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EARLY OXFORDIAN RADIOLARIA FROM ZALAS QUARRY, KRAKÓW UPLAND, SOUTH POLAND

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Abstract: This paper presents preliminary research on radiolarian faunas from the Upper Jurassic deposits of the Kraków Upland (South Poland) carried at Zalas quarry. The systematic description of twenty-five species of Radiolaria from the lower Oxfordian deposits has been presented herein. The species belong to the orders Nassellaria (16 species) and Spumellaria (9 species). In number of specimens, the assemblage is dominated by spumellarians. The radiolarians show features of Boreal faunas, influenced by Tethyan realm. The assemblage has been correlated with *cordatum* ammonitic subzone (early Oxfordian).

Abstrakt: W pracy przedstawiono wstępne wyniki badań promienic (Radiolaria) z utworów górnej jury, prowadzonych na Wyżynie Krakowskiej w kamieniołomie w Zalasie. Przedstawiono opis systematyczny 25 gatunków promienic z dolnego oksfordu. Spośród opisanych form 16 reprezentuje rząd Nassellaria, a 9 należy do rzędu Spumellaria. Pod względem liczby okazów, w zespole przeważają przedstawiciele rzędu Spumellaria. Promienice reprezentują faunę borealną, która żyła w środowisku o znacznym wpływie morza tetydzkiego. Analizowany zespół promienic został skorelowany z podpoziomem amonitowym *cordatum* (wczesny oksford).

Key words: early Oxfordian, Radiolaria, Kraków Upland, biostratigraphy, taxonomy, palaeoecology.

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INTRODUCTION

The Middle and Upper Jurassic deposits at Zalas quarry in the Kraków Upland have been a subject of detailed lithological, palaeontological and biostratigraphical studies for over a hundred years. These strata yield a lot of fossils which have been described by previous authors (e.g., Roemer, 1870; Siemiradzki, 1891, 1899; Wójcik, 1910; Różycki, 1953). Detailed stratigraphic and sedimentary environment analyses have been made by Garlicka (1976), Giżejewska & Wieczorek (1976), Garlicka & Tarkowski (1980), and Matyja & Tarkowski (1981). The previous authors noted the presence of common radiolarian fauna in thin sections from different lithotypes of mentioned above deposits (e.g., Garlicka, 1976; Garlicka & Tarkowski, 1980). Despite this, there was no palaeontological description and the application of the radiolarians for biostratigraphy.

The present paper is a first attempt of systematic description and palaeoecological interpretation of radiolarian fauna from the Kraków Upland.

GEOLOGICAL SETTING

During the Late Jurassic time, the area investigated was a part of northern Tethyan shelf, with diverse carbonate sedimentation. The investigations of ammonites fauna (Garlicka & Tarkowski, 1980) suggest that in the Oxfordian, this territory was situated in the zone of mixing influences of Submediterranean and Boreal provinces.

The section investigated is located at Zalas quarry, situated about six kilometres south from Krzeszowice town (southern Poland) (Fig. 1). The Middle and Upper Jurassic deposits overlay porphyry, which are explored there. Stratigraphically, lower part of this section is represented by stromatolite (Fig. 2). There follows calcareous-marly complex (Matyja & Tarkowski, 1981). The lowermost bed of these deposits consists of marly limestone yellow-coloured at the base, and red at the top, with infrequent siliceous sponges and ammonites indicating *bukowskii* and *costicardia* ammonitic subzones (early Oxfordian age – see Matyja & Tarkowski, 1981). It is overlain by grey marly limestones interbedded by green to grey marls with siliceous sponges,

