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Radiolarians of the uppermost Oxfordian (Hypselum Zone) of the Wieluń Upland (central Poland)

Jolanta SMOLEŃ[1]

Key words: radiolarians, Upper Oxfordian, Wieluń Upland, central Poland, stratigraphy, palaeogeography.

Abstract. Radiolarian assemblages from the uppermost Oxfordian (Hypselum Zone) deposits of two sections (Katarowa Góra and Bobrowniki) in the Wieluń Upland (central Poland) are studied for the first time. The overall composition of the assemblages is characterized by low taxonomic diversity, with many individuals of spherical morphotypes, with dominance of the family Williriedellidae and Gongylothoracidae, among the nassellarians. The radiolarians show features mostly of the Northern Tethyan fauna. Additionally, more cosmopolitan forms consisting of spumellarians and of cold water representatives of the family Parvicingulidae appear in the middle and upper parts of the Hypselum Zone. This change in the character of the radiolarian assemblages suggests Boreal influences into the Submediterranean basin related to activity of sea currents, which have been stimulated by climatic changes during the latest Oxfordian.

INTRODUCTION

Records of radiolarian faunas are still relatively rare in the Upper Jurassic epicontinental deposits of Poland. The occurrence of radiolarians was noted by Barwicz-Piskorz (1989) and Bielecka (1956, 1960), but these microfossil assemblages have been described in detail in only a few works. Wiśniowski (1889) described fairly well preserved forms in siliceous concretions from Upper Jurassic deposits in the vicinity of Kraków. Smoleń (1998) distinguished a Lower Oxfordian horizon with radiolarians in the area between Częstochowa and Zawiercie. Górka and Bąk (2000) gave a systematic description and palaeoecological interpretation of a radiolarian fauna from the Lower Oxfordian at Zalas quarry in the Kraków Upland. The characteristics of the Lower Oxfordian radiolarian assemblages from the deposits of Kraków–Wieluń Upland and their importance for biostratigraphy and palaeogeography were considered by Smoleń (2002). The occurrence of radiolarians in the earliest Kimmeridgian deposits was noted for the first time by Smoleń (Smoleń *et al*., 2014; Wierzbowski A. *et al*., 2015b) from boreholes in the Peri-Baltic Syneclise (north-eastern Poland), where a radiolarian horizon was distinguished. This horizon is well dated by ammonites as corresponding to the lowermost Kimmeridgian (lower part of the Boreal Bauhini Zone and Subboreal Baylei Zone). Analysis of the radiolarian species provided the basis for palaeogeographical and palaeoecological interpretations of the depositional environment.

The present paper is the first study of the radiolarian fauna from the uppermost Oxfordian deposits in Wieluń Upland (central Poland). The radiolarians were found in the bedded limestones – marly limestones of sponge megafacies deposits, in two sections: Katarowa Góra and Bobrowniki. The stratigraphical position of the deposits studied was estimated on the basis of ammonites as uppermost Oxfordian (Hypselum Zone) (Wierzbowski A., Matyja, 2014; Wierzbowski A., 2015; Wierzbowski A. *et al*., 2015a).

[1] Polish Geological Institute – National Research Institute, 4, Rakowiecka Str., 00-975 Warszawa, Poland; e-mail: jolanta.smolen@pgi.gov.pl.

GEOLOGICAL SETTING

During the Late Oxfordian, the area of the Wieluń Upland was covered by a deep neritic sea, which constituted a part of the northern shelf of the Tethys. The typical sediments are those of the Late Jurassic spongy megafacies. Detailed lithological and biostratigraphical characteristics of the deposits in the Wieluń Upland, based on ammonite faunas have been given in many works (*e.g.* Matyja, Wierzbowski A., 2000; Wierzbowski A. *et al.*, 2010; Wierzbowski A., Matyja, 2014).

Study of the Katarowa Góra and Bobrowniki sections in the abandoned quarries located in the northern part of Polish Jura Chain between the towns Częstochowa and Wieluń (Fig. 1) showed a fairly thick succession of limestones with cherts, containing marly intercalations. The deposits have yielded numerous ammonites accompanied by belemnites and benthic fossils such as: siliceous sponges – preserved as calcareous mummies, brachiopods, bryozoans, serpulids and others. It should be remembered that the succession studied corresponds to the two ammonite zones of the Submediterranean zonal scheme: the Hypselum Zone (Katarowa Góra section and lowermost part of the Bobrowniki section) and the Bimammatum Zone (Bobrowniki section except the lowermost part). The former is correlated with the uppermost Oxfordian in its Boreal/Subboreal interpretation, the latter with the lowermost Kimmeridgian (Wierzbowski A., Matyja, 2014; Wierzbowski A. *et al.*, 2016 – this issue). The succession of the Katarowa Góra and Bobrowniki sections studied shows also the presence of ammonites of Boreal character – indicating that stronger Boreal influences existed temporarily. These are noted in the middle and upper parts of the Hypselum Zone beginning with well known "*Amoeboceras* layer" (see Wierzbowski A., Matyja, 2014 and earlier papers cited therein).

