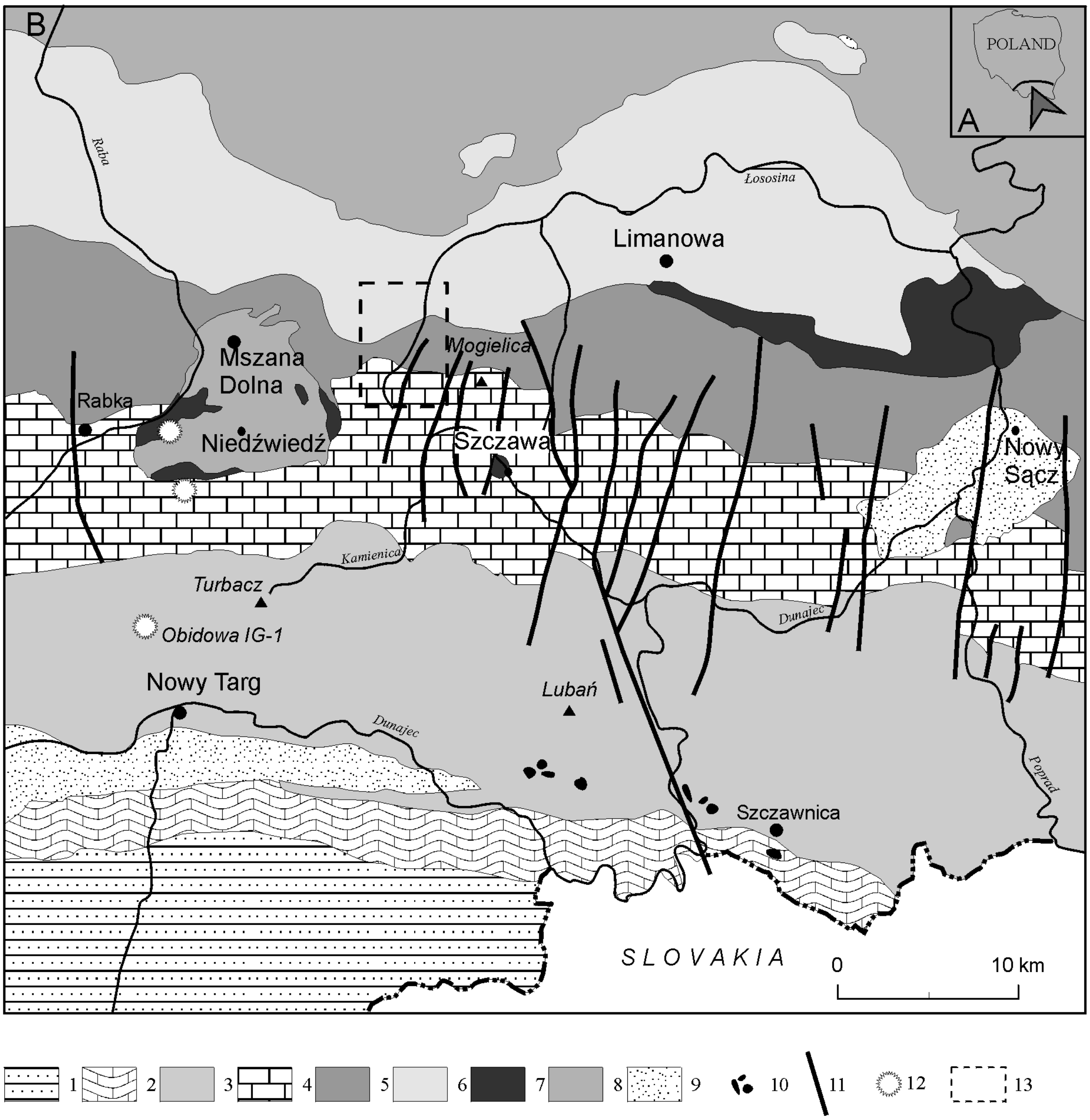

Fig. 1. Sketch-map of the middle part of the Polish Western Carpathians (after Oszczypko et al. 1999, supplemented). **1** — Podhale Flysch, **2** — Pieniny Klippen Belt; Magura Nappe: **3** — Krynica Subunit, **4** — Bystrica Subunit, **5** — Rača Subunit, **6** — Siary Subunit; **7** — Grybów Unit; **8** — Dukla, Silesian and Subsilesian units, **9** — Miocene onto the Carpathians, **10** — Miocene andesites, **11** — fault, **12** — Albian-Cenomanian deposits in outcrops and borehole Obidowa IG-1, **13** — study area.

Study area

The study area is located along the Łososina stream in the Półrzeczki village, within the SE part of the Beskid Wyspowy Range, close to Mogielica Mt. (Figs. 1, 2). This area belongs to the Rača Subunit of the Magura Nappe, building up the eastern periphery of the Mszana Dolna tectonic window (Fig. 1; see also Burtan et al. 1976, 1978; Burtan & Łydka 1978). This part of the Rača Subunit is composed of the Upper Cretaceous–Middle Eocene deposits belonging to: Malinowa Formation, Jaworzynka and Ropianka beds, and Łabowa and Beloveža formations (Fig. 2; Oszczypko et al., submitted paper).

The **Malinowa Shale Formation** (see Birkenmajer & Oszczypko 1989) is represented by cherry-red, non-calcareous shales, which occur in 30–50 cm layers, intercalated by grey-greenish shales, a few up to 25 cm thick. In this area, the formation contains a few intercalations of thick-bedded, coarse to medium-grained quartz-glauconite sandstones, laminated quartzitic mudstones and hornstones. The thick-bedded quartz-glauconite sandstones revealed the paleotransport from W and WNW. The frequency of the grey-greenish intercalations increases in the upper part of the formation, displaying features of the Hałuszowa lithofacies described from the Zasadne section (Malata & Oszczypko 1990). The thickness of the Malinowa Formation reaches at least 50 m (Oszczypko et al.,