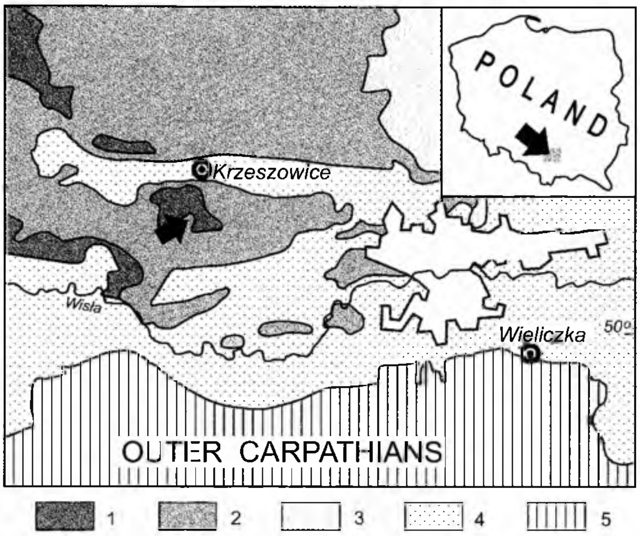

Fig. 1. Location of the area investigated in the vicinity of Kraków (geological map after Żytko *et al.* (1988), simplified); Fore-Carpathian platform elements: *1* – pre-Jurassic strata; *2* – Jurassic; *3* – Cretaceous; *4* – undivided Carpathian Foredeep deposits; *5* – undivided Carpathians units. Black arrows mark location of Zalas quarry

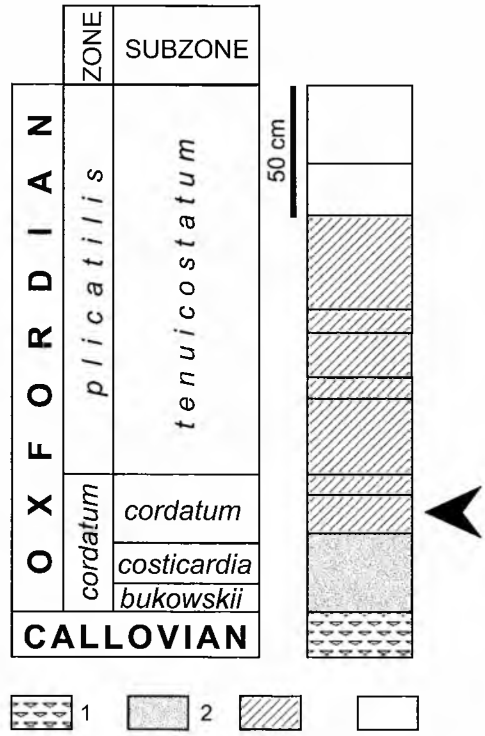

Fig. 2. Stratigraphic profile with ammonite zonal scheme (after Matyja & Tarkowski, 1981). Arrow marks position of radiolarian sample: *1* – stromatolite; *2* – marly limestone yellow and red; *3* – grey marly limestone with green and grey marls; *4* – grey marls and marly limestone

ammonites, belemnites and brachiopods, which are followed by grey marls and marly limestones. These strata belong to the *cordatum* and *tenuicostatum* ammonitic subzones (early to middle Oxfordian age – see Matyja & Tarkowski, 1981).

The radiolarian fauna has been found within the layer of green-grey marls, which belong to the *cordatum* ammonitic subzone (Matyja & Tarkowski, 1981; Fig. 2). The Radiolaria occur with common sponge's spicules (Criccorhabd and Rhax), and abundant foraminifers of species *Spirillina gracillis* Terquem. The spicules of sponges have been described previously from these deposits by Trammer (1982).

RADIOLARIAN ASSEMBLAGE

Radiolaria are common in the sample investigated, but they are generally poorly preserved. The radiolarian association comprises nine taxa belonging to order Spumellaria and sixteen taxa of Nassellaria. Spumellarians belong to four families and seven genera as: Cavaspongidae (genus *Cavaspongia*), Patulibracchidae (genera *Paronaella*, *Angulobracchia*), Xiphostylidae (genera *Xiphostylus*, *Triactoma*), and Orbiculiformidae (genera *Crucella*, *Orbiculiforma*). Nassellaria are represented by nine families and fourteen genera: Syringocapsidae (*Parapodocapsa*), Theoperidae (genera *Artocapsa*, *Cyrtocapsa* and *Dictyomitrella*), Spongocapsulidae (genus *Obesacapsula*), Sethocapsidae (genus *Stylocapsa*), Williriedellidae (genus *Zhamoidellum*), Archaeodictyomitridae (genera *Hsuum*, *Stichomitra*), Pseudodictyomitridae (genus *Parahsuum*), Xithidae (genus *Crolanium*), and Amphipyndacidae (genera *Dibolachras*, *Podocapsa* and *Syringocapsa*).