The Katarowa Góra and Bobrowniki sections studied yielded also many microfossils. Most of them are radiolarians, but benthic foraminifera, single ostracods and sponge spicules are also present. Radiolarians were found in all the samples taken from several beds of the sections studied but only those coming from the Upper Oxfordian (Hypselum Zone) deposits were suitable for palaeontological studies. Even so, radiolarian tests are predominantly poorly preserved, being calcified and often mechanically damaged, with broken spicules, which hinders their precise taxonomical identification, and makes it impossible in many cases. A list of selected, identified taxa is given in Figure 2. In general, the radiolarian assemblages from the studied sections are characterized by low taxonomic diversity and the presence of many individuals of spherical morphotypes, especially among the nassellarians. Noticeable differences in the composition of species and in the number of specimens in the individual samples were observed in the vertical distribution of the radiolarian assemblages.

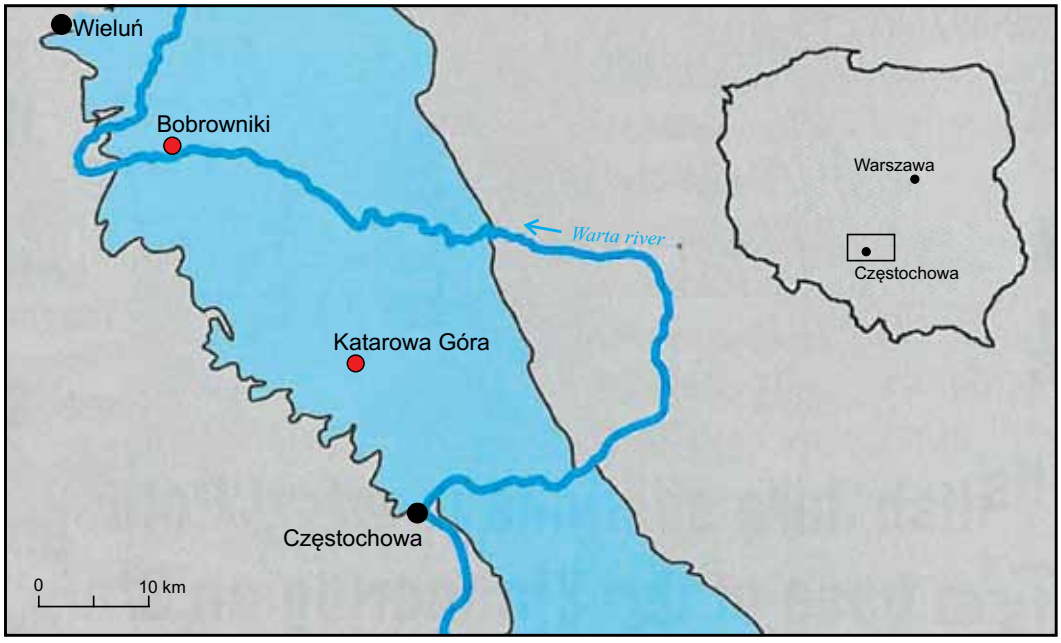

Fig. 1. Location of the sections studied in the Wieluń Upland at the northern part of the Polish Jura Chain