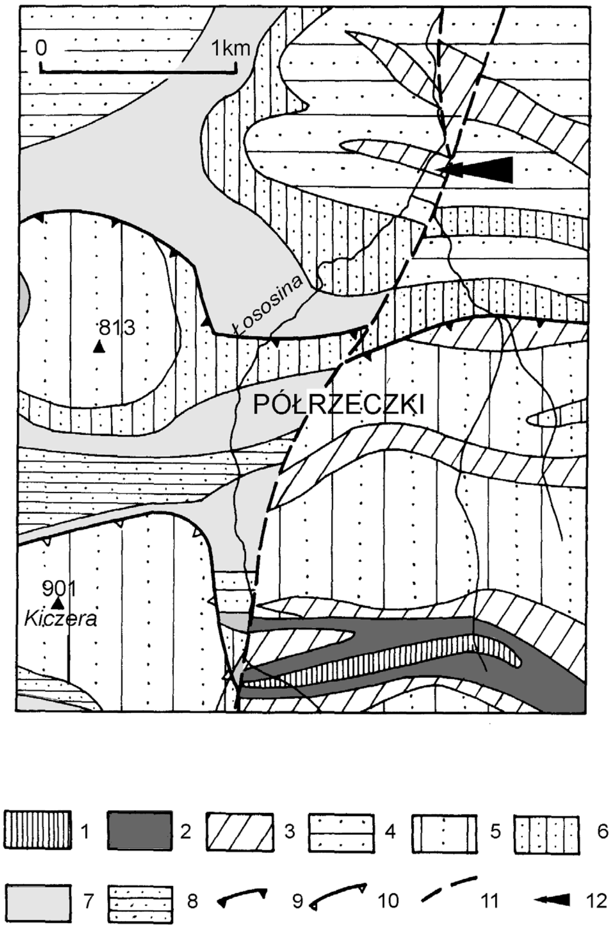

Fig. 2. Geological map of the Półrzeczki area in the Mogielica Range (Rača Subunit, Magura Nappe, Polish Western Carpathians; after Oszczypko et al., submitted paper). **1** — Late Albian-Cenomanian spotty shales, **2** — Malinowa Shale Formation, **3** — Kanina beds, **4** — Jaworzynka beds, **5** — Szczawina Sandstones, **6** — Ropianka beds, **7** — Łabowa Shale Formation, **8** — Beloveža and Bystrica formations (not divided), **9** — Bystrica thrust, **10** — other thrust, **11** — fault, **12** — study section.

submitted paper). According to Malata & Oszczypko (1990) and Oszczypko et al. (submitted paper), the Malinowa Shale Formation represents the Turonian through Santonian stages.

The Malinowa Shale Formation passes upward into the Senonian-Paleocene deposits, which have been traditionally referred to the Inoceramian beds. In the investigated area these beds have been divided into four divisions, known as the lower (Kanina beds), the middle (Jaworzynka and Szczawina beds) and the upper (Ropianka beds) Inoceramian beds (Burtan et al. 1976, 1978; Burtan & Łydka 1978; Cieszkowski et al. 1989; Oszczypko 1992).

The **Kanina beds** are composed of thin- to medium-bedded sandstones with intercalations of grey-bluish and grey-yellowish mudstones and shales, corresponding to the early-middle Campanian. The uppermost part of the formation consists of thin- to medium-bedded siliciclastic turbidites with numerous 5–30 cm thick intercalations of turbiditic limestones (see Cieszkowski et al. 1989). At the Półrzeczki village, this part of the beds displays thin intercalations of grey-green and black argillaceous shales with sideritic concretions and layers of black silicified mudstones (hornstones, see sample Pół-0/93; Fig. 4). The thickness of the Kanina beds reaches 100 m.

The **Jaworzynka beds** are composed of thick-bedded sandstones, dirty-green in colour, medium to coarse-grained, rich in feldspars and admixture of glauconite and biotite (Burtan et al. 1976, 1978; Burtan & Łydka 1978; Oszczypko et al., submitted paper). These sandstones revealed the paleotransport direction from W and NW. The Jaworzynka beds are upper Senonian in age. Their maximum thickness is about 200 m.

The **Ropianka beds** are represented by thin to medium-bedded, green-greyish sandstones, dark, muscovite mudstones, enriched with coalfield plant flakes and dark-grey, blue, usually carbonate-free shales. In the upper part of the beds, intercalations of dark-grey medium-bedded and very fine-grained, glauconite and biotite non-calcareous sandstones occur. A few layers of turbiditic limestones and siderites have also been found. Flute-cast measurements display paleotransport from WNW (280°) in the lowermost portion of the beds, to ESE and SES (100–160°) in their upper part. The Ropianka beds (150 m thick) are Maastrichtian to Paleocene in age (Oszczypko et al., submitted paper) in the Półrzeczki section.

The **Łabowa Shale Formation** (Oszczypko 1991) is represented by a few meters thick, repeated packets of soft, carbonate-free, red and green shales, intercalated with very thin-bedded turbidites in its lower part, and thick (2–3 m) packets of red shales in its middle part. Locally, green and blue shales with intercalations of thin-bedded sandstones have been observed at the Półrzeczki section. The thickness of the formation attains up to 150 m. According to biostratigraphical studies (see Oszczypko 1991; Oszczypko et al., submitted paper), the Łabowa Shale Formation represents the Early Eocene.

The uppermost part of the Rača Subunit sequence belongs to the **Beloveža Formation** in the study area. The formation is represented mainly by thin- to medium-bedded turbidites. Shales, varying in colour (green, grey, blue, brown and yellowish) prevail distinctly over sandstones. In the basal part of the formation, a few intercalations of red shales have been observed in the studied section. The thickness of the formation reaches about 50 m. Its age has not been investigated at the Półrzeczki section, however, by comparison with the Zasadne section (see Oszczypko 1991), it could correspond to the Middle Eocene.

Material and methods

Samples of black and dark siliceous shales of the Kanina beds were taken from the Półrzeczki section (Figs. 2, 3) for micropaleontological study. Seven samples (Pół-33/94–Pół-39/94) were collected from two limbs of an overturned anticline. The samples weigthing 500–750 g were dried and disintegrated in a solution of sodium carbonate. One sample (Pół-0/93), taken from a 10 cm thick, black, silicified mudstone layer was dissolved in 5 % dilute hydrofluoric acid. The material was then washed through sieves with mesh diameters of 63 μm and 1500 μm. The microfauna were picked from 63–1500 μm fraction and mounted on cardboard slides for microscopic examination.

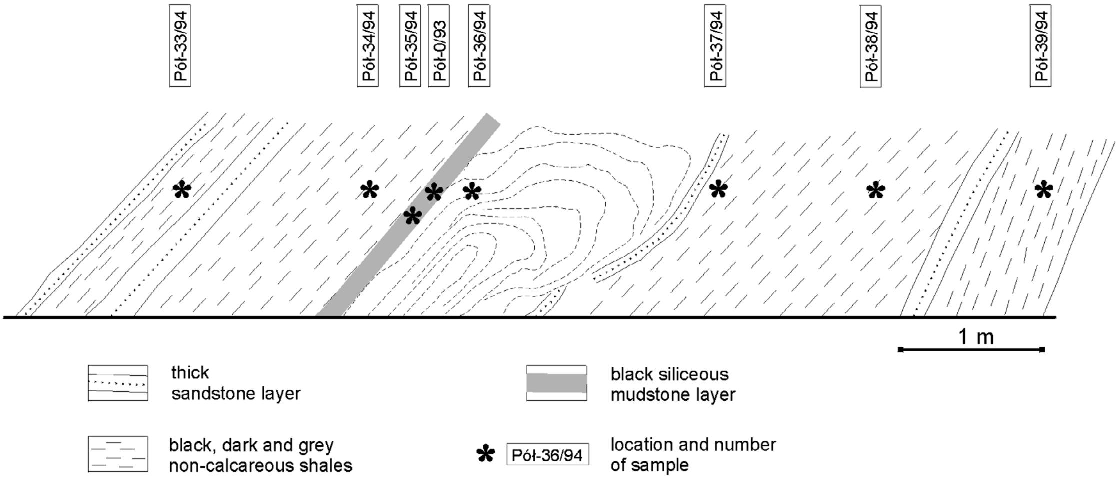

Fig. 3. The sampled section of the lower-middle Campanian black turbidite deposits (Kanina beds) at the Półrzeczki village (Rača Subunit, Magura Nappe, Polish Western Carpathians).