The following semi-quantitative features permit characterisation of the assemblage investigated (Fig. 3):

1. Dominance of spumellarians in number of specimens (62 per cent of all specimens found);
2. Abundance and high diversity of spongy spumellarians as *Crucella*, *Cavaspongia*, *Orbiculiforma*, *Paronaella*, and *Angulobracchia*;
3. Scarcity of Williriedellidae, Xitidae and Spongocapsulidae;

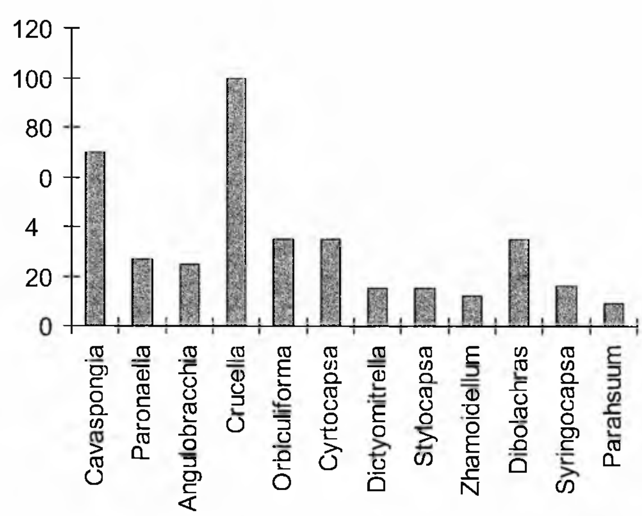

Fig. 3. Frequency (in number of specimens) of the radiolarian genera in the sample investigated