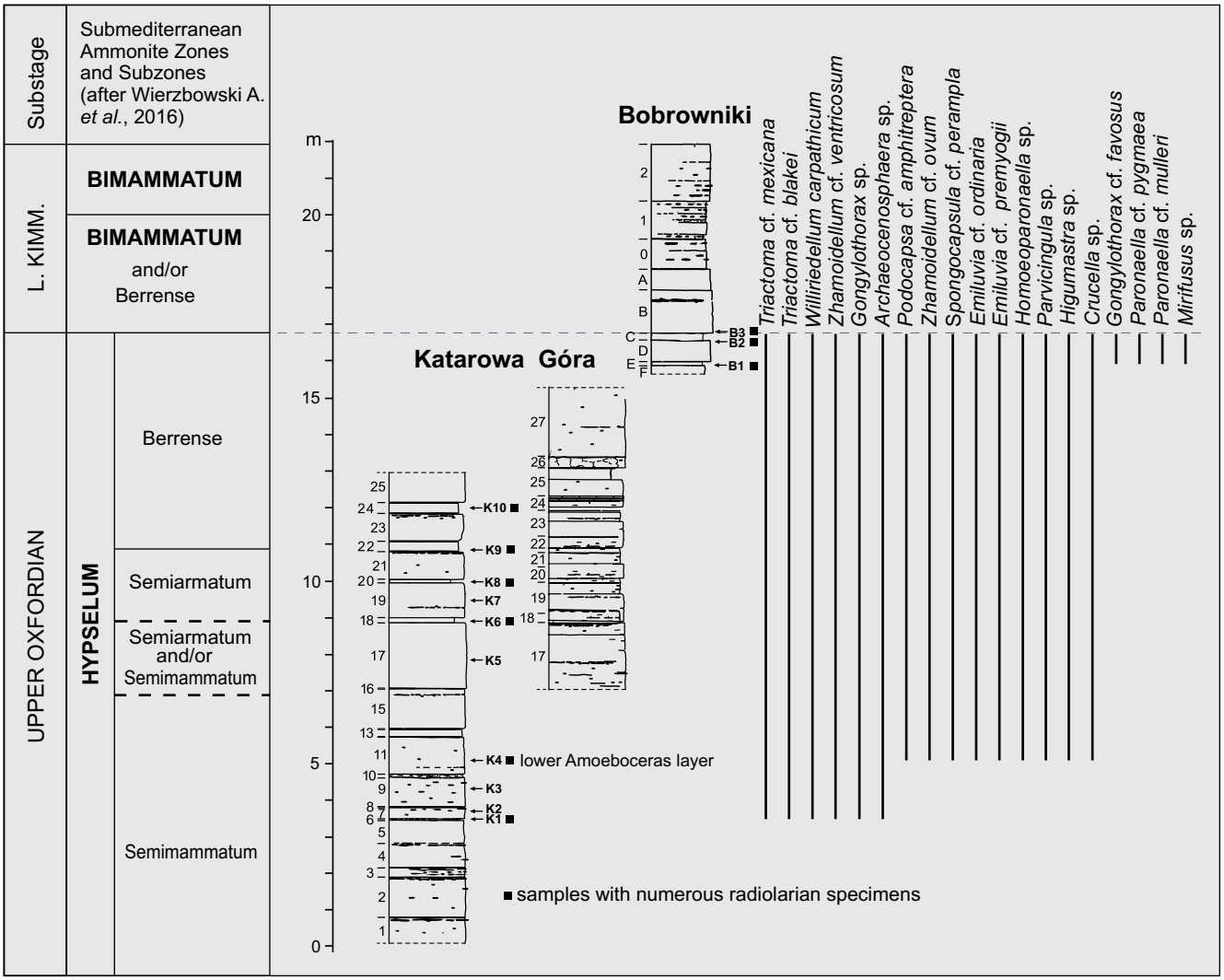

Fig. 2. Biostratigraphy and lithological columns of the Upper Oxfordian and lowermost Kimmeridgian deposits in the Katarowa Góra and Bobrowniki sections (after Wierzbowski A. *et al.*, 2016) and the stratigraphical distribution of selected, identified radiolarians

On the left-hand side of the sections bed numbers are given. The locations and the numbers of radiolarian samples are given on the right-hand side. L. KIMM – lowermost Kimmeridgian

KATAROWA GÓRA SECTION

In the Katarowa Góra section numerous radiolarians are present, especially in the marly limestones and micritic limestones. A smaller number of radiolarians have been noted in the organogenic limestones with cherts (see Fig. 2). In the lower part of Katarowa Góra section rich radiolarian associations are present in sample K1 from bed 6. They are predominantly composed of nassellarians from the families: Williriedellidae and Gongylothoracide with many individuals of the species: *Williriedellum carpathicum* Dumitrica, *Zhamoidellum* cf. *ventricosum* Dumitrica and *Gongylothorax* sp. (Pl. 1: 5). Other nassellarians are represented by single specimens of ?*Spinosicapsa* sp. (Pl. 1: 15), and of the genera: *Stichocapsa*, *Sethocapsa*, and by unidentified multicyrtid forms (*e.g.* Pl. 1: 4). The spumellarians are scarce and mostly represented by the family Xiphostylidae comprising the species: *Triactoma* cf. *blakei* (Pessagno) (Pl. 1: 2), *Triactoma* cf. *mexicana* Pessagno et Yang and *Archaeocenosphaera* sp. (Pl. 1: 9). Single spumellarian specimens of: *Paronaella* sp. (Pl. 1: 8), ?*Cyclastrum* sp. (Pl. 1: 7), *Praeconocaryomma* sp. (Pl. 1: 1), and *Tripocylia* sp. (Pl. 1: 6), and of the genera: *Emiluvia*, *Spongodiscus* and *Orbiculiforma*, are also present.

A marked change in the faunal assemblage is observed in bed 11 (sample K4), which has been taken from the middle part of the Hypselum Zone ("*Amoeboceras* layer").

A characteristic feature of this sample is the much greater number of individuals as well as the larger taxonomical diversity. The radiolarian faunal composition in this sample is similar to that from the lower part of the section in question, with dominance of the spherical Nassellaria, but there occur also new nassellarian species such as: *Podocapsa* cf. *amphitreptera* Foreman (Pl. 2: 5), *Spongocapsula* cf. *perampla* (Rüst) (Pl. 1: 11), and *Zhamoidellum* cf. *ovum* Dumitrica (Pl. 1: 3). Other nassellarians which could not be accurately indentified from that level belong to the family Parvicingulidae (Pl. 2: 1, 12) and probably the genus *Parvicingula* (Pl. 2: 4) and to the genera: *Sethocapsa*, *Podobursa*, and other multicyrtid forms (Pl. 1: 12; Pl. 2: 13). The Spumellaria are represented by a greater number of specimens and species when compared with the lower part of the Katarowa Góra section. Some of them such as: *Triactoma* cf. *blakei* (Pessagno) (Pl. 1: 10), *Triactoma* cf. *mexicana* Pessagno et Yang, and ?*Cyclastrum* (Pl. 2: 11) are known from older deposits, but some are new – such as: *Emiluvia* cf. *ordinaria* Ozvoldova, *Emiluvia* cf. *premyogii* Baumgartner, *Paronaella* cf. *kotura* Baumgartner, and *Homoeoparonaella* sp. (Pl. 2: 2). Similar radiolarian assemblages are also present in younger marly limestones and micritic limestones in the middle part of the Katarowa Góra section above bed 11 (beds: 18, 20, 22 and 24; samples: K6, K8, K9 and K10), but they contain more individuals of the spongy radiolarians, multi-rayed, triangular and discoidal in shape, belonging to the spumellarians and the representing genera: *Higumastra*, *Emiluvia*, *Crucella*, *Paronaella* and *Spongodiscus*.