The microfaunal slides are housed in the Institute of Geography, Cracow Pedagogical University (collection No. 07 Mg).

Microfaunal assemblages

The black and dark silicified shales contain scarce and poorly diversified deep-water agglutinated foraminifers with *Caudammina gigantea* (Geroch), which is important for stratigraphy. The assemblage is dominated by tubular, mostly pyritized forms of the superfamily Astrorhizacea (Fig. 4; Pls. I, II). Specimens of the genera *Paratrochamminoides*, *Trochamminoides*, *Reophax*, *Trochammina*, *Recurvoides* as well as *Saccammina placenta* (Grzybowski), *S. grzybowskii* (Dylążanka) and *Caudammina ovulum* (Grzybowski) also occur frequently.

The occurrence of *Caudammina gigantea* in these deposits, the species used as an index taxon in most zonations of non-calcareous, Late Cretaceous facies (e.g. Geroch & Nowak 1984; Kuhnt et al. 1992; Bubík 1995; Bąk in print) and the stratigraphical data of younger deposits in the studied section suggest the early-middle Campanian age of the black, siliceous facies.

However, one sample (Pół-0/93), taken from a 10 cm thick chert layer (silicified mudstone) includes a well-preserved and rich assemblage of planktonic and benthic (calcareous and agglutinated) foraminifers (Fig. 4; Pl. III). The species *Hedbergella delrioensis* (Carsey), accompanied by other hedbergellids, such as *H. planispira* (Tappan), *H. simplex* (Morrow) dominates there (more than 140 specimens). Other common planktonic forms include species of *Planomalina buxtorfi* (Gandolfi) (10 specimens), *Rotalipora appenninica* (Renz) (8 specimens), *Globigerinelloides ultramicra* (Subbotina) (6 specimens), *Praeglobotruncana delrioensis* (Plummer) (3 specimens) and *Heterohelix moremani* (Cushman) (2 specimens). Benthic foraminifers are represented by single forms (1–5 specimens) of *Gyroidinoides infracretacea* (Morozova), *Lenticulina gaultina* (Berthelin), *Gavelinella intermedia* (Berthelin), *Dentalina* sp., *Marginulina* sp., *Rhabdammina* sp. and *Ammodiscus cretaceus* (Reuss). Silicified (all recrystallized) small radiolaria (Pl. IV; undeterminable, *pers. inf.* by Marta Bąk) are a significant element (50 specimens) of this assemblage.

These foraminifers represent the Planomalina buxtorfi-Rotalipora appenninica Zone *sensu* Gasiński (1988) and Bąk (1998), corresponding to Vraconian. Unusual micropaleontological results obtained from the sample Pół-0/93, encouraged us to study more samples from this chert layer. Unfortunately, they were devoid of microfauna.

In the author's opinion the described foraminifers can be interpreted as redeposition of microfauna from the shallower part of the basin, which represented another type of environment. Hieroglyphs measured from the base of this silicified black mudstone layer show paleotransport from the west and north-west.

The younger deposits of the studied section at the Beskid Wyspowy Mts., belonging to the lower Paleocene Ropianka beds, contain single redeposited Cenomanian planktonic foraminifers (Pl. IV). A few specimens of *Rotalipora cushmani* (Morrow), *Praeglobotruncana gibba* Klaus and *P. delrioensis* (Plummer) have been found in the sample Pół-2/94 (Pl. IV), taken from the uppermost part of the Ropianka beds (early Paleocene; Oszczypko et al., submitted to print).

Late Albian-Early Cenomanian paleogeographical implications

The Late Albian-Early Cenomanian paleogeography of the Outer Carpathian sedimentary area was reconstructed mainly for its northern (Silesian/Subsilesian Basin) and eastern (Skole Basin) parts (e.g. Książkiewicz 1962; Birkenmajer 1977; Birkenmajer 1986). The tectonic amputation of the Lower/Middle Cretaceous deposits of the Magura Nappe makes difficult such reconstruction for the Magura Basin.

Taking into account all published data from the Magura Nappe (Burtan et al. 1976, 1978; Burtan & Łydka 1978; Cieszkowski & Sikora 1976; Birkenmajer 1977; Bubík et al. 1993;

AGE	Lower-Middle Camp.							
					L.A.			
Samples (Pół)	39/94	38/94	37/94	36/94	0/93	35/94	34/94	33/94
Nothia sp.	1-4							
Hyperammina sp.	5-9							
Hyperammina cf. *dilatata*	1-4							
Kalamopsis grzybowskii	1-4							
Rhabdammina sp.	1-4	20-100	> 100	> 100			20-100	10-19
Saccammina grzybowskii	1-4							
Saccammina placenta	1-4	1-4						
Saccammina sp.	1-4							
Ammodiscus cretaceus	1-4				1-4			
Ammodiscus sp.		1-4				1-4		
Glomospira charoides		1-4						
Glomospira gordialis	1-4							
Glomospira irregularis	1-4			1-4				
Glomospira serpens								1-4
Aschemocella grandis							1-4	
Reophax sp.	5-9			1-4				
Subreophax cf. *splendidus*				1-4				
Subreophax cf. *scalaris*	1-4							
Pseudonodosinella parvula	1-4							
Caudammina cf. *crassa*	1-4							
Caudammina ovulum	1-4	1-4				1-4		
Caudammina gigantea	1-4							
Haplophragmoides sp.	1-4							
Recurvoides spp.	1-4	10-19		5-9				
Cribrostommoides cf. *trinitatensis*	1-4							
Trochammina sp.	1-4	5-9	1-4					
Paratrochamminoides variolarius	1-4							
Paratrochamminoides spp.	5-9							
Gerochammina conversa		1-4						
Karrerulina coniformis		1-4						
Karrerulina sp.		1-4						
Dentalina sp.					1-4			
Marginulina sp.					1-4			
Lenticulina gaultina					1-4			
Heterohelix cf. *moremani*					1-4			
Globigerinelloides ultramicra					5-9			
Hedbergella delrioensis					> 100			
Hedbergella planispira					5-9			
Hedbergella simplex					5-9			
Planomalina buxtorfi					10-19			
Praeglobotruncana delrioensis					1-4			
Rotalipora appenninica					5-9			
Gavelinella intermedia					1-4			
Gyroidinoides infracretacea					1-4			
Radiolaria					20-100			

1-4 specimens
5-9 specimens
10-19 specimens
20-100 specimens
> 100 specimens

Fig. 4. Occurrence of microfauna in the investigated samples; Półrzeczki village, Rača Subunit, Magura Nappe; L.A. — Late Albian.