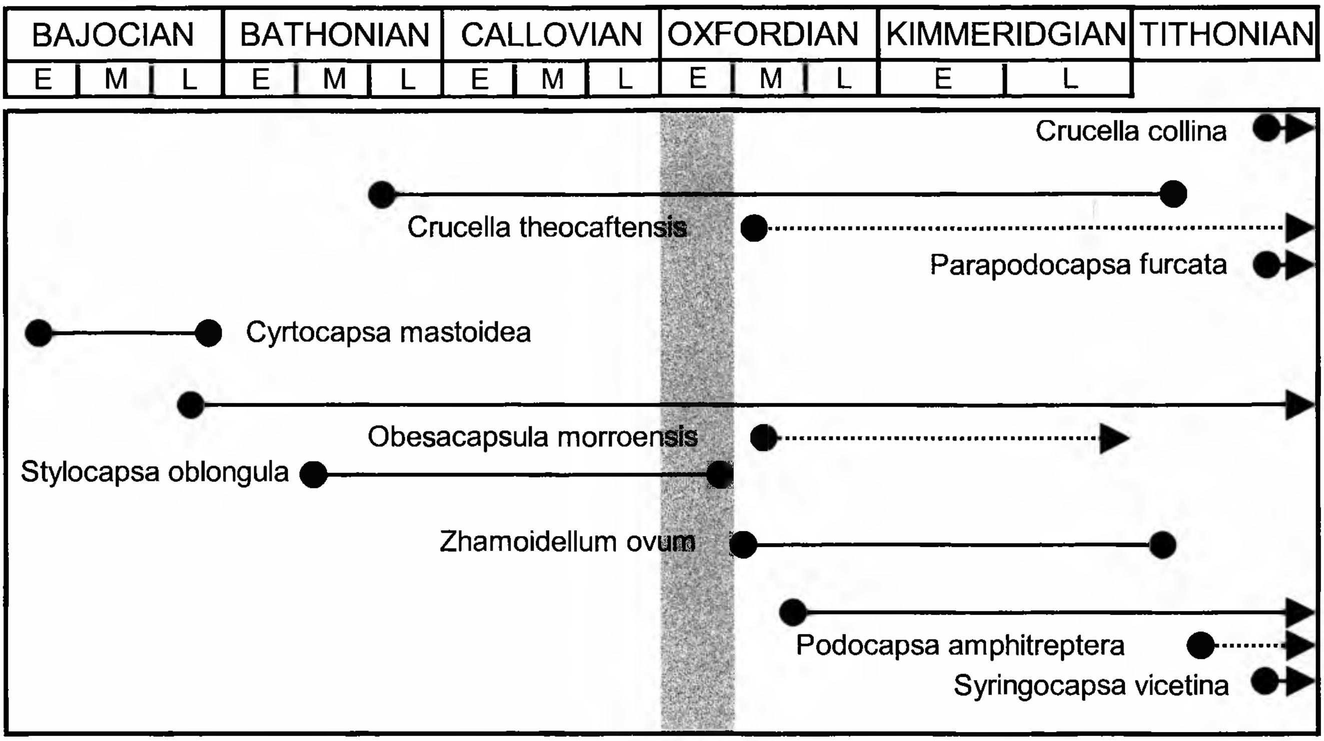

Fig. 4. Stratigraphic ranges of radiolarian species (mostly Tethyan – after Baumgartner *et. al.*, 1995) founded in the deposits investigated. Boreal species (after Hull, 1997) marked by dashed line. Grey rectangle indicates age of radiolarian assemblage based on ammonitic fauna

4. Absence of *Parvicingula, Praeparvicingula* and *Mirifusus*.

The radiolarian assemblage described herein is housed in the Laboratory of Palaeontology in the Institute of Geology (Warsaw University). The collection acronym is IGPUW-VII. The scanning electron micrographs have been prepared using SEM Philips XL-20.

AGE OF THE RADIOLARIAN ASSEMBLAGE

The early Oxfordian age of the assemblage has been based on the ammonitic biozonation, established for the deposits investigated by Matyja & Tarkowski (1981). Sample with radiolarians was taken from deposits, which belong to the *cordatum* ammonitic subzone (*op. cit.*). The applicability of the described radiolarians taxa for biostratigraphical purpose is difficult. One of the reasons is poor state of skeletons' preservation. Among all taxa described, only nine have been assigned to genus level (Fig. 4). These species belong mostly to Tethyan Realm (Baumgartner *et al.*, 1995), but some of them have been also noted from Boreal Province (e.g., *Parapodocapsa furcata*, *Obesacapsula morroensis* and *Podocapsa amphitreptera* – Hull, 1997). Despite this, all marker taxa used in published radiolarian zonal schemes (Baumgartner *et al.*, 1995; Hull, 1997; Vishnevskaya, 1993) are absent. Moreover, the present species have long lasting ranges or their ranges are not adequate to interval investigated (Fig. 4).

PALAEOECOLOGICAL AND PALAEOGEOGRAPHICAL REMARKS

The radiolarian fauna exhibit features, which are related to the particular palaeoceanographical setting of the area investigated during the early Oxfordian. One of them is abundance of spongy spumellarians, which dominate in number of specimens. This fact was interpreted by previous authors as indicating cold water influence (cf. Quaternary assemblage: Alperin, 1993) and a shallow-water depositional environment (cf. Late Cretaceous assemblage: Empson-Morin, 1984). Spongy spumellarians are also interpreted to be cosmopolitan in the recent oceans, but they are mostly abundant under unstable oceanic conditions (Blueford & King, 1983; Anderson *et al.*, 1989). Abundant spongy spumellarian assemblage were recorded in the Late Jurassic deposits from the Antarctic Peninsula (Kiessling, 1999). According to this author, low salinity and salinity fluctuations were the major reasons for the great abundance of this group.

Distribution of some Late Jurassic and Early Cretaceous radiolarian taxa were controlled also by palaeoceanographic factors, recorded by climatic belts (Pessagno & Blome, 1986; Baumgartner, 1992, 1993; Kiessling, 1999). One of the important markers were presence or absence of Pantanellidae and Parvicingulidae. (Pessagno & Blome, 1986; Baumgartner, 1992, 1993; Hull, 1995; Kiessling, 1999). In the Northern Hemisphere, four radiolarian provinces were distinguished based on these taxa content: Central Tethyan Province, Northern Tethyan Province (Tethyan Realm), Southern Boreal Province, and Northern Boreal Province (Boreal Realm).Total absence of pantanellids and "Ristola-type" parvicingulids as well as common occurrence of orbiculiformids were characteristic to higher palaeolatitudes (Northern Boreal Radiolarian Province) (Pessagno & Blome, 1986; Vishnevskaya, 1997; Kiessling, 1999).

The absence of pantanellids and "Ristola-type" parvicingulids in our assemblage confirm that, it represent the Boreal radiolarian fauna.

Tethyan taxa as Williriedellidae, Xithidae, Syringocapsidae and Spongocapsulidae are also present within the radiolarian assemblage investigated. This fact suggests Tethyan influences on the southern part of the European Platform (Kraków area) during the early Oxfordian.