BOBROWNIKI SECTION

The Bobrowniki section shows deposits of the uppermost Oxfordian (upper part of Hypselum Zone) and the lowermost Kimmeridgian (Bimammatum Zone) (Fig. 2). The radiolarians are present in the whole section, but unfortunately in the Kimmeridgian deposits they are heavily recrystallized and unsuitable for study.

The lower part of the Bobrowniki section, belonging to the uppermost Oxfordian (upper part of the Hypselum Zone), yielded a rich radiolarian fauna at the top of bed "E" (sample B1) and bed "C" (samples: B2, B3). The assemblages from this part of the Bobrowniki section coming from particular beds are almost identical in composition, both in number of specimens and in species, as those from the upper part of the Katarowa Góra section (above the "*Amoeboceras* layer"). They are mostly composed of spherical morphotypes of Nassellaria, but spongy, multi-rayed, triangular and discoidal spumellarians as well as rare conical nassellarians are also present. Precise determination of many of the species is difficult because of the poor preservation of their shells, which are often mechanically damaged and many of them are fragmentarily preserved, especially in bed "C". The radiolarian assemblages from the uppermost Oxfordian of the Bobrowniki section consist of the following taxa: *Gongylothorax* cf. *favosus* Dumitrica (Pl. 2: 3), *Williriedellum* cf. *carpathicum* Dumitrica (Pl. 2: 8), *Podocapsa* cf. *amphitreptera* Foreman, *Triactoma blakei* (Pessagno), *Triactoma* cf. *mexicana* Pessagno et Yang (Pl. 2: 6), *Homoeoparonaella* sp., *Mirifusus* sp. (Pl. 2: 9), *Paronaella* cf. *mulleri* Pessagno, *Paronaella* cf. *pygmaea* Baumgartner, *Emiluvia* cf. *ordinaria* Ozvoldova (Pl. 1: 13), *Crucella* sp. (Pl. 2: 10), *Sethocapsa* sp. (Pl. 1: 14), ?*Parvicingula* sp. (Pl. 2: 15), ?*Higumastra* sp. (Pl. 2: 7), *Cyclastrum* sp. Other species belong to the genera: *Spongocapsula*, *Zhamoidellum*, *Archaeocenosphaera*, *Emiluvia*, *Tripocylia*, *Spongodisus*, *Orbiculiforma*, along with rare unidentified multicyrtid nassellarians.

PALAEOGEOGRAPHICAL AND PALAEOECOLOGIAL REMARKS

During the Late Oxfordian the area of the Wieluń Upland (central Poland) was covered by an epicontinental sea widely open to the Tethyan and the Boreal seas of the north and northern-eastern Europe (Wierzbowski A., Matyja, 2014; Wierzbowski A. *et al*., 2015a). The radiolarian faunas occurring here are characterized by Tethyan and the cosmopolitan species with Boreal forms occurring at some levels.

Distribution of radiolarian species in Late Jurassic times was closely related to climatic zones and showed a high degree of provincialism. Using diversity abundance of parvicingulids and pantanellids, four provinces have been distinguished: two characteristic of the Tethyan Realm (Central Tethyan Province and Northern Tethyan Province) and two of the Boreal Realm (Southern Boreal Province and Northern Boreal Province) in the Northern Hemisphere. In general, the typical features of the Tethyan provinces (especially that of the Central Tethys) are high radiolarian diversity of nassellarians as well as of spumellarians with dominance of the family Pantanellidae, while in Boreal provinces pantanellids are infrequent or absent and the representatives of genus of *Parvicingula* become dominant (Pessagno, Blome, 1986; Pessagno *et al*., 1993; Hull, 1995, 1997; Kiessling, 1999). The radiolarians of the moderate palaeolatitudes of the Peri-Tethyan regions are characterized by mixed Tethyan and Boreal faunas, and assemblages are less diversified in terms of both numbers and diversity of specimens and species (Baumgartner, 1987; Kiessling, 1999).

A main feature of the uppermost Oxfordian radiolarian assemblages studied from the Wieluń Upland is the high fre-

quency of the spherical nassellarians of the families Williriedellidae (genera: *Williriedellum*, *Zhamoidellum*) and Gongylothoracidae *(*genus: *Gongylothorax*), which are the most important forms of the Tethyan Realm (Baumgartner *et al*., 1995*)*. In the lower part of the succession studied (lower part of the Katarowa Góra section), which corresponds to some lower parts of the Hypselum Zone, additionally the cosmopolitan forms of the Xiphostylidae (genera: *Triactoma*, *Archaeocenosphaera*, *Tripocylia*) and Conocaryommidae (genus: *Praeconocaryomma*) are also present as well as single spumellarians with spongy structure of the test. In the assemblages in question the lack of pantanellids typical of Central Tethys (Pessagno, Blome, 1986; Kiessling, 1999), but also of parvicingulids cited from the areas of the Boreal Provinces is observed (cf. *e.g.* Pessagno *et al.*, 1993; Hull, 1995; Vishnevskaya *et al*., 1999, and others).