Švabenická et al. 1997; Oszczypko et al., submitted paper) and the present results, the authors propose the following reconstruction of the paleogeography for the Magura Basin, during the Late Albian/Early Cenomanian (Fig. 6).

Calcareous oozes (Vraconian in age) were deposited on the submarine plateau or basin slope, to the south of the Silesian submerged (or uplifted) ridge. Occurrence of this facies is speculated here on the basis of the present results. The studied Vraconian foraminiferal assemblage is very similar to that from pelagic deposits of the Pieniny Klippen Belt (Fig. 5). The number of foraminifers, species composition with abundant hedbergellids and scarce agglutinated forms are similar to assemblages of the same planktonic foraminiferal Zone from the Niedzica Succession (see sample Kos-4/92; Bąk 1998), and from the Czorsztyn Succession (comp. Gasiński 1988). This may suggest a similar type of sedimentation, interpreted here for the Magura Basin, as pelagic deposition on submarine plateau under lower neritic-upper bathyal depths. Presence of similar facies-zone during the Early Cretaceous in the Rača Subunit was documented in the Bile Karpaty Mts., within the so-called Kurovice Klippe (e.g. Benešová et al. 1968). According to Bubík (in Švábenická et al. 1997), single foraminifers such as *Caudammina ovulum* and *Globigerinelloides ultramicra*, described from this area by Benešová et al. (1962), may be indicators of the Albian in the Kurovice Klippe.

On the lower slope of the Silesian Ridge and adjacent part of the basin, black-grey, calcareous, thin- to medium-bedded turbidites were deposited (Fig. 6). These deposits are known from the Hostynske Vrchy Mts. in the Rača Subunit, Czech part of the Magura Nappe (Bubík et al. 1993; Švábenická et al. 1997). Occurrence of deep-water agglutinated foraminifers with *Recurvoides imperfectus* Hanzliková, and numerous calcareous nannoplantkon with *Eiffelithus turriseiffelii* could indicate Middle-Late Albian age (since CC9a Zone). The deposits of the latter locality represents flysch-type sedimentation (Švábenická et al. 1997), compared to the Gault Flysch known from the Rhenodanubicum of the Eastern Alps (Salzburg environs).

The deepest part of the Magura Basin, up to the slope of the Czorsztyn Ridge was probably occupied by pelagic, strongly bioturbated green shales and spotty shales (see Burtan et al. 1976, 1978; Burtan & Łydka 1978; Birkenmajer 1977; Švábenická et al. 1997; Oszczypko et al., submitted paper), deposited below the calcium compensation depth (Fig. 6).

On the lower slope of the Czorsztyn Ridge, non-calcareous, mostly siliceous black and dark shales with siliceous mudstones (partly radiolarites) were the dominant deposits (Hulina Formation; Grajcarek Unit). Their sedimentation took place under deep-water conditions, near the calcium compensation depth (CCD) (rare planktonic foraminifers are present there). To the west (Bile Karpaty Subunit), the Hulina Formation is replaced by the upper part of the Hluk Formation (Stráník et al. 1995), represented by carbonate flysch with black and grey-