However the assemblage does not include the Tethyan forms such as *Mirifusus* and *Ristola*, which were suggested to be rather deep-dwelling (Steiger, 1992), and are expected to be absent in shallow environments.

In summary, the radiolarian investigated shows features of Boreal faunas, influenced by Tethyan realm. Assemblage includes mixed cold and warm-water taxa, which prefered shallow-water depositional environment.

SYSTEMATIC PALAEONTOLOGY

Classification in this paper follows Baumgartner *et al.* (1995). It is supplemented with data given by Jud (1994) and Pessagno (1973).

Subclass RADIOLARIA Müller, 1858
Superorder POLYCYSTINA Ehrenberg, 1875, emend. Riedel, 1967
Order SPUMELLARIA Ehrenberg, 1875

Family CAVASPONGIDAE Pessagno, 1973

Genus *Cavaspongia* Pessagno, 1973
Type species *Cavaspongia antelopensis* Pessagno, 1973

Cavaspongia sp.
Fig. 5 A–F

Description: Test is triangular in outline, biconvex, with slightly rise central area. Test posseses three spines on angles. Meshwork is spongy.
Material: 70 specimens, which differ in stage of preservation.
Remarks: Specimens vary in outer shape. Triangular tests differ in width of angles. The angles change from oval to sharply pointed. Meshwork is usually indistinct.
Range: Early Oxfordian in the Kraków Upland.

Family PATULIBRACCHIDAE Pessagno, 1971a, emend. Baumgartner, 1980

Genus *Paronaella* Pessagno, 1971 emend. Baumgartner, 1980
Type species *Paronaella solanoensis* Pessagno 1971a

Paronaella aff. *corpulenta* De Wever, 1981
Fig. 5 G, H

1981. *Paronaella* aff. *corpulenta* De Wever: p. 33, pl. 2, figs 7-9.
1995. *Paronaella* sp. aff. *P. corpulenta* De Wever: Baumgartner *et al.*, p. 394, pl. 3310, figs 1-4.

Diagnosis: Test is triangular, massive, with three broad arms. Each arm terminated in short, robust spine. Meshwork of the test is spongy. Test lacking of bracchiopyle.
Material: 12 poorly preserved specimens, usually with broken primary spines, without secondary spines between arms or on the arms. Meshwork of the tests is indistinct.
Remarks: Specimens investigated herein are very similar to those one described and illustrated as *Paronaella* sp. aff. *P. corpulenta* De Wever, by Baumgartner *et al.* (1995, pl. 3310, fig. 3).
Range: Early Oxfordian in the Kraków Upland; early middle Aalenian to late Aalenian in the Tethyan region (Baumgartner *et al.*, 1995).

Paronaella sp. cf. *P. mulleri* Pessagno, 1977
Fig. 5 I–L; Fig. 6 A, B

1977. *Paronaella mulleri* Pessagno: p. 71, pl. 2, figs 2, 3.
1980. *Paronaella* sp. cf. *P. mulleri* Pessagno: Baumgartner, p. 304, pl. 9, fig. 8.
1984. *Paronaella mulleri* Pessagno: Baumgartner, p. 778, pl. 6, fig. 21.
1991. *Paronaella mulleri* Pessagno: Widz, p. 250, pl. 2, figs 26, 27.

Material: 15 poorly preserved specimens.
Remarks: Specimens investigated differ in degree of narrowing of rays. Meshwork of the tests indistinct. Tests lacking massive spines, terminating the rays.
Range: Early Oxfordian in the Kraków Upland.

Genus *Angulobracchia* Baumgartner, 1980
Type species *Paronaella* (?) *purisimaensis* Pessagno, 1977

Angulobracchia (?) *rugosa* Jud, 1994
Fig. 6 C, F

1980. Hagiastridae gen. et sp. indet.: Holzer, pl. 2, figs 15-16.
1994. *Angulobracchia* (?) *rugosa* Jud: p. 62, pl. 3, figs 8-9.
1995. *Angulobracchia* (?) *rugosa* Jud: Baumgartner *et al.*, p. 92, pl. 3911, figs 1-5.