The radiolarian composition of the lower part of the succession studied indicates the Northern Tethyan origin of the radiolarian assemblages which is in general agreement with presence of an ammonite fauna mostly of Submediterranean character in this part of the succession (Matyja, Wierzbowski A., 2000; Wierzbowski A., Matyja, 2014; Wierzbowski A. *et al*., 2015a). The dominance of large, spherical forms within the radiolarians is considered to be the result of sorting by current activity. According to Baumgartner (1987), radiolarians which made up the main mass the Tethys Ocean plankton could be brought by sea currents to shallower shelf zones.

In middle parts of the succession studied from the "*Amoeboceras* layer" upwards (from the middle part of Katarowa Góra section to its upper part and to the lower part of the Bobrowniki section), mixed Tethyan – Boreal associations of radiolarians are observed. In addition to numerous specimens of the families Williriedellidae and Gongylothoracidae, cosmopolitan spumellarians occur more commonly, especially representatives of the genera: *Higumastra*, *Crucella*, *Paronaella*, *Emiluvia*, *Homeoparonaella* and *Archaeocenosphaera*. In this part of the succession also cold water representatives of the family Parvicingulidae (genus *Parvicingula*), and species *Podocapsa* cf. *amphitreptera*, *Triactoma* cf. *blakei* and *Triactoma* cf. *mexicana* are present at some levels. The taxa mentioned are often components of the Jurassic cold water association characteristic of the Southern Boreal Radiolarian Province of the North Hemisphere. In Europe such associations are well known from Late Jurassic deposits (mostly from the Kimmeridgian and Volgian) on the European part of the Russian Platform (Kozlova, 1971, 1973, 1976, 1994; Bragin, 1997; De Wever, Vishnevskaya, 1997; Vishnevskaya *et al.,* 1999; Olferiev, 2012; Vishnevskaya, Kozlova, 2012; Bragin, Kiselev, 2013). The radiolarian assemblages described in these works are composed of rich and varied faunas (also Tethyan species) with dominance of Boreal type taxa, especially a varied set of species of *Parvicingula.* Study of the *Parvicingula* distribution in the Kimmeridgian of the Timan-Pechora and Barrents regions confirms the possibility of using this species as the palaeoclimatic indicator of cold water environments (Vishnevskaya, 1996; Vishnevskaya, Murchey, 2002). The assemblages with *Parvicingula* have been described also from the Upper Oxfordian in the Krylatskoe section (Moscow City, central part of the East European Platform) (Ustinova *et al*., 2014). In the Flodigarry section at Staffin Bay on the Isle Sky in Scotland, poorly preserved radiolarians including the genus *Parvicingula* were noted in the upper part of the Upper Oxfordian Rosenkrantzi Zone (Gregory, 1995). Mixed radiolarian faunas with *Ristola* and *Parvicingula* were described also in the Upper Oxfordian deposits of Greenland (Kelly *et al*., 2015). Similar radiolarian faunas from the Upper Oxfordian deposits in the area of the Peri-Tethys in Central Europe are so far unknown.

The radiolarian assemblages discussed from the uppermost Oxfordian (middle and upper part of the Hypselum Zone) in the Wieluń Upland in Poland, which contain mixed Tethyan and cosmopolitan forms and also rare representatives of the cold water genus *Parvicingula*, can be thus considered as representing the Northern Tethyan Radiolarian Province associations with influences of a Boreal fauna.

The change in the composition of the radiolarian assemblages, starting from the "*Amoeboceras* layer" and continuing almost to the end of Oxfordian, may be related to activity of sea currents, which were probably stimulated by temporary climatic changes. Additionally the sea currents brought nutrient-rich waters which enabled the development of the plankton. This is generally consistent with a decrease of the $\delta^{13}C$ value of marine carbonate fossils which attain their lowest values during the latest Oxfordian; this suggests a high level of nutrients and increased productivity of seawater at the Oxfordian/Kimmeridgian boundary in the pericratonic Tethyan basins (Wierzbowski H., 2015). It is in general accordance with the marked increase in terrigenous material supply and the high values of the Th/U and P/Al ratios, which points to oxic conditions of the bottom water and increased productivity (Grabowski *et al*., 2015). Relatively high input of terrigenous material is observed in the "*Amoeboceras* layer" and some younger beds (Katarowa Góra section, beds: 11, 18, 20, 22; samples: K4, K8, K9) and in the Bobrowniki section (bed "C", sample B2). At some of these levels a prominent maximum of occurrence of the cold-water Boreal-Subboreal ammonite fauna is also observed (Matyja, Wierzbowski A., 2000; Wierzbowski A., Matyja, 2014; Wierzbowski A. *et al.*, 2015a). In the deposits above the "*Amoeboceras* layer" containing rich radiolarian faunas (Katarowa Góra section: beds: 17, 18 and others) specimens of the bivalve *Buchia concentrica* (Sowerby)

were also found. These molluscs which preferred the cold and moderate environments of the Boreal and Subboreal areas in the Upper Oxfordian and Lower Kimmeridgian, were able to penetrate to the south during the cooling events (see also Zakharov, 2014).