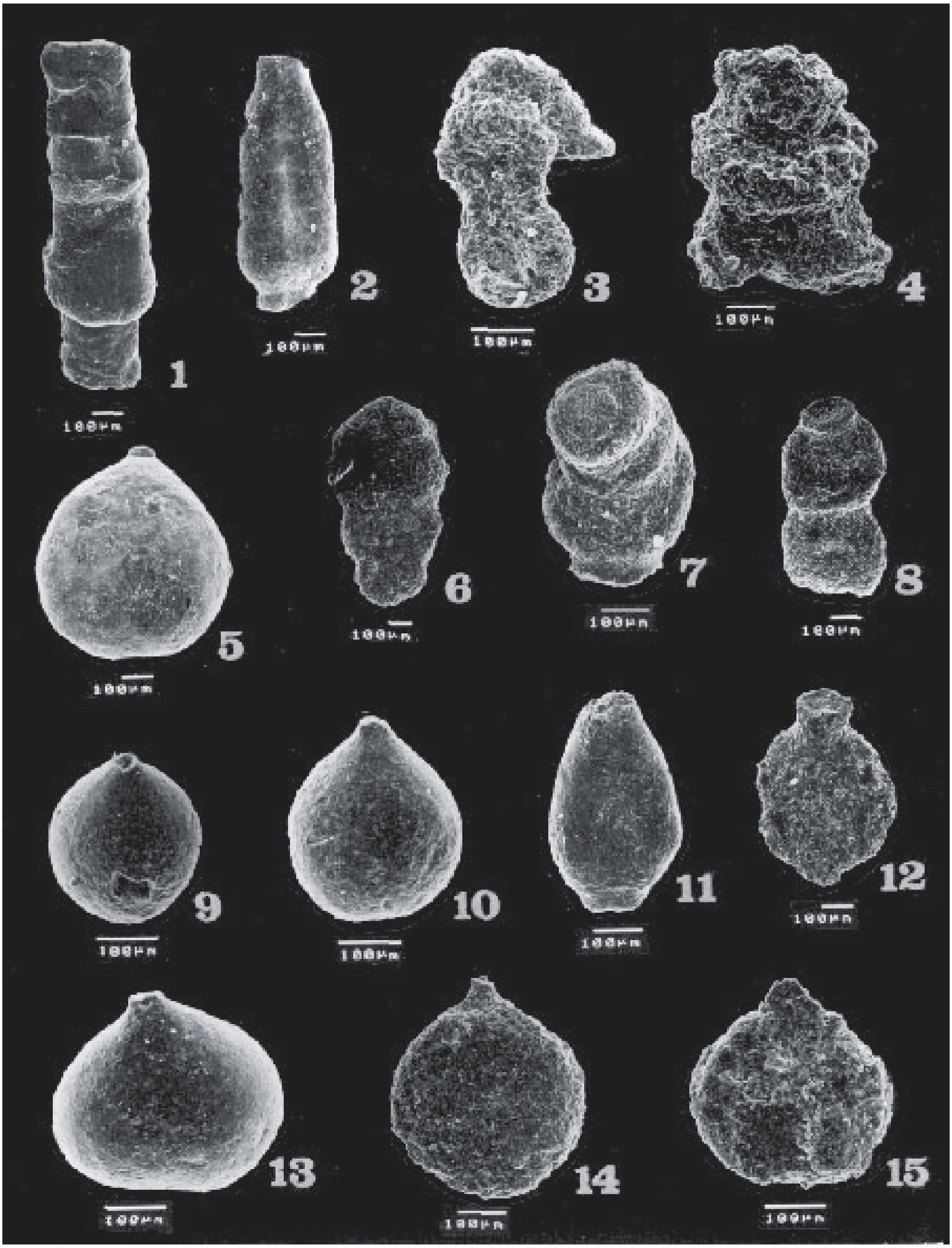

Plate I: SEM photomicrographs of autochthonous Campanian deep-water agglutinated Foraminifera at the Półrzeczki section; Rača Subunit, Magura Nappe, Polish Western Carpathians: **Fig. 1.** ?*Hyperammina* cf. *dilatata*, sample Pół-39/94. **Fig. 2.** *Kalamopsis grzybowskii* (Dylążanka), sample Pół-39/94. **Fig. 3.** *Subreophax* cf. *splendidus* (Grzybowski), sample Pół-36/94. **Fig. 4.** *Subreophax* cf. *scalaris* (Grzybowski), sample Pół-39/94. **Fig. 5.** *Caudammina gigantea* (Geroch), sample Pół-39/94. **Fig. 6.** *Pseudonodosinella parvula* (Huss), sample Pół-39/94. **Figs. 7, 8.** *Subreophax splendidus* (Grzybowski), sample Pół-36/94. **Figs. 9, 10.** *Caudammina ovulum* (Grzybowski), sample Pół-35/94. **Fig. 11.** *Caudammina* cf. *crassa* (Geroch), sample Pół-39/94. **Fig. 12.** *Aschemocella grandis* (Grzybowski), sample Pół-34/94. **Fig. 13.** *Caudammina ovulum* (Grzybowski), sample Pół-38/94. **Figs. 14, 15.** *Saccammina grzybowskii* (Schubert), Pół-39/94.

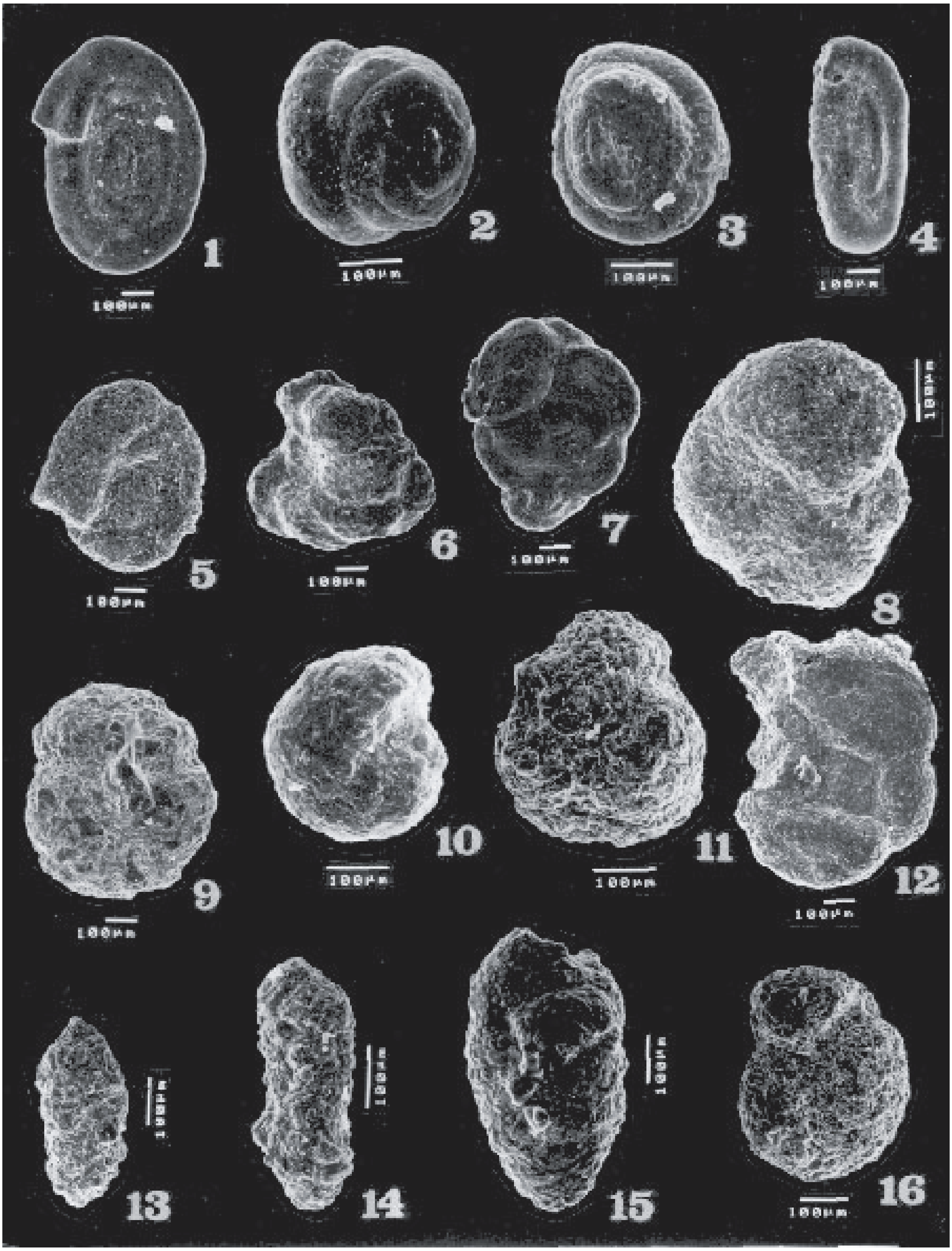

Plate II: SEM photomicrographs of autochthonous Campanian deep-water agglutinated Foraminifera at the Półrzeczki section; Rača Subunit, Magura Nappe, Polish Western Carpathians: **Fig. 1.** *Ammodiscus cretaceus* (Reuss), sample Pół-39/94. **Figs. 2, 3.** *Glomospira charoides* (Parker & Jones), sample Pół-38/94. **Fig. 4.** *Glomospira serpens* (Grzybowski), sample Pół-33/94. **Fig. 5.** *Glomospira irregularis* (Grzybowski), sample Pół-36/94. **Figs. 6, 7.** *Paratrochamminoides* sp., sample Pół-39/94. **Fig. 8.** *Trochammina* sp., sample Pół-38/94. **Figs. 9, 10.** *Cribrostommoides* cf. *trinitatensis* Cushman, sample Pół-39/94. **Fig. 11.** *Recurvoides* sp., sample Pół-36/94. **Fig. 12.** *Paratrochamminoides* cf. *variolarius* (Grzybowski), sampe Pół-39/94. **Figs. 13, 14.** *Gerochammina conversa* (Grzybowski), sample Pół-38/94. **Fig. 15.** *Karrerulina coniformis* (Grzybowski), sample Pół-38/94. **Fig. 16.** *Haplophragmoides* sp., sample Pół-39/94.