Diagnosis: Test three-rayed, with rays equal in length and arranged at 120 degrees. Upper part of rays forming a fan terminating with small beams. Central area of the test inflated. Upper and lower surface of the test with prominent nodes connected by small bars forming triangular or irregular pore frames.
Material: 25 moderately preserved specimens.
Remarks: Specimens investigated usually with broken beams situated on ray tips. Meshwork of the tests is usually unrecognisable.
Range: Early Oxfordian in the Kraków Upland; youngest part of the late Tithonian to early Valanginian in the Tethyan region (Baumgartner *et al.*, 1995).

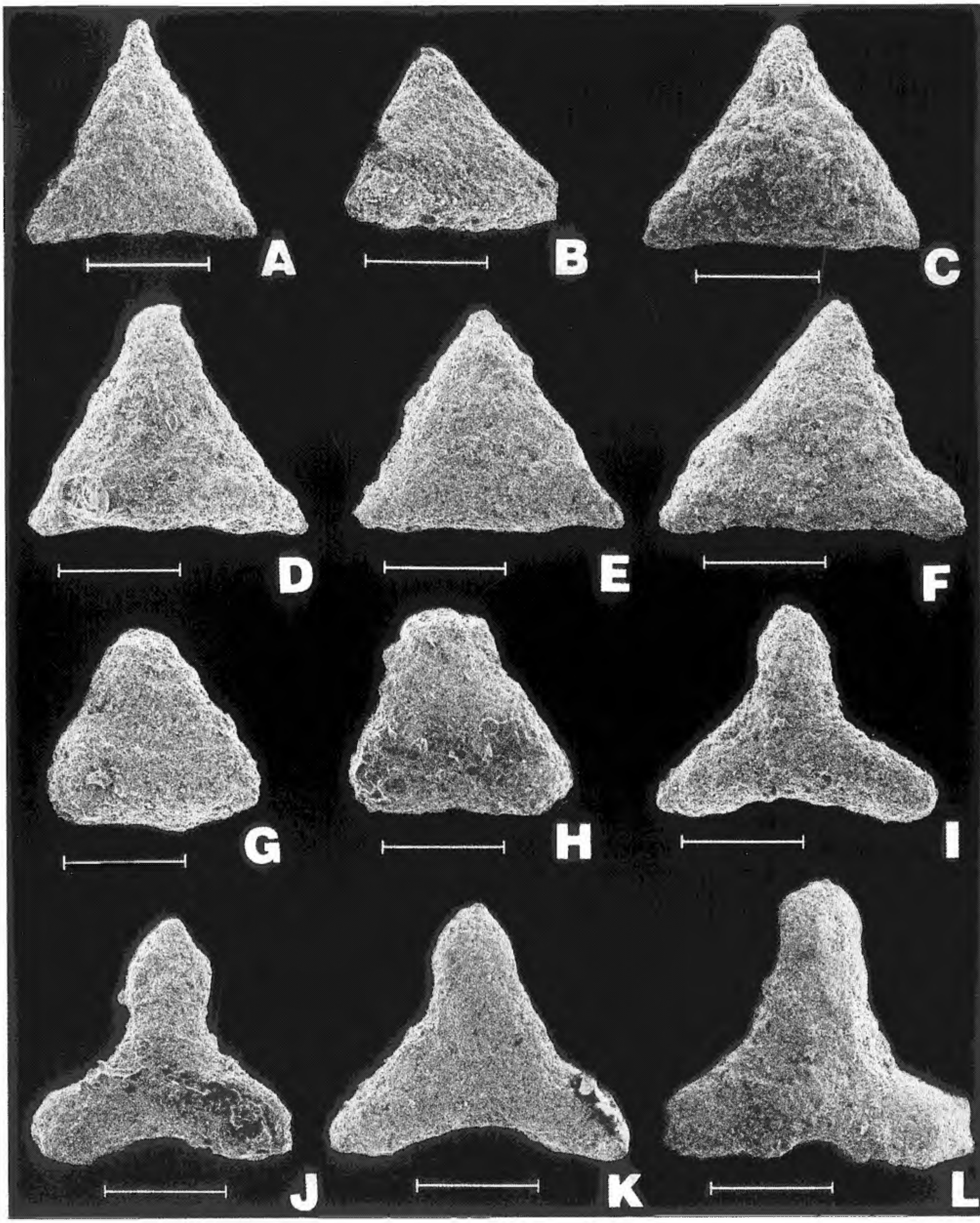

Fig. 5. SEM micrographs of Spumellaria. **A-F.** *Cavaspongia* sp.; **G, H.** *Paronaella* aff. *corpulenta* De Wever; **I-L.** *Paronaella* sp. cf. *P. mulleri* Pessagno. Length of scale bar – 100 μm