In general most of the radiolarian taxa from the assemblages described belong to the Tethyan Realm, however some of them are cosmopolitan and were noted also in the Boreal Provinces. In terms of the species composition, the assemblages studied are similar to those of the Northern Tethyan Province and represent the Tethyan U.A. Zone 9 (Middle–Upper Oxfordian age), according to Baumgartner *et al.* (1995). Such associations were cited from the radiolarites and beds with radiolarians from the Carpathian and Balkan ranges of the Tethyan provinces (*e.g.* Mišik *et al*., 1991; Widz, 1991; Polák, Ondrejičková, 1993; Ožvoldová *et al*., 2000; Vishnevskaya *et al*., 2009; Jach *et al.*, 2014), but also from the Upper Oxfordian sediments in the Krylatskoe section (Moscow City, central part of the East European Platform) of the Southern Boreal Radiolarian Province (Ustinova *et al.*, 2014).

In the uppermost part of the Hypselum Zone the radiolarian assemblages are characterized a very poor state of preservation of the tests, which are heavily calcified and covered with iron components but also are often mechanically damaged. This is seen in the Bobrowniki section in bed "C" (sample B3), near the Kimmeridgian boundary. In this sample also a gradual loss of benthic foraminifera can be observed, which become rare and very small in size. This fact may be indicative of unfavorable conditions of the marine environment. Studies of the inorganic geochemistry of the deposits from the uppermost part of the Hypselum Zone indicate an extremely high content of terrigenous elements and magnetic minerals (Grabowski *et al*., 2015). This is related with the occurrence of a well developed omission surface whose occurrence has been possibly related to some tectonic event at the Oxfordian/Kimmeridgian transition which markedly changed the palaeogeographic relations in large areas of northern (and central) Europe (Wierzbowski A. *et al*., 2015a, 2016 – this issue).

CONCLUSION

Radiolarians assemblages have been identified in the bedded limestones and marly limestones of the sponge megafacies, in two sections: Katarowa Góra and Bobrowniki in Central Poland. These deposits yielded ammonites indicative of the Hypselum Zone of the uppermost Oxfordian. In general, the radiolarians occurring in the studied assemblages are mostly of Tethyan character, but cold water species are also present at some levels.

In a lowermost part of the succession studied (lower part of Katarowa Góra section), which corresponds to some lower parts of the Hypselum Zone, radiolarian assemblages are dominated by spherical nassellarians, characteristic of the Northern Tethyan Radiolarian Provinces with common occurrence of the families Williriedellidae (genera: *Williriedellum*, *Zhamoidellum*) and Gongylothoracidae (genus: *Gongylothorax*) and rare spherical and spongy spumellarians. In the middle and upper parts of the succession studied from the "*Amoeboceras* layer" (in the middle part of Katarowa Góra section) to the uppermost Hypselum Zone (in the upper part of Katarowa Góra and lower part of Bobrowniki sections) a marked change in faunal assemblages is visible. In this part of the succession, beside the typical Tethyan species, the cosmopolitan spumellarians, especially the genera: *Triactoma*, *Archaeocenosphaera*, *Paronaella*, *Emiluvia*, *Higumastra* and *Crucella* commonly occur but there occur also at some levels cold-water representatives of family Parvicingulidae. These mixed warm- and cold-water assemblages show features of the Northern Tethyan faunas with influences of Boreal elements. This change in the character of the radiolarian assemblages was related to activity of sea currents, which have been stimulated by the climatic changes during the latest Oxfordian.

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Plates

PLATE 1

Uppermost Oxfordian (Hypselum Zone) radiolarians from the Katarowa Góra and Bobrowniki sections

Fig. 1. *Praeconocaryomma* sp. – Katarowa Góra, bed 6, sample K1

Fig. 2. *Triactoma* cf. *blakei* (Pessagno) – Katarowa Góra, bed 6, sample K1

Fig. 3. *Zhamoidellum* cf. *ovum* Dumitrica – Katarowa Góra, bed 11, sample K4

Fig. 4. Nassellaria gen. et. sp. indent. – Katarowa Góra, bed 6, sample K1

Fig. 5. *Gongylothorax* sp. – Katarowa Góra, bed 6, sample K1

Fig. 6. *Tripocylia* sp. – Katarowa Góra, bed 6, sample K1

Fig. 7. ?*Cyclastrum* sp. – Katarowa Góra, bed 6, sample K1

Fig. 8. *Paronaella* sp. – Katarowa Góra, bed 6, sample K1

Fig. 9. *Archaeocenosphaera* sp. – Katarowa Góra, bed 6, sample K1

Fig. 10. *Triactoma* cf. *blakei* (Pessagno) – Katarowa Góra, sample K4

Fig. 11. *Spongocapsula* cf. *perampla* (Rüst) – Katarowa Góra, bed 11, sample K4