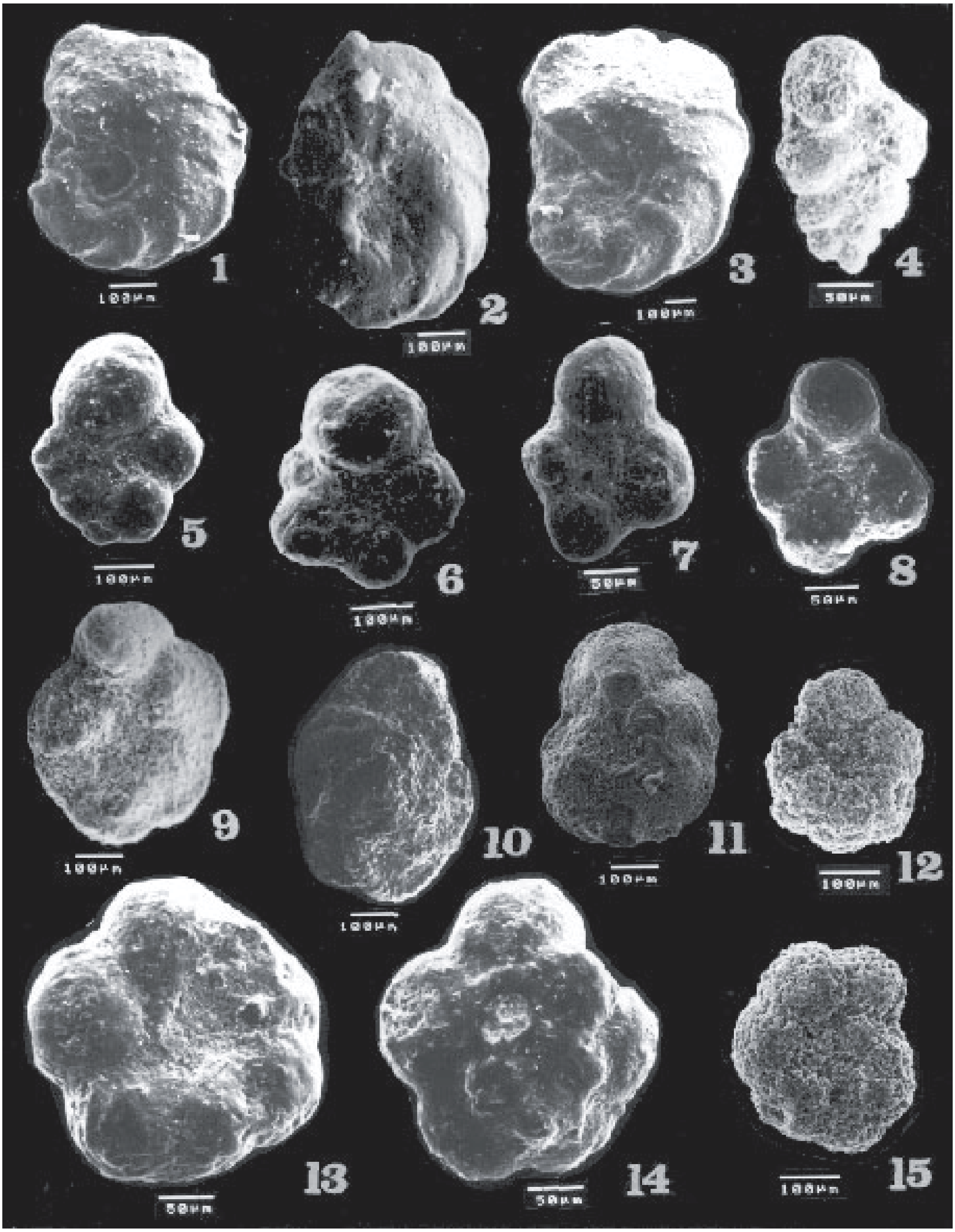

Plate III: SEM photomicrographs of planktonic Vraconian Foraminifera at the Półrzeczki section (sample Pół-0/93); Rača Subunit, Magura Nappe, Polish Western Carpathians: **Figs. 1–3.** *Planomalina buxtorfi* (Gandolfi). **Fig. 4.** *Heterohelix* cf. *moremani* (Cushman). **Figs. 5, 6.** *Hedbergella delrioensis* (Carsey). **Figs. 7, 8.** *Hedbergella simplex* (Morrow). **Figs. 9–11.** *Rotalipora appenninica* (Renz). **Fig. 12.** *Globigerinelloides ultramicra* (Subbotina). **Figs. 13, 14.** *Praeglobotruncana delrioensis* (Plummer). **Fig. 15.** *Globigerinelloides ultramicra* (Subbotina).

