Annales Societatis Geologorum Poloniae (1999), vol. 69: 161–172.

BADENIAN RADIOLARIA FROM THE KRAKÓW AREA (SOUTH POLAND)

Wanda BARWICZ-PISKORZ

Department of Stratigraphy and Regional Geology, University of Mining and Metallurgy, Mickiewicza 30; 30-059 Kraków, Poland; E-mail: barwicz@geol.agh.edu.pl

Barwicz-Piskorz, W., 1999. Badenian Radiolaria from the Kraków area (South Poland). *Ann. Soc. Geol. Polon.*, 69: 161–172.

Abstract: Thirty four Upper Badenian radiolarian species from the Kraków area have been analysed. Seventeen species are illustrated. This assemblage represents the *Dorcadospyris alata* radiolarian Zone. The comparision of Badenian Radiolaria assemblage from the Kraków area with the contemporaneous ones from Gliwice area and eastern part of the Carpathian Foredeep shows some dissimilitarity between them. The assemblages from the western part of the Carpathian Foredeep include some warm water species, while assemblages from the central and eastern parts include predominantly cold water species.

The comparision of Miocene radiolarian assemblages from Polish part of the Carpathian Feredeep with the contemporaneous ones from Romanian part of the Carpathian Foredeep, Italy (Apeniny Foredeep) and South California (intermountain depression) is also presented.

Abstrakt: Z górnego badenu okolic Krakowa opisano zespół promienic (Radiolaria) złożony z 34 gatunków, 17 spośród nich zilustrowano. Zespół ten został włączony do zony radiolariowej *Dorcadospyris alata.* Porównanie zespołu badeńskich promienic z okolic Krakowa z równowiekowym zespołem z okolic Gliwic oraz z zespołami ze wschodniej części zapadliska przedkarpackiego wykazało istnienie pewnych różnic między nimi. Zespoły z zachodniej części zapadliska przedkarpackiego zawierają kilka gatunków ciepłolubnych promienic, natomiast zespoły z części wschodniej zawierają gatunki typowe dla klimatu chłodnego.

Porównano także mioceńskie zespoły promienic z polskiej części Paratetydy z zespołami z Rumunii, Włoch i USA.

Key words: Paratethys, Carpathian Foredeep, Kraków area, Badenian, Radiolaria, stratigraphy, taxonomy.

Manuscript received 29 July 1999, accepted 19 November 1999

INTRODUCTION

The Carpathian Foredeep is a long, narrow region situated in the north and east-north of Carpathians. The trough was filled with Miocene deposits of the Paratethys ocean. The most important are the Badenian deposits. They consist of gray clays so-called subgipsum clays, gypsum and anhydrite layer and supragypsum gray clays with tuffite intercalations and sandstones.

Radiolaria occurrence in the Upper Badenian deposits of the Polish part of the Carpathian Foredeep has been known for a long time (Łuczkowska, 1953). Rich radiolarian fauna in study occurs within clayey deposits (about 20–30m thick) located about 10 to 20m above the evaporites. It occurs within the foraminiferal zone IIIA (Alexandrowicz, 1961, 1963). These radiolarian-bearing deposits belong to the *Velapertina indigena* planktonic foraminifera Zone distinguished by Łuczkowska (1971) (Table 1). In the Upper Badenian deposits of the whole Paratethys they form characteristic "radiolarian horizon". The Badenian Radiolaria from the Polish part of the Paratethys have been a subject of several taxonomical investigations. The research was carried in the areas of Gliwice, Lędziny, Posądza, Kraków, Wieliczka, Bochnia and several other places between Tarnów and Przemyśl (Barwicz-Piskorz, 1978, 1981, 1997; Smoleń, 1980).

In this paper, the abundant radiolarian fauna from five shallow boreholes and wells from the suburbs of Kraków have been analized (Fig. 1.).

GEOLOGICAL SETTING

In boreholes gray marly clays with sandy intercalations and tufits have been drilled. They are considered to be a part of Chodenice beds. The Chodenice beds in their lower part include abundant radiolarian faunas, which are present only in clay layers. Scarcity of microfauna in Bronowice (BR) and Tonie (TN) profiles is undoubtedly the effect of destruction. Nineteen samples with Radiolaria were taken from the following boreholes: Bronowice, Ojców Street 100 (O-100); Pasternik, Tetmajer Street (OW); Kobierzyn (KB);

Table 1

Stratigraphy of the Badenian deposits in the Polish part of the Paratethys

Stratigraphical units			Lithostratigraphical units	Foraminiferal zones (after Łuczkowska, 1971)		
Miocene	Badenian	Kossovian	Grabowiec beds	IIIB	*Hanzavaia crassiseptata*	*Velapertina indigena*
			Chodenica beds	IIIA	*Neobulimina longa*	
		Vielician	Chemical deposits			

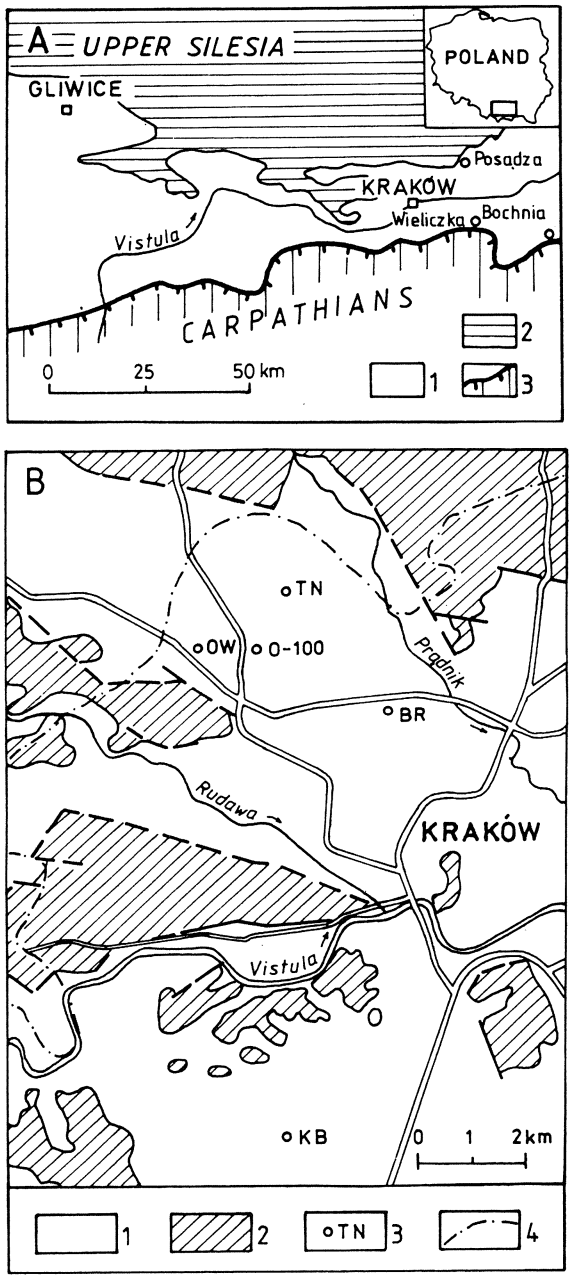

Fig. 1. **A.** Location of places with radiolarian-baering Upper Badenian deposits in western part of the Carpathian Foredeep. *1* – Miocene deposits, *2* – pre-Miocene deposits, *3* – Carpathian flysch; **B.** Location of studied profiles. *1* – Miocene deposits, *2* – Mesozoik deposits, *3* – Boreholes investigated: O-100 – Bronowice, Ojców Street; OW – Pasternik, Tetmajer Street; BR – Bronowice, Rydel Street; TN – Tonie; KB – Kobierzyn, *4* – Town boundary

Bronowice, Rydel Street (BR) and Tonie (TN).