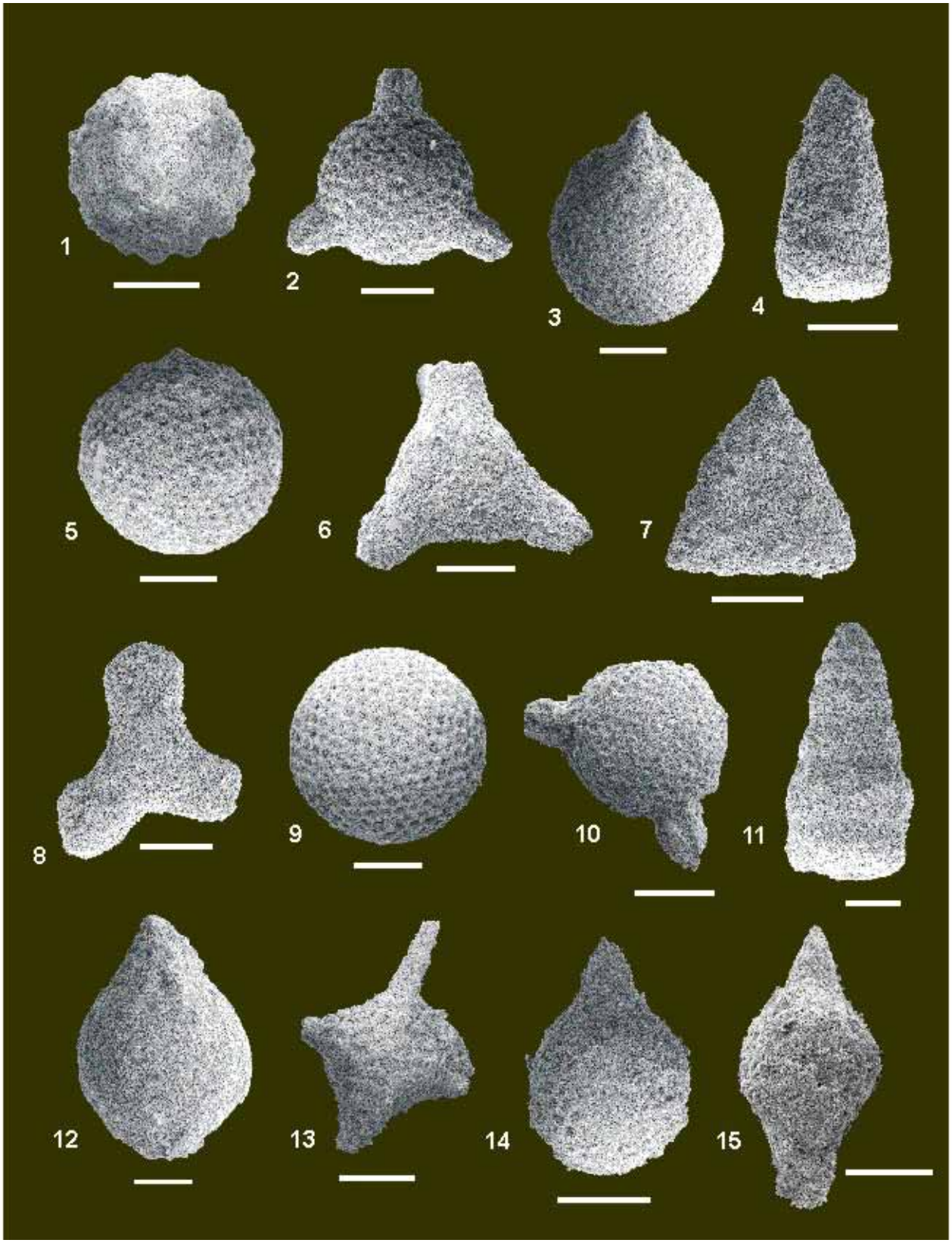
Fig. 12. Nassellaria gen. et. sp. indent. – Katarowa Góra, bed 11, sample K4

Fig. 13. *Emiluvia* cf. *ordinaria* Ozvoldova – Bobrowniki, bed C, sample B2

Fig. 14. *Sethocapsa* sp. – Bobrowniki, bed C, sample B2

Fig. 15. ?*Spinosicapsa* sp. – Katarowa Góra, bed 6, sample K1

Scale bar 100 μm.



Jolanta SMOLEŃ — Radiolarians of the uppermost Oxfordian (Hypselum Zone) of the Wieluń Upland (central Poland)

PLATE 2

Uppermost Oxfordian (Hypselum Zone) radiolarians from the Katarowa Góra and Bobrowniki sections.