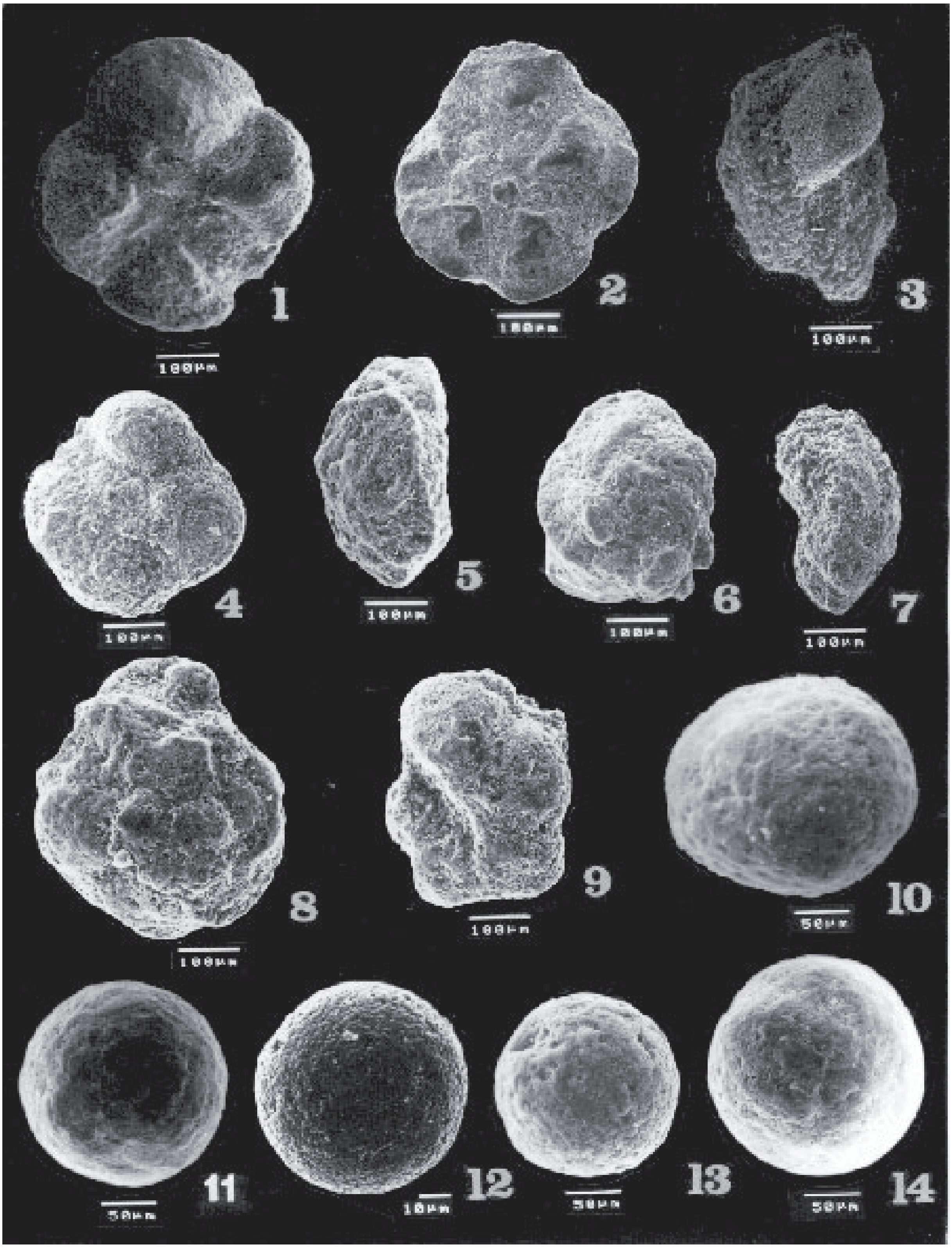

Plate IV: SEM photomicrographs of redeposited planktonic Cenomanian Foraminifera (sample Pół-2/93; Rzehakina fissistomata Zone, early Paleocene) and Vraconian Radiolaria (sample Pół-0/93) at the Półrzeczki section; Rača Subunit, Magura Nappe, Polish Wetern Carpathians: **Figs. 1, 2.** *Rotalipora cushmani* (Morrow). **Figs. 3–7.** *Praeglobotruncana gibba* Klaus. **Figs. 8, 9.** *Praeglobotruncana delrioensis* (Plummer). **Figs. 10–14.** Spherical tests of Radiolaria.

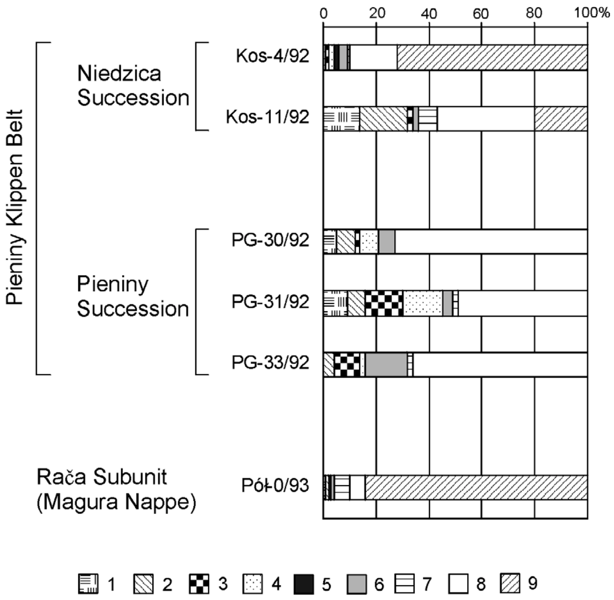

Fig. 5. Comparison of foraminiferal assemblages within the Planomalina buxtorfii-Rotalipora apeninnica Zone (Vraconian) from the Półrzeczki section (Rača Subunit, Magura Nappe, Polish Western Carpathians) and from the Pieniny Klippen Belt (Bąk 1998). **1** — tubular agglutinated foraminifers; **2** — *Ammodiscus, Glomospira;* **3** — *Saccammina, Trochammina, Haplophragmoides, Recurvoides;* **4** — *Reophax, Dorothia, Gaudryina, Tritaxia;* **5** — *Globulina, Dentalina, Lenticulina, Planularia, Marginulina;* **6** — *Epistommina, Gavelinella, Gyroidinoides;* **7** — *Planomalina buxtorfii;* **8** — *Rotalipora, Praeglobotruncana,* **9** — *Hedbergella, Globigerinelloides, Heterohelix.*

green claystones, whitish marls and limestones. They are intercalated with carbonate-free clays of the *Glomospira-Rhizammina* and *Rhabdammina-Rzehakina* biofacies, which could be evidence of an environment below the CCD (Švábenická et al. 1997).

Towards the Czorsztyn submerged ridge, these deposits were replaced by the calcareous oozes, partly silicified (planktonic foraminiferal-radiolarian microfacies) of the Pomiedznik Formation and the Brynczkowa Marl Member (Jaworki Formation) (see Birkenmajer 1977; Birkenmajer & Jednorowska 1987) (Fig. 6). The foraminiferal associations suggest the shelf and upper slope depth of the Czorsztyn Ridge (Birkenmajer & Gasiński 1992).

Similar, upper Albian-lower Cenomanian facies occur in the Ukrainian part of the Klippen Belt, described as the Tissalo Formation (Vialov et al. 1988). These deposits are represented by 145 m thick, light and dark-grey marls (partly fucoide), with thin intercalations of black shales and grey-green limestones. The Tissalo Formation is underlain by the Neocomian cherty limestones and covered by the Late Cenomanian-Senonian variegated marls of the Puchov Formation.

The Albian and Cenomanian deposits are also known in the Ukrainian and Romanian Outer Carpathians, in their parts, which are correlated with the Magura Unit (Fig. 6). According to Săndulescu (1988; see also Oszczypko 1992), the Silesian Cordillera was a prolongation of the Middle and Outer Dacides, which were tectonized during the Middle Cretaceous. Thus, since that time, the Marmarosh (Maramuresh) Massif could supply the material to the NE part of the Magura Basin (Rača sedimentary area; see Żytko 1999). The NW prolongation of the Marmarosh Massif is known as the Marmarosh Klippen (Vezhany Nappe; Żytko 1999).