Occurrences of Radiolaria in samples investigated is presented on Tables 2 and 3.

RADIOLARIAN ASSEMBLAGE

Thirty four radiolarian species have been recognised in nineteen samples taken from the Upper Badenian deposits from the Kraków area (Tables 2, 3). The assemblage is dominated by spumellarians which show the greatest diversity. The order Spumellaria is represented by twenty five species belonging to fifteen genera as: *Cenosphaera*, *Melitosphaera*, *?Halio- metta*, *Caryosphaera*, *Didymocyrtis*, *Cyphonium*, *Prunopyle*, *Euchitonia*, *Hymeniastrum*, *Rhopalastrum*, *Porodiscus*, *Spongodiscus*, *Tetrapyle*, *?Lithelius*, *Cenodiscus* and to four families: Actinommidae, Coccodiscidae, Spongodiscidae and Lithelidae. Order Nassellaria includes nine species belonging to one family Theoperidae and to four genera as: *Cyrtocapsella*, *Eucyrthidium*, *Stichocorys*, *?Theocorys*.

CHARACTERISTIC OF THE UPPER BADENIAN RADIOLARIAN ASSEMBLAGE IN THE POLISH PART OF THE PARATETHYS

The Upper Badenian Radiolaria from the Kraków area is distinguishable among the others of the same age described previously, from localities in the Polish part of the Capathian Foredeep mentioned above. It shows some features distinguishing it from the Upper Silesian assemblage (Barwicz-Piskorz, 1997). It is also different, although in less importance, from Bochnia assemblage (Barwicz-Piskorz, 1978). The radiolarian assemblage from Kraków area is similar to the assemblage from Posądza (Smoleń, 1980).

Discussed microfauna is characterised by:

– numerous occurrence of artiscinids (*Didymocyrtis laticonus*, *D.* cf. *mammifera*, *Cyphonium virgineum*, *Prunopyle hayesi*), litheliids (*?Lithelius minor*) and spongodiscids (*Spongodiscus* div. sp.) like in Posądza region;

– quite numerous occurrence of species belonging to family Euchitoniidae like in vicinity of Bochnia town (in Upper Silesia they are rare);

– smaller frequency of Nassellaria than in the Upper Silesia region;

– lack of pylonids, which are abundant in the Upper

Table 2

Occurrence and frequency of the Badenian Radiolaria in borehole O-100

Radiolaria	Borehole O-100							
	samples, depth (m)							
	9.0	10.0	12.0	16.5	20.0	21.0	23.0	32.0
Caryosphaera sphaerica	++	+						
Cenosphaera coronata	+	+	+	+			++	
Cenosphaera eridami	+	+					+	
Cenosphaera sp.	+							+
Cyphonium virgineum	+	+++	+++					
Dictyastrum trirhopalum							+	
Didymocyrtis laticonus	++	+++	+++			+		
Didymocyrtis cf. *mammifera*		++	++					
Euchitonia furcata	+	+	+	+			+++	
?*Haliometta miocenica*							+	
Hymeniastrum euclidis							++	
?*Lithelius minor*	+++	+++	+++					
Melitosphaera minima	++	+		++			+++	
Melitosphaera sp.			+	+				+
Porodiscus concentricus				+				
Prunopyle hayesi	+	+	+					
Rhopalastrum irvinense							++	
Rhopalastrum malagaense							+	
Spongodiscus enodatus			+	+		+		+
Spongodiscus gigas				+				
Tetrapyle sp.		+		+				
Cyrtocapsella tetrapera		++	+				++	+
Cyrtocapsella cornuta		+++	++					
Cyrtocapsella cylindroides		+	+					
Cyrtocapsella japonica		+	+					
Eucyrthidium cienkowskii			+			+		
Eucyrthidium calvertense		+	+	+				
Stichocorys coronata		+					+	
Stichocorys delmontensis		+	+				+	
?*Theocorys* sp.			+				+	

Numbers of specimens: + 1–4; ++ 4–100 specimens; +++ more than 100 specimens.

Silesia region;

– lack of actinommids with many concentrically arranged shells and spines, which are common in Bochnia region;

– lack of species *Lithopera renzae* Sanfilippo & Riedel, which is rather common in the Upper Silesia and Bochnia regions.

The radiolarian-bearing Upper Badenian deposits and underlying evaporites horizon in Kraków region are covered directly by the Quaternary sediments. They form here an elevated area, named Kraków bold, which devided Paratethys into easter and western parts. It may have influenced the diferentiation of radiolarians in both parts of the Carpathian Foredeep.

The occurrence of radiolarian-bearing deposits close the Quaternary sediments in discussed area is the reason of destruction of the weak and fragile skeletons. Scanning microphotographs show different stages of tests preservation i.e. *Didymocyrtis laticonus*, ?*Lithelius minor*, *Caryosphaera sphaerica* and *Melitosphaera minima* (Figs 2B, C, E-G, J-L, 3A, B).

Table 3

Occurrence and frequency of the Badenian Radiolaria in boreholes Pasternik (OW), Kobierzyn (KB), Bronowice (BR) and Tonie (TN)

Boreholes	OW				KB				BR		TN
Radiolaria	samples, depth (m)				samples, depth (m)				nr		nr
	11.0	21.0	30.0	38.0	10.0	12.0	20.0	23.0	609	610	53
Caryosphaera sphaerica	++		++	++		++				+	++
Cenodiscus rotula		++			++	+	+++	+++			
Cenosphaera coronata	+		+						+		
Cenosphaera eridami	++	+									
Cenosphaera sp.							+	+	+	++	
Cyphonium virgineum	+	++	++	++	++	+			++	+	
Dictyastrum trirhopalum					+	++	+	+		+	+
Dictyocoryne triangularis					+	+				+	
Didymocyrtis laticonus		+++	+++	+++	++	++	++	++	++		
?Didymocyrtis mammifera		++	++	++							
Euchitonia furcata	+	+	+	+	+	++	++	++		++	
?Haliometta miocenica	+										
Hymeniastrum euclidis	+				+	++	+	+		+	
?Lithelius minor	+	+++	++	++	+++						
Melitosphaera minima	++	+	++	+						++	++
Melitosphaera sp.			+	+			+	+			+
Porodiscus concentricus	+		+	+							
Prunopyle hayesi	+	++	+		+	+	+	+	+		+
Rhopalastrum irvinese			+	+	+		+				
Rhopalastrum malagaense		+	+	+		+	+				
Spongodiscus bulla		+							+		
Spongodiscus charybdaeus										+	
Spongodiscus enodatus		++	++	++	++	++		+	++		
Spongodiscus gigas		++	+	++	++	+	+	++	+		
Cyrtocapsella cornuta			+	+							
Cyrtocapsella tetrapera			+	+							
Eucyrthidium calvertense	+		+			++	+	+			
Eucyrthidium cienkowskii			+	+							+
Stichocorys delmontensis	++	+	+	+			+	+			

Numbers of specimens: + 1–4; ++ 4–100 specimens; +++ more than 100 specimens.