Fig. 1. Parvicingulidae gen. et. sp. indent – Katarowa Góra, bed 11, sample K4

Fig. 2. *Homoeoparonaella* sp. – Katarowa Góra, bed 18, sample K6

Fig. 3. *Gongylothorax* cf. *favosus* Dumitrica – Bobrowniki, bed E, sample B1

Fig. 4. ?*Parvicingula* sp. 1 – Katarowa Góra, bed 11, sample K4

Fig. 5. *Podocapsa* cf. *amphitreptera* Foreman – Katarowa Góra, bed 11, sample K4

Fig. 6. *Triactoma* cf. *mexicana* Pessagno & Yang – Bobrowniki, bed E, sample B1

Fig. 7. ?*Higumastra* sp. – Bobrowniki, bed C, sample B2

Fig. 8. *Williriedellum* cf. *carpathicum* Dumitrica – Bobrowniki, bed E, sample B1

Fig. 9. *Mirifusus* sp.– Bobrowniki, bed E, sample B1

Fig. 10. *Crucella* sp. – Bobrowniki, bed C, sample B2

Fig. 11. ?*Cyclastrum* sp. – Katarowa Góra, bed 11, sample K4

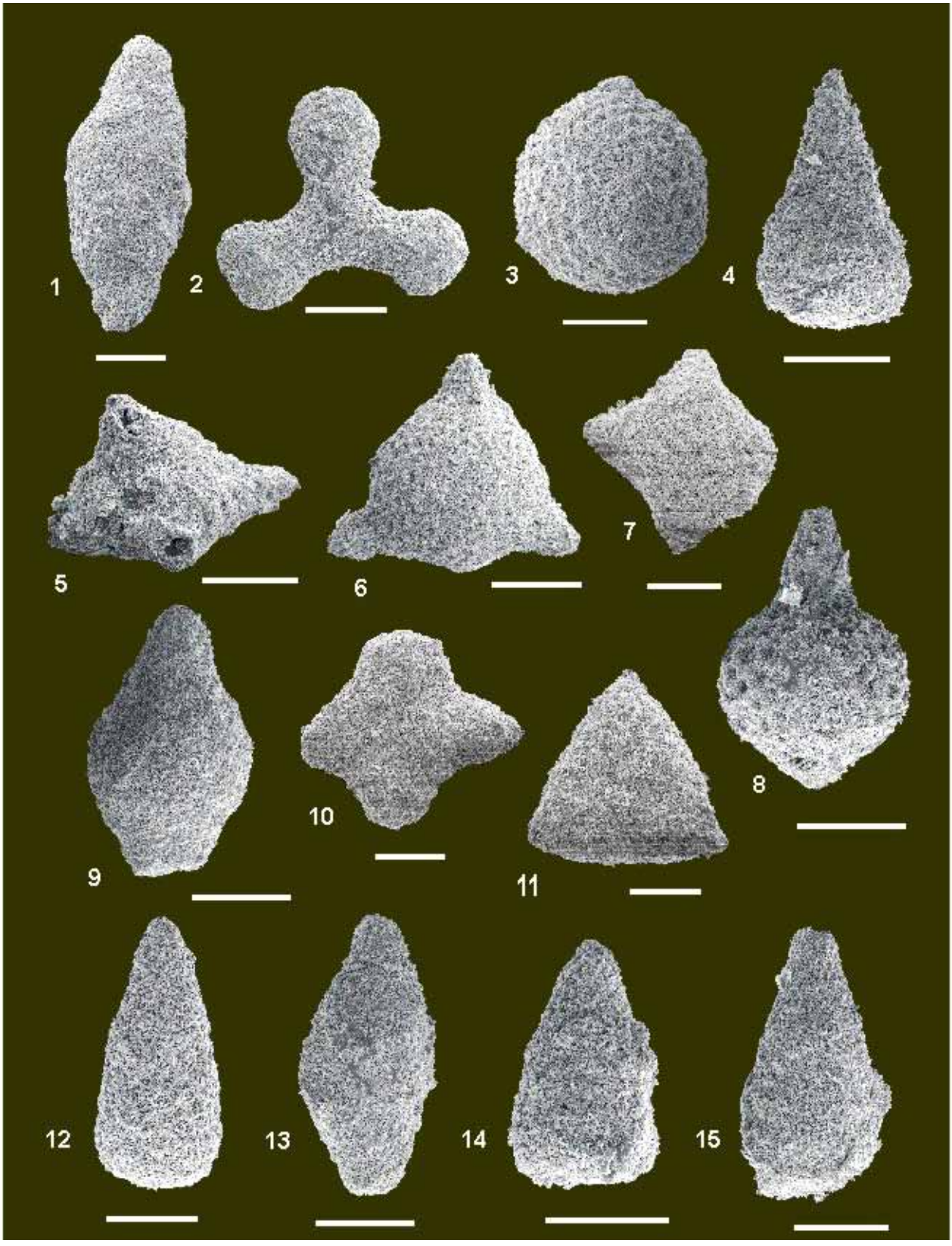
Fig. 12. Parvicingulidae gen. et. sp. indent – Katarowa Góra, bed 11, sample K4

Fig. 13. Nassellaria gen. et. sp. indent. – Katarowa Góra, bed 11, sample K4

Fig. 14. Nassellaria gen. et. sp. indent. – Bobrowniki, bed E, sample B1

Fig. 15. ?*Parvicingula* sp. 2 – Bobrowniki, bed E, sample B1

Scale bar 100 μm.



Jolanta SMOLEŃ — Radiolarians of the uppermost Oxfordian (Hypselum Zone) of the Wieluń Upland (central Poland)