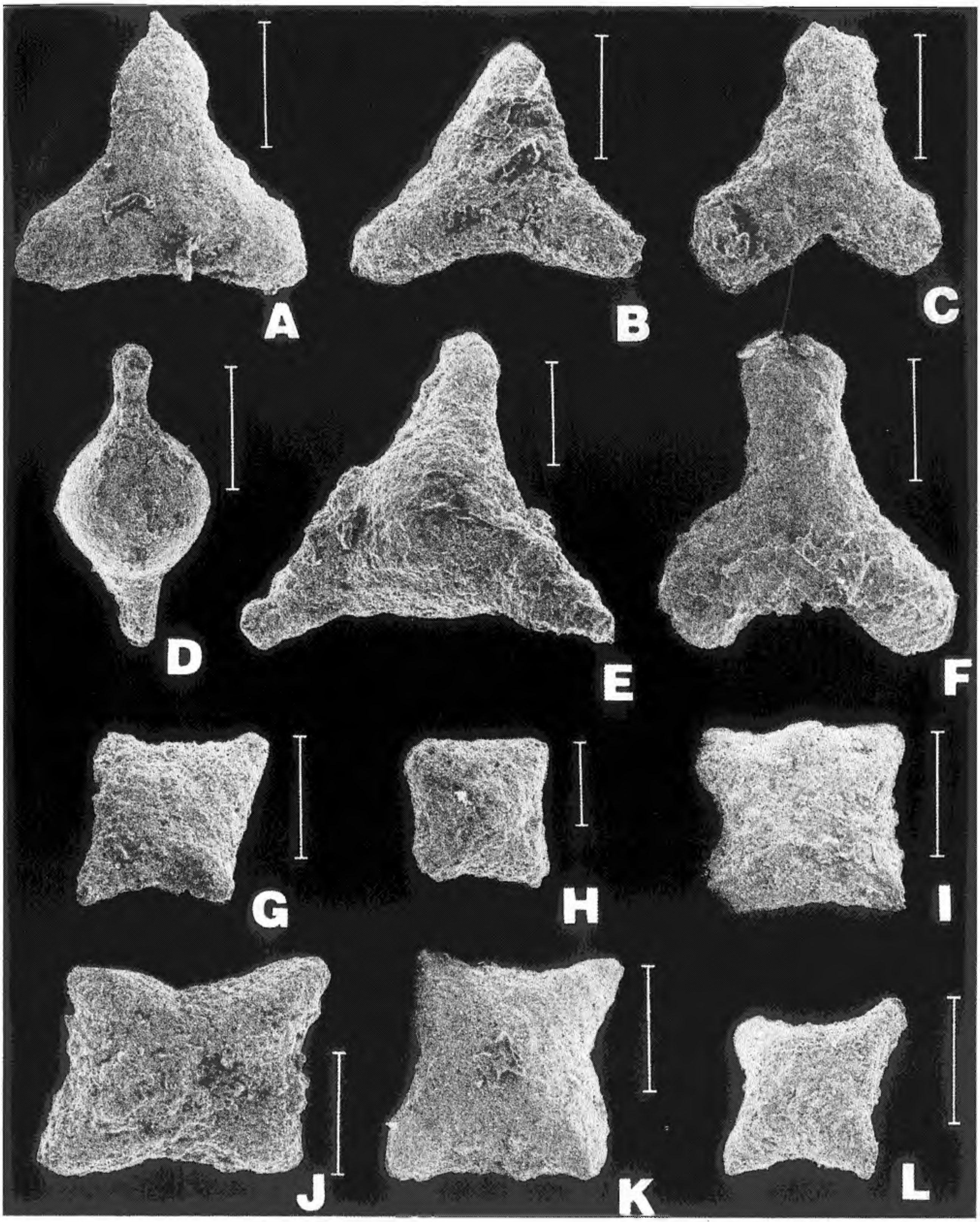

Fig. 6. SEM micrographs of Spumellaria. **A, B.** *Paronaella* sp. cf. *P. mulleri* Pessagno; **C, F.** *Angulobracchia* (?) *rugosa* Jud; **D.** *Xiphostylus* sp.; **E.** *Triactoma* sp.; **G-L.** *Crucella collina* Jud. Length of scale bar – 100 μm

Family XIPHOSTYLIDAE Haeckel, 1881,
emend. Pessagno & Yang in Pessagno *et al.*, 1989

Genus *Triactoma* Rüst, 1885
Type species *Triactoma tithonianum* Rüst, 1885
subsequent designation by Campbell, 1954

Triactoma sp.
Fig. 6 E

Diagnosis: Spherical test with three straight spines arranged in one plane.
Material: Two poorly preserved specimens. Meshwork indistinct.
Range: Early Oxfordian in the Kraków Upland.

Genus *Xiphostylus* Haeckel, 1881;
emend. Pessagno & Yang in Pessagno *et al.*, 1989
Type species *Xiphostylus attenuatus* Rüst, subsequent designation by Campbell, 1954

Xiphostylus sp.
Fig. 6 D

Description: Test with spherical cortical shell, with opposed secondary spines. Secondary spines are moderately massive, triradiate in axial section.
Material: One poorly preserved specimen.
Remarks: Meshwork of the cortical shell indistinct. Secondary spines broken.
Range: Early Oxfordian in the Kraków Upland.

Family ORBICULIFORMIDAE Pessagno, 1973,
emend. Dumitrica, 1995

Genus *Crucella* Pessagno, 1971
Type species *Crucella messinae* Pessagno, 1971

Crucella collina Jud, 1994
Fig. 6 G–L

1977. *Crucella* sp.: Muzavor, p. 62, pl. 3, fig. 5.
1982. *Crucella messinae* Pessagno: Taketani, p. 50, pl. 9, fig. 17.
1988. *Crucella espartoensis* Pessagno: Thurow, p. 399, pl. 2, figs 14-15.
1994. *Crucella collina* Jud: p. 70-71, pl. 6, figs 11-12; pl. 7, figs 1-2.
1995. *Crucella collina* Jud: Baumgartner *et al.*, p. 152, pl. 5194, figs 1-4.

Diagnosis: Test with four concave rays approximately at right angles. Rays decreasing in height from the central area towards the distal end. Test without central lacuna. Rays separated in the central part of the test by interradial depression. Pore frames in the surface regular. Interradial space filled with patangium.
Material: 15 specimens in different state of preservation.
Remarks: Pore frames of the test's surface usually indistinct.
Range: Early Oxfordian in the Kraków Upland; late Tithonian to early Barremian in the Tethyan region (Baumgartner *et al.*, 1995).

Crucella theokaftensis Baumgartner, 1980
Fig. 7 D–K

1980. *Crucella theokaftensis* Baumgartner: p. 308, pl. 8, figs 19-22; pl. 12, fig. 1.
1995. *Crucella theokaftensis* Baumgartner: Baumgartner *et al.*, p. 158, pl. 3131, figs 1-3.

Diagnosis: Test four-rayed. Rays slender and conical. Each one tapered into long, triradiate spine. Central area slightly inflated in both sides, with small, irregular pore frames.
Material: 85 moderately to poorly preserved specimens.
Remarks: Specimens differ in rays slender, and concaveness of interradial area. Spines on the ends of rays are usually broken, Meshwork indistinct.
Range: Early Oxfordian in the Kraków Upland; late Bathonian to early Tithonian in the Tethyan region (Baumgartner *et al.*, 1995).

Genus *Orbiculiforma* Pessagno, 1973
Type species *Orbiculiforma quadrata* Pessagno, 1973

Orbiculiforma sp.
Fig. 7 A–C

Material: 35 specimens on different stage of preservation.
Remarks: Specimens differ in outer shape of their tests which changing from circular to subcircular. Central cavity is more or less concave. Specimens lacking spines on the periphery of the test.
Range: Early Oxfordian in the Kraków Upland.

Order NASSELLARIA Ehrenberg, 1875
Family SYRINGOCAPSIDAE Foreman, 1973

Genus *Parapodocapsa* Steiger, 1992
Type species *Parapodocapsa furcata* Steiger, 1992

Parapodocapsa furcata