SYSTEMATIC PALEONTOLOGY

The taxonomy follows classification as proposed by Riedel (1971) from Pacific with some modifications after Petrushevskaya & Kozlova (1972) from Atlantic. In some cases the classification after Haeckel (1887) is adopted.

Subclass RADIOLARIA Müller, 1858
Superorder POLYCYSTINA Ehrenberg, 1838; emend. Riedel, 1967
Order SPUMELLARIA Ehrenberg, 1875
Family ACTINOMMIDAE Haeckel, 1862; emend. Riedel, 1967
Subfamily ACTINOMMINAE Haeckel, 1862; emend. Riedel, 1967
Genus *Cenosphaera* Ehrenberg, 1854

Cenosphaera sp.
Fig. 2 A

Material: More than 50 well preserved specimens.
Diagnosis: Test sphaerical, porous, with surface fairly rough. Pores are rounded, diffrent in shapes and dimensions; spaced closely and irregularly.
Dimensions: diameter of tests 160–200 μm, diameter of pores 10–30 μm, spaces between pores about 5 μm.
Occurrence: Common in the Upper Badenian deposits of the Carpathian Foredeep.

Genus *Melitosphaera* Haeckel, 1882

Melitosphaera minima (Clark & Campbell, 1942)
Fig. 2 E-G

1942. *Carposphaera (Cerasosphaera) minima* n.sp.: Clark & Campbell, 21, pl. 4, figs 8, 9.
1978. *Melitosphaera minima* (Clark & Campbell): Barwicz-Piskorz, 226, pl. 2, fig. 2.

Material: 20 specimens well preserved, about 100 incomplete.
Occurrence: Common in the Upper Badenian of Upper Silesia and Kraków regions.

Genus *Caryosphaera* Haeckel, 1887

Caryosphaera sphaerica Barwicz-Piskorz, 1978
Fig. 2 B-D

1978. *Caryosphaera sphaerica* n.sp.: Barwicz-Piskorz, 228, pl. 2, fig. 6.
1980. *Caryosphaera sphaerica* Barwicz-Piskorz: Smoleń, 312, pl. 3, fig. 1.

Material: 120 specimens well preserved, some incomplete.
Occurrence: Common in the Upper Badenian deposits of the Carpathian Foredeep.

Family COCCODISCIDAE Haeckel, 1862; emend. Sanfilippo & Riedel, 1980
Subfamily ARTISCINAE Haeckel, 1881; emend. Riedel, 1967

Genus *Didymocyrtis* Sanfilippo & Riedel, 1980

Didymocyrtis laticonus (Riedel, 1959)
Fig. 3 C-F

1959. *Cannartus laticonus* n.sp.: Riedel, 291, pl. 1, fig. 5.
1985. *Didymocyrtis laticonus* (Riedel): Sanfilippo *et al.*, 658, pl. 8, fig. 5a, b.

Material: 50 specimens well preserved.
Remarks: Shape variability of the shells is observed (Figs. 2 B-C, E)
Occurrence: Common in the Upper Badenian deposits of Kraków area.

Genus *Cyphonium* Ehrenberg 1860

Cyphonium virgineum Haeckel 1887
Fig. 2 H, I

1887. *Cyphonium virgineum* n. sp.: Haeckel, 363, pl. 39, figs 12, 12a
1978. *Ommatospyris virginea* (Haeckel): Barwicz-Piskorz, 235, pl. 1, figs 3, 9.

Material: 20 specimens well preserved.
Remarks: According to present taxonomy the species has been included to the genus *Cyphonium*.
Occurrence: Only few specimens have been recognized in the Upper Badenian deposits of the Carpathian Foredeep.

Genus *Prunopyle* Dreyer, 1888

Prunopyle hayesi Chen, 1975
Fig. 3 G-J

1975. *Prunopyle hayesi* n.sp.: Chen, 454, pl. 9, figs 3-5.
1978. *Prunopyle* sp.: Barwicz-Piskorz, 106, pl. 3, fig. 5.

Material: 30 specimens.
Remarks: Well preservation enabling good photographical documentation (Fig. 2G-J).
Occurrence: In the Upper Badenian deposits of the Capathian Foredeep few to common.

Family SPONGODISCIDAE Haeckel, 1896, emend. Riedel, 1967

Genus *Porodiscus* Haeckel, 1881

Porodiscus concentricus (Ehrenberg, 1838)
Fig. 3 A

1875. *Flustrella concentrica* Ehrenberg: Ehrenberg, 72, pl. 22, fig. 13.
1887. *Porodiscus concentricus* (Ehrenberg): Haeckel, 492.
1978. *Flustrella concentrica* Ehrenberg: Barwicz-Piskorz, 238, pl. 1, fig. 6, pl. 5, fig. 1a, b.

Material: 5 specimens.
Remarks: Rare, poorly preserved specimens have been found in the vicinity of Kraków.
Occurrence: Few to common in the Upper Badenian deposits of the whole Carpathian Foredeep.

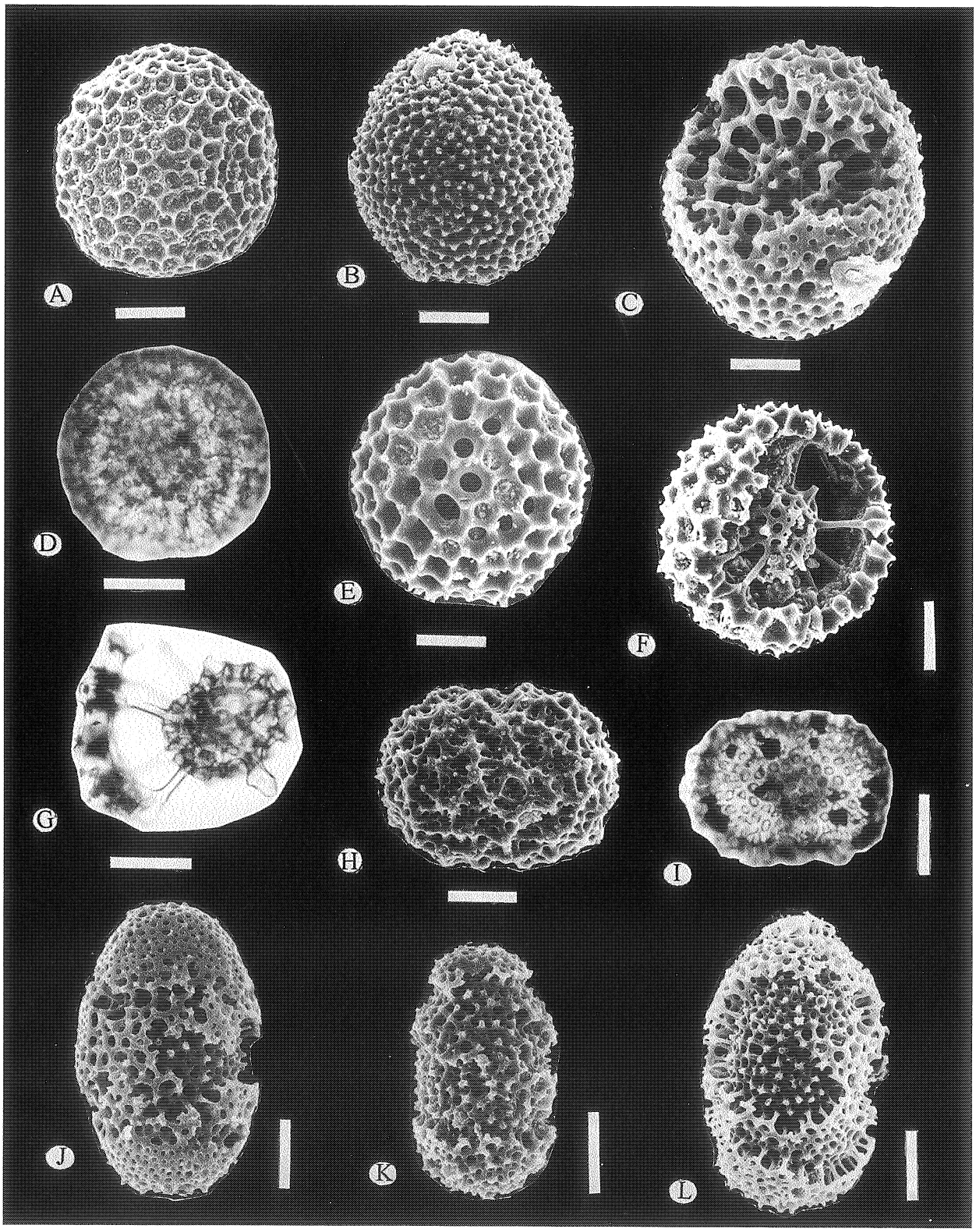

Fig. 2. Badenian radiolarians from the Kraków area. **A.** *Cenosphaera* sp. **B-D.** *Caryosphaera sphaerica* Barwicz-Piskorz. B-C. Specimens different preservation. D. Inner structure of the test, transmitted light. **E-G.** *Melitosphaera minima* (Clark & Campbell). F. Specimens with visible medular shell. G. Inner structure, transmitted light. **H-I.** *Cyphonium virgineum* Haeckel. I. Inner structure, transmitted light. **J-L.** ? *Lithelius minor* Jörgensen, specimens different preservation. A: O-100, depth 21–23 m, B-D, H-L: O-100, depth 10–12 m, E-G: O-100, depth 9–10 m. Length of scale bar – 50 μm

Family LITHELIIDAE Haeckel, 1862

Genus *Lithelius* Haeckel, 1862

?*Lithelius minor* Jörgensen 1900
Figs 2 J-L, 3 A, B

1978. *Cromyodruppa concentrica* Lipman: Barwicz-Piskorz, 233, pl. 1, fig. 2, pl. 3, figs. 4a, b.
1984. *Lithelius minor* Jörgensen: Nigrini & Lombari, S95, pl. 14, fig.1a, b.
1997. *Spongurus* ? sp.: Barwicz-Piskorz, 93, pl. 1, fig. 6.

Material: 60 specimens well to moderately preserved, some skeletons incomplete (broken).
Remarks: Limited resistance to destruction caused the different state of tests preservation which makes identification more difficult. In some cases similar forms were described under different species and genera names.
Occurrence: Common to abundant in the Upper Badenian deposits of the Carpathian Foredeep.

Order NASSELLARIA
Suborder CYRTIDA Haeckel, 1862,
emend. Petrushevskaya, 1971
Family THEOPERIDAE Haeckel, 1881,
emend. Riedel, 1967

Genus *Cyrtocapsella* Haeckel, 1887

Cyrtocapsella tetrapera Haeckel, 1887
Fig. 3 D

1887. *Cyrtocapsa tetrapera* n.sp.: Haeckel, 1512, pl. 78, fig. 5.
1973. *Cyrtocapsella tetrapera* Haeckel: Sanfilippo *et al.*, 221, pl. 5, figs 4-6.
1980. *Cyrtocapsella tetrapera* Haeckel: Smoleń, 319, pl. 2, fig. 5.

Material: 50 specimens well preserved.
Occurrence: Common in the Upper Badenian deposits of the Upper Silesia and Kraków area.

Cyrtocapsella cornuta Haeckel, 1887
Fig. 3 C

1887. *Cyrtocapsa cornuta* n.sp.: Haeckel, 1513, pl. 78, fig. 8.
1973. *Cyrtocapsella cornuta* (Haeckel): Sanfilippo *et al.*, 220, pl. 5, figs 1, 2.
1980. *Cyrtocapsella cornuta* Haeckel: Smoleń, 320, pl. 4, fig.1.

Material: 40 specimens well preserved.
Occurrence: Common in the Upper Badenian deposits of the Upper Silesia and Kraków area.

Cyrtocapsella japonica Nakaseko, 1963
Fig. 3 E

1963. *Cyrtocapsella japonica* n.sp.: Nakaseko, 193, pl. 4, figs. 1-3.
1973. *Cyrtocapsella japonica* Nakaseko: Sanfilippo *et al.*, 220, pl. 5, fig. 3.

Material: 5 specimens well preserved.
Occurrence: Rare in the Upper Badenian deposits of Kraków area.

Cyrtocapsella cylindroides (Principi, 1909)
Fig. 3 I, J

1909. *Stichocapsa cylindroides* n.sp.: Principi, 21, pl. 1, fig. 43.
1984. *Cyrtocapsella cylindroides* (Principi): Nigrini & Lombari, N103, pl. 16, fig. 2.

Material: 10 specimens well preserved.
Occurrence: Rare in the Upper Badenian deposits of Kraków area.

Genus *Eucyrthidium* Ehrenberg, 1872

Eucyrthidium cienkowskii Haeckel group, 1887
Fig. 3 H

1887. *Eucyrthidium cienkowskii* n.sp.: Haeckel, 1493, pl. 80, fig. 9.
1973. *Eucyrthidium cienkowskii* Haeckel group: Sanfilippo *et al.*, 221, pl. 5, figs 7-11.
1980. *Eucyrthidium cienkowskii* Haeckel group: Smoleń, 318, pl. 2, figs 3, 3a.

Material: 10 specimens.
Occurrence: Few to common in the Upper Badenian deposits of the Carpathian Foredeep.

Eucyrthidium calvertense Martin, 1904
Fig. 3 G

1963. *Eucyrthidium calvertense* Martin: Nakaseko, 120, pl. 3, figs 7, 8.
1997. *Eucyrthidium calvertense* Martin: Barwicz-Piskorz, 93, pl. 2, fig. 5.

Material: 10 specimens.
Occurrence: Few in the Upper Badenian deposits of the Carpathian Foredeep.

Genus *Stichocorys* Haeckel, 1881

Stichocorys delmontensis (Campbell & Clark, 1944)
Fig. 3 B

1944. *Eucyrthidium delmontense* n.sp.: Campbell & Clark, 56, pl. 7, figs 19, 20.
1973. *Stichocorys delmontensis* (Campbell & Clark): Sanfilippo *et al.*, 222, pl. 6, fig. 3.
1980. *Stichocorys delmontensis* (Campbell & Clark): Smoleń, 319, pl. 2, fig. 4.

Material: 20 specimens.
Occurrence: Few in the Upper Badenian deposits of the Upper Silesia and Kraków regions.

Stichocorys coronata (Carnevale, 1908)
Fig. 3 F

1908. *Calocyclas coronata* n.sp.: Carnevale, 33, pl. 4, fig. 24.
1972. *Stichocorys coronata* (Carnevale): Petrushevskaya & Kozlova, 547, pl. 25, figs 23, 24.

Material: 3 specimens.
Occurrence: Rare in the Upper Badenian deposits of the Upper Silesia and Kraków area.

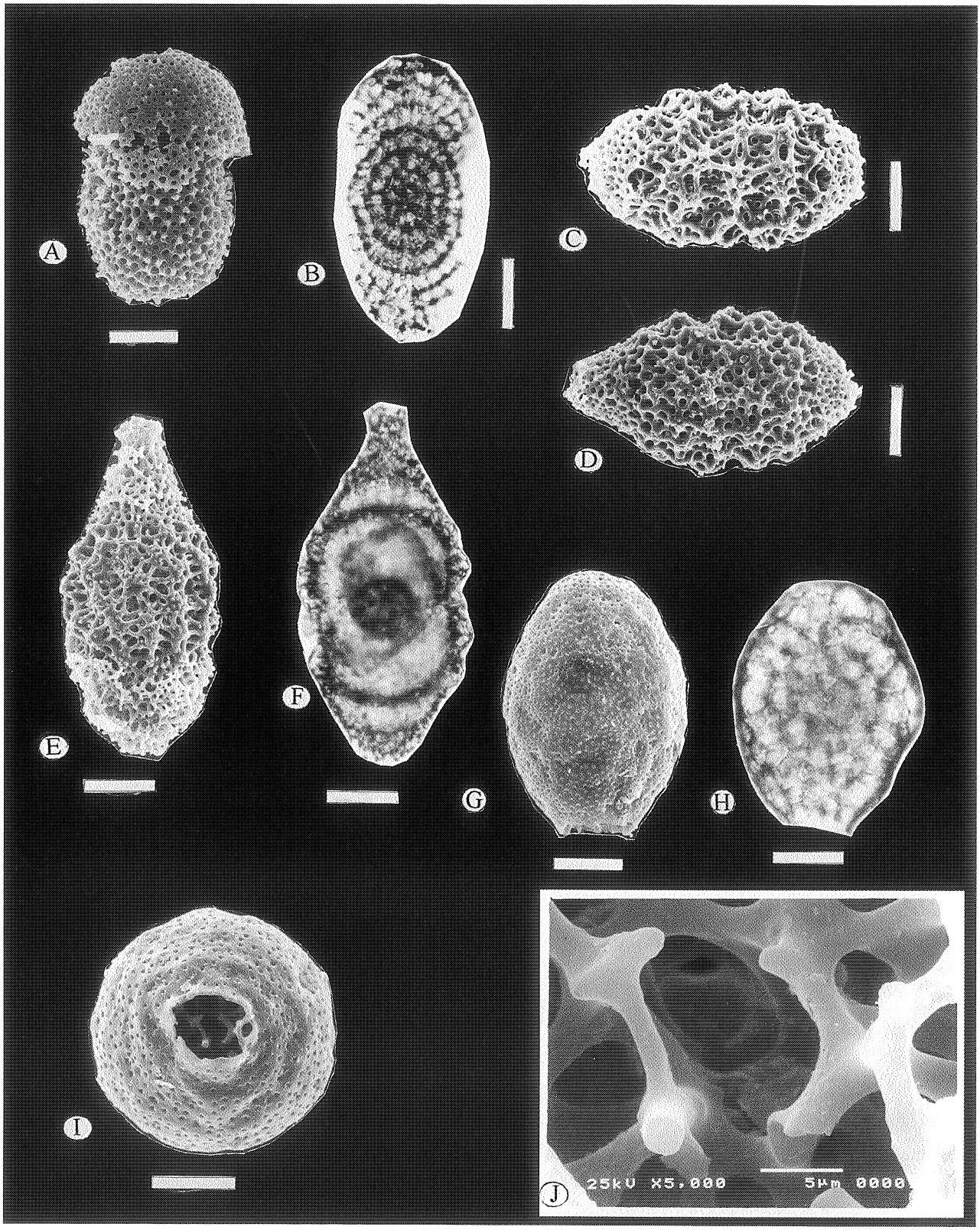

Fig. 3. Badenian radiolarians from the Kraków area. **A-B.** ? *Lithelius minor* Jörgensen. B. Inner structure, transmitted light. **C-F.** *Didymocyrtis laticonus* (Riedel). F. Inner structure, transmitted light. **G-J.** *Prunopyle hayesi* Chen. H. Inner structure, transmitted light. I. Pylom side viev. J. Inner structure of pylom. A, B, G-J: O-100, depth 10–12 m, C-F: O-100, depth 12–13 m. Length of scale bar – 50 µm

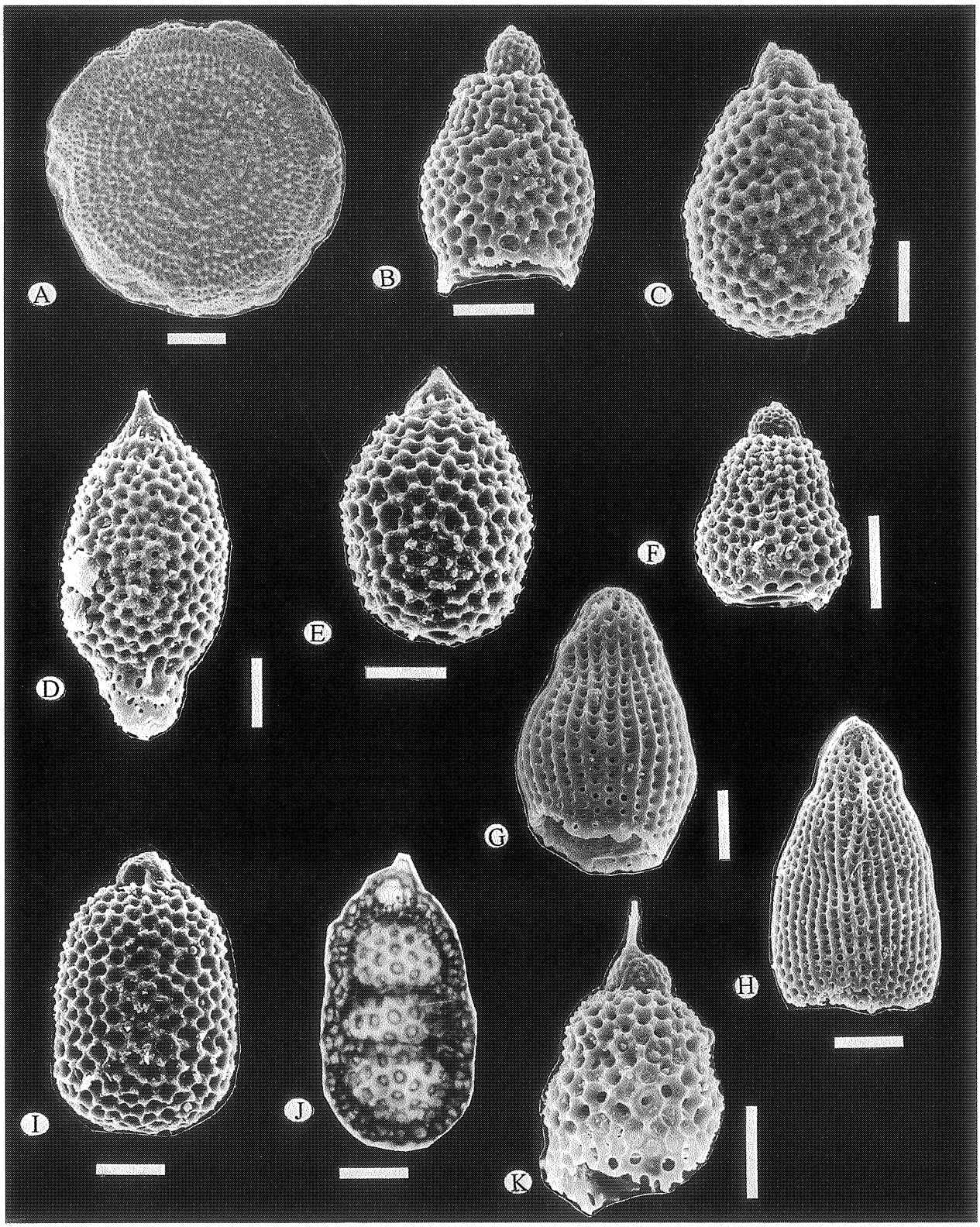

Fig. 4. Badenian radiolarians from the Kraków area. **A.** *Porodiscus concentricus* (Ehrenberg). **B.** *Stichocorys delmontensis* (Campbell & Clark). **C.** *Cyrtocapsella cornuta* Haeckel. **D.** *Cyrtocapsella tetrapera* Haeckel. **E.** *Cyrtocapsella japonica* Nakaseko. Borehole **F.** *Stichocorys coronata* (Carnevale). **G.** *Eucyrthidium calvertense* Martin. **H.** *Eucyrthidium cienkowskii* Haeckel. **I, J.** *Cyrtocapsella cylindroides* (Principi). J. Inner structure, transmitted light. **K.** ?*Theocorys* sp. A-D, F, I, J: O-100, depth 10–12 m. E, G, H, K: O-100, depth 12–13 m. Length of scale bar – 50 μm

Table 4

Miocene radiolarian and foraminiferal zones (Sanfilippo *et al.*, 1985)

Stratigraphy		Radiolarian zones (after Sanfilippo *et al.*, 1985)	Ranges of radiolarian species	Foraminiferal zones
Pliocene		*Stichocorys peregrina*	⑤	
Miocene	Late	*Didymocyrtis penultimus*		–N17
		Didymocyrtis antepenultimus	② ③ ④	N16–
	Middle	*Diartus peterssoni*	①	–N15 N13–
		Dorcadospyris alata		–N12 N9–
	Early	*Calocycletta costata*		–N8
		Calocycletta virginis		N4–

① – *Didymocyrtis mammifera*, ② – *D. laticonus*, ③ – *Cyrtocapsella tetrapera*, ④ – *C. cornuta*, ⑤ – *Stichocorys delmontensis*.
The Paratethys species ranges are shaded.

Genus *Theocorys* Haeckel, 1882

? *Theocorys* sp.
Fig. 3 K

Material: 10 specimens poor preservation, lower parts of tests are destroyed.
Diagnosis: Test consist of hemisphaerical cephalis, thorax and abdomen. Cephalis with many, very small pores and short, thick apical horn.
Dimensions: Length of the test about 110 μm, maximum breadth 80 μm, length of the horn 20 μm, diameter of pores on abdomen and thorax 5 μm.
Occurrence: Rare in the Upper Badenian deposits of Kraków area.

CONCLUSIONS

The Badenian Radiolarian microfauna from the Polish part of the Paratethys shows some similarities to the radiolarian associations of the same age from another regions of the world. In the Badenian deposits of the Carpathian Foredeep in Romania has been described by Dumitrică (1978) seven radiolarian species the same as in Poland occur: *Cannartus laticonus*, *Stichocorys wolffii* Haeckel, *Stichocorys delmontensis*, *Lithopera renzae*, *Eucyrthidium cienkowskii*, *Cyrtocapsella tetrapera*, *Tetrapyle* sp. Many spumellarian species looking very similar like there from Poland but included to another genus and species occur too.

In the Italian Miocene (Carnevale, 1908; Principi, 1909) occur several species common in the Badenian deposits of Paratethys. Relatively numerous species described from the California Miocene have been found in Poland (Campbell & Clark, 1944). Some species from the Miocene deposits of Pacific (Haeckel, 1887; Nakaseko, 1963) and Atlantic (Petrushevskaya & Kozlova, 1972) have been observed.in the Badenian deposits of the Polish part of Paratethys.

Radiolarian associations from the open ocean regardless the climatic zones are more differentiated than those from Paratethys Badenian especially concerning the number of Nassellaria species. It is caused by the paleogeographical situation as Paratethys was a narrow bay with distant connection with the ocean.

Upper Badenian Radiolaria from the Polish, Ukrainian and Romanian parts of the Capathian Foredeep have been included in the *Dorcadospyris alata* radiolarian Zone (Sanfilippo *et al.*, 1985) – zonation for the low geographical latitudes (Table 4). In the material discussed the index species is absent. But some typical species occur: *Didymocyrtis laticonus*, *D.* cf. *mammifera*, *Stichocorys delmontensis*, *Cyrtocapsella cornuta* and *C. tetrapera*.

In the material studied the index species (Abelmann, 1990) of the high latitude zones is not observed, although some considered as cold water species (*Prunopyle hayesi*, ? *Lithelius minor*, *Spongodiscus enodatus* and *S. bulla*) occur, sometimes very frequently. In major gatherings they occur only in the eastern part of the Carpathian Foredeep and in Kraków vicinity.

L. minor occurs in the Miocene deposits in California (Mullineaux & Westberg-Smith, 1986), and is regarded as useful palaeogeographical indicator of strong upwelling and

low paleotemperature. *S. enodatus* and *S. bulla* were described from Sachalin Island (Kozlova, 1960). The species *P. hayesi* is known from Antarctic (Abelmann, 1990, Lazarus, 1990) and North Pacific where it occurs in high latitude Radiolarian Zones (Morley & Nigrini, 1995, Shilov, 1995). In the latter the species of wide geographical range typical of Miocene biostratigraphical zones from high and low latitudes, such as: *Stichocorys delmontensis*, *Cyrtocapsella cornuta* and *C. tetrapera* occur.

The assemblage investigated herein lacks some typical, warm water species such as: *Tetrapyle octacantha* Müller, *Phorticium pylonium* Haeckel and *Larnacantha* sp., but these species are common in Gliwice vicinity.

Low differentiation of Nassellaria is the important feature of the Badenian Radiolaria association from the whole Polish part of the Carpathian Foredeep. All species observed belong to one suborder – Cyrtida and one family – Theoperidae. In coeval Miocene deposits in Romania some species belonging to the suborder Spyrida occur. These forms are also known from other regions such as Italy and USA, California.

It may be supposed therefore, that during Badenian time span the Kraków area was an elevated block impeding migration of radiolarian fauna. In the west (Upper Silesia) slightly differentiated assotiations containing warm water species were developed. In the east, however, as well as in the center (Kraków region) the species typical of cold water were more numerous and the radiolarian assotiation was more differentiated.

Acnowledgments

Scanning microphotographs have been prepared at the Polish Academy of Science by dr. E. Bielańska, those in transmitted light at the University of Mining and Metallurgy (by the author).

This research was financially supported by University of Mining and Metallurgy, project 10. 140. 550.

REFERENCES

Abelmann, A., 1990. 40. Oligocene to Middle Miocene Radiolarian stratigraphy of Southern high latitudes from Leg 113, sites 689 and 690, Maud Rise. In: Barker, P. F. *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, 113, pp. 675–708.

Alexandrowicz, S. W., 1961. Stratigraphy of Chodenice and Grabowiec Beds at Chełm on the Raba River. (In Polish, with English summary). *Kwartalnik Geologiczny*, 5: 5–25.

Alexandrowicz, S. W., 1963. Stratigraphy of Miocene deposits in the Upper Silesia Basin. (In Polish, with English summary). *Prace Instytutu Geologicznego*, 39: 1–150.

Barwicz-Piskorz, W., 1978. The Miocene Radiolaria from the Carpathian Foredeep. *Acta Palaeontologica Polonica*, 23: 223–248.

Barwicz-Piskorz, W., 1981. Horizon with Radiolarians in the Miocene sediments of the Carpathian Foredeep. *Biulletin de l'Academie Polonaise des Sciences, Sciences de la Terre*, 29: 99–107.

Barwicz-Piskorz, W., 1997. Badenian (Miocene) Radiolaria from the Gliwice area (Upper Silesia, Poland). *Bulletin of the Polish Academy of Science, Earth Sciences*, 45: 87–95.

Clark B. L. & Campbell A. S., 1942. Eocene radiolarian faunas from the Mt. Diabolo area, California. *Geological Society of America. Special Papers*, 39: 1–112.

Campbell, A. S. & Clark, B. L., 1944. Miocene Radiolarian faunas from Southern California. *Geological Society of America, Special Papers*, 51: 1–76.

Carnevale, P., 1908. Radiolarie e Silicoflagellati di Bergonzano (Reggio Emilia). *Memorie del Reale Instituto Veneto di Science, Lettere ed Arti*, 28: 1–22.

Chen, P. H., 1975. Anctarctic radiolaria. In: Hayes, D. E. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project*, 28, pp. 437–513. Washington U.S. Government Printing Office.

Dumitrică, P., 1978. Badenian Radiolaria from Central Paratethys. In: Papp A. *et al.* (eds), *Chronostratygraphie und Neostratotypen.* Miozän M 4. Badenian. Veda. Slovenska Akademie Vied. Bratislava, pp. 231–261.

Ehrenberg, C. G., 1875. Forsetsung der mikrogeologischen dien als Gesamtübersicht der mikroskopischen Paleontologie gleichartig analysirter Gebirgsarte der Erde mit spezieller Rücksicht auf den Polycystinen-Mergel von Barbados. *Abhandlungen der Königlische Akademie der Wissenschaften,* Berlin: 1–160.

Haeckel, E., 1887. Report on the Radiolaria collected by HMS Challenger during the years 1873-76. *Report on the Scientific Results of the Voyage of HMS Challenger during the years 1873-76*, Zoology 18. London.

Kozlova, G. E., 1960. Radiolaria in Middle and Upper Miocene of Sachalin Island. (In Russian). *Mikrofauna SSSR, Trudy VNIGRI*, 153: 307–317.

Lazarus, D., 1990. 41. Middle Miocene to Recent radiolarians from the Weddell Sea, Antarctica, ODP Leg. 113. In: Barker, P. F. *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, 113, pp. 709–727.

Łuczkowska, E., 1953. O tortońskich otwornicach z warstw chodenickich i grabowieckich okolic Bochni. *Rocznik Polskiego Towarzystwa Geologicznego*, 23: 77–156.

Łuczkowska, E., 1971. A new zone with *Praeorbulina indigena* (Foraminiferina, Globigerinidae) in the Upper Badenian (Tortonian s.s.) of the Central Parathethys. *Rocznik Polskiego Towarzystwa Geologicznego*, 40: 445–448.

Morley, J. J. & Nigrini, C., 1995. Miocene to Pleistocene radiolarian biostratigraphy of North Pacific sites 881, 884, 885, 886 and 887. In: Rea, D. K. *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, 145, pp. 55–92.

Mullineaux, L. S. & Westberg-Smith, M. J., 1986. Radiolarians as paleoceanographic indicators in the Miocene Monterey Formation, Upper Newport Bay, California. *Micropaleontology*, 32: 48–71.

Nakaseko, K., 1963. Neogene Cyrtoidea (Radiolaria) from the Isozaki Formation in Ibaraki Prefecture, Japan. *Osaka University, Science Reports*, 12: 165–198.

Nigrini, C. & Lombari, G., 1984. A guide to Miocene Radiolaria. *Cushman Foundation for Foraminiferal Research, Special Publication*, 22: 1–300.

Petrushevskaya, M. G. & Kozlova, G. E., 1972. 16. Radiolaria: Leg 14, DSDP. In: Hayer D. E. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project*, 14, pp. 495–648, Washington U. S. Government Printing Office.

Principi, P., 1909. Contribute alla studio dei radiolarii miocenici Italini. *Bolletino della Societá Geologica Italiana*, 28: 1–22.

Riedel, W. R., 1959. Oligocene and Lower Miocene Radiolaria in Tropical Pacific sediments. *Micropaleontology*, 5: 285–302.

Riedel, W.R., 1971. Systematic classification of Polycystine Radiolaria. In: Funnell, B. M. & Riedel, W. R. (eds), *The Micropaleontology of Oceans*. Cambridge University Press, pp.

649– 661.
Sanfilippo, A., Burckle, L. M., Martini, E. & Riedel, W. R., 1973. Radiolarians, diatoms, silicoflagellates and calcareous nannofossils in the Mediterranean Neogene. *Micropaleontology*, 19: 209–235.
Sanfilippo, A., Westberg-Smith, M. J. & Riedel, W. R., 1985. Cenozoic Radiolaria, In: Bolli, H. M. *et al.* (eds), *Plankton stratigraphy.* Cambridge University Press, pp. 631–712.
Shilov, V. V., 1995. 5. Miocene–Pliocene radiolarians from Leg 145, North Pacific. In: Rea V. V. *et al.* (eds), *Proceedings of the Ocean Drilling Program. Scientific Results*, 145, pp. 93–116.
Smoleń, J., 1980. Radiolarie z miocenu okolic Posądzy (zapadlisko przedkarpackie). *Kwartalnik Geologiczny*, 24: 311–332.

Streszczenie

BADEŃSKIE PROMIENICE (RADIOLARIA) Z OBSZARU KRAKOWA

Wanda Barwicz-Piskorz

Promienice z badenu polskiej części zapadliska przedkarpackiego występują w obrębie zony otwornicowej IIIA (Alexandrowicz, 1963). Według Łuczkowskiej (1971) jest to zona *Velapertina indigena* (Tab. 1).

Przeanalizowano zespół promienic z pięciu płytkich wierceń wykonanych w okolicach Krakowa (Fig. 1). Badane utwory zaliczane do warstw chodenickich (górny baden), są rozwinięte jako szare iły margliste z wkładkami piaszczystymi oraz z tufitami. Zawierają one w dolnej swej części liczne promienice (Tab. 2–3).

Badany zespół składa się z 34 gatunków należących do 15 rodzajów, pięciu rodzin i 2 rzędów: Spumellaria i Nassellaria. Rząd Spumellaria reprezentowany jest przez 25 gatunków, 15 rodzajów: *Cenosphaera*, *Melitosphaera*, ?*Haliometta*, *Caryosphaera*, *Didymocyrtis*, *Cyphonium*, *Prunopyle*, *Euchitonia*, *Hymeniastrum*, *Rhopalastrum*, *Porodiscus*, *Spongodiscus*, *Tetrapyle*, ?*Lithelius*, *Cenodiscus*, należących do 4 rodzin: Actinommidae, Coccodiscindae, Spongodiscidae i Lithelidae. Do rzędu Nassellaria należy 9 gatunków zaliczonych do jednej rodziny Theoperidae. Omawiany zespół promienic wyróżnia się wśród równowiekowych zespołów z innych rejonów polskiej części zapadliska przedkarpackiego. Od zespołu z Górnego Śląska (Barwicz-Piskorz, 1997) różni się mniejszą liczebnością Nassellaria, brakiem przedstawicieli rodziny Pyloniidae i gatunku *Lithopera renzae*. Od zespołu z okolic Bochni (Barwicz-Piskorz, 1978) – mniejszą liczebnością form z rodziny Euchitoniidae i brakiem wielopowłokowych Actinommidae z kolcami. Jest natomiast podobny do zespołu z Posądzy (Smoleń, 1980) dzięki obecności licznych Artiscinae, Litheliidae i Spongodiscidae.

Utwory górnego badenu z promienicami oraz niżejległy poziom osadów chemicznych na obszarze Krakowa leżą płytko pod czwartorzędem. Ten podniesiony obszar (rygiel krakowski) rozdzielający zbiornik Paratetydy na część wschodnią i zachodnią mógł mieć wpływ na zróżnicowanie fauny promienic. Znaczny stopień skorodowania skorupek niektórych gatunków (Figs. 2 C, F, G, K, L, 3 A, B) spowodowany jest zwietrzeniem iłów z radiolariami leżących w badanym obszarze płytko pod czwartorzędem.

Mikrofauna promienic z badenu polskiej części zapadliska przedkarpackiego wykazuje pewne analogie do równowiekowych zespołów z innych regionów – górny baden zapadliska przedkarpackiego w Rumunii (Dumitrică, 1978), miocen Włoch – zapadlisko przedapenińskie (Carnevale, 1908, Principi, 1909), miocen zapadliska śródgórskiego w Kalifornii (Campbell & Clark, 1944) oraz mioceńskie osady dna oceanu Spokojnego (Haeckel, 1887; Nakaseko, 1963) i Atlantyckiego (Petrushevskaya & Kozlova, 1972). Mikrofauna mioceńskich promienic pochodząca z dna oceanu światowego jest bardziej urozmaicona niż ta z osadów badenu polskiej części Paratetydy. Wynika to z sytuacji paleogeograficznej – Paratetyda stanowiła wąski zbiornik o odległych połączeniach z oceanem.

Radiolarie z osadów górnego badenu zapadliska przedkarpackiego zostały włączone do zony radiolariowej *Dorcadospyris alata* schematu biostratygraficznego wg Sanfilippo *et al.* (1985) (Tab. 4) – zonacji opracowanej dla niskich szerokości geograficznych.

W badanym materiale pojawiają się, niekiedy bardzo licznie, gatunki zimnolubne: *Prunopyle hayesi*, *Lithelius minor*, *Spongodiscus enodatus* i *S. bulla*, brak natomiast gatunków typowych dla wód ciepłych – *Tetrapyle octacantha*, *Phorticium pylonium* i *Larnacantha* sp.

Można przypuszczać, że rygiel krakowski stanowił w badenie próg utrudniający migrację radiolarii. Na zachodzie rozwijały się mało urozmaicone zespoły zawierające gatunki ciepłolubne, na wschodzie i w centrum (okolice Krakowa) liczniejsze są gatunki typowe dla wód chłodnych, a zespoły są bardziej urozmaicone.