The Marmarosh Massif was transgressively overlapped by the Late Albian-Cenomanian postectonic Sojmul Formation in the SE part of the Ukrainian Carpathians (Vialov et al. 1988). This formation, up to 120 m thick, overlaying the Triassic folded deposits, includes the shallow-water, marine clastic deposits, coarse-grained in their lower part and fine-grained in the upper ones. The formation includes also deep-water, basinal turbidites, passing upward to the pelagic Puchov Marls (Late Cenomanian-Maastrichtian; see Panomareva in: Vialov et al. 1988) in the area of the Marmarosh Klippen (Dragovo section).

It should be stressed that there is a lack of the Aptian-Lower Cenomanian deposits in the Poiana Botizei section (East Carpathians, Romania), the SE termination of the Pieniny Klippen Belt and the Magura Nappe (Bombita et al. 1992). This is probably an effect of a latter (or synsedimentary) erosion in that area.

Source of the Cenomanian redeposited foraminifers

The source area for the Cenomanian redeposited foraminifers is reconstructed here on the basis of paleotransport measurements in the upper part of the Ropianka beds. Flute casts on soles of thin- to medium-bedded sandstones suggest the ESE and SES (100–160°) transport directions. These directions were similar to those during deposition of the Campanian, thick-bedded, turbidite sandstones, belonging to the Szczawina beds (transport also from SE). Thus, the clastic material of the Ropianka and Szczawina beds derived, most probably, from the peri-Pieninian source area (see Sikora 1970).

Conclusions

The presented micropaleontological data confirm that deep-water sedimentation in the northernmost part of the Magura Basin, in its Polish segment, started during the Late Albian. The paleotransport directions of the mudstone layer (from W and NW), in which the foraminifers have been found, and for other turbidity layers of the Kanina beds, show that the Silesian Ridge (or its southern slope) was the source area for the redeposited material. The studied Vraconian foraminiferal assemblage resembles microfauna from the pelagic deposits of the Pieniny Klippen Belt. Taking into account these similarities, the lower neritic-upper bathyal depths and pelagic-type of sedimentation are interpreted for this part of the Silesian Ridge during the Late Albian.

Redeposited Cenomanian planktonic foraminifers, found in the early Paleocene flysch of the Ropianka beds could also be indicators of pelagic sedimentation, but on the southern periphery of the Magura Basin, connected with the peripieninian area.

The published data, concerning the Late Albian-Early Cenomanian sedimentation in the Magura Basin, have been used

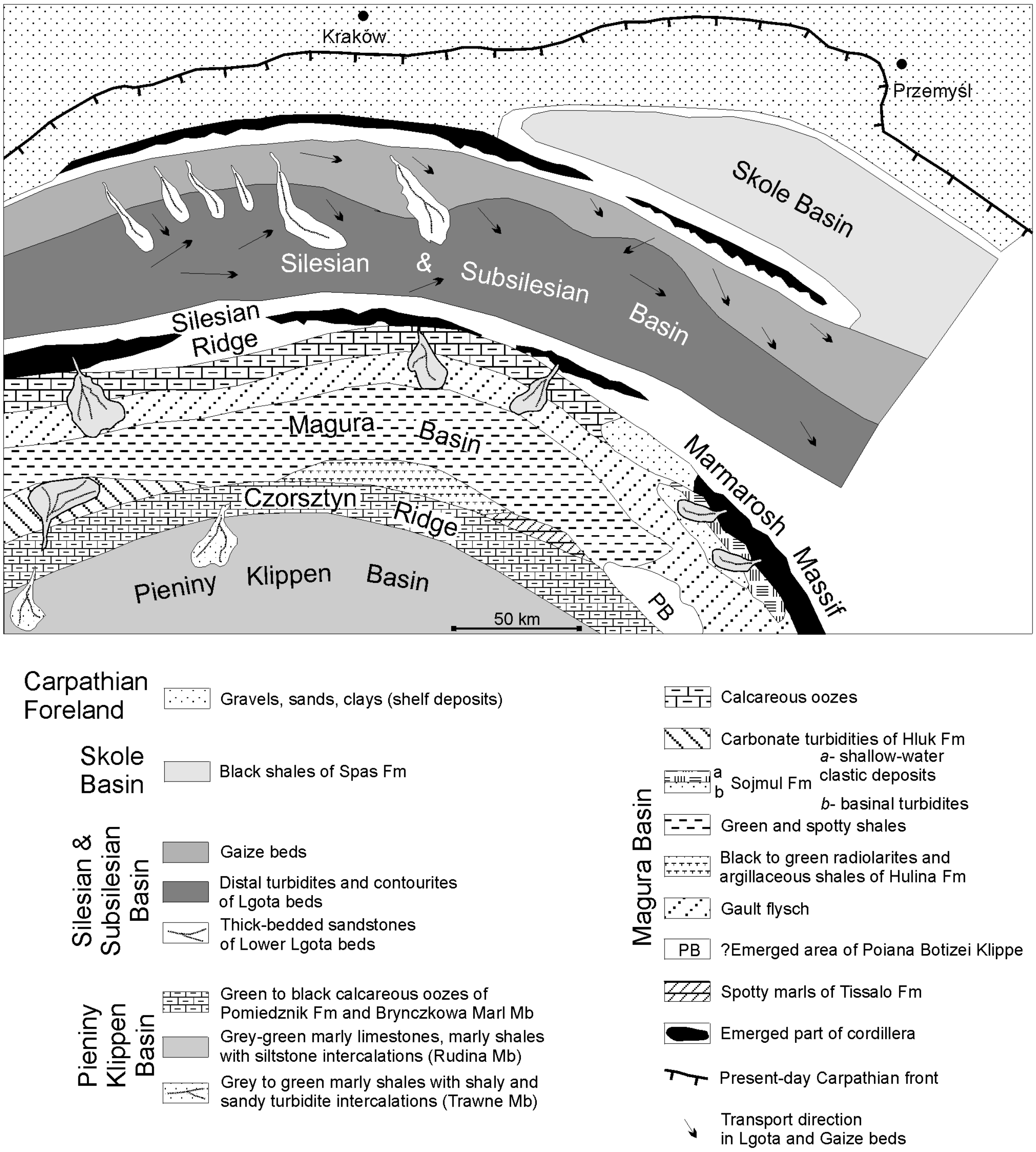

Fig. 6. Late Albian-Early Cenomanian paleogeography of the Outer Carpathians (Magura Basin — this paper; Silesian/Subsilesian and Skole basins after Książkiewicz 1962).

here to reconstruct the main facial zones during this time. The type of deposits and microfossil content show deep-water, mostly pelagic and hemipelagic sedimentation below the calcium compensation depth in the central part, and pelagic sedimentation under lower neritic-upper bathyal depths in the northern (Silesian Ridge) and southern (Czorsztyn Ridge) peripheries of the Magura Basin.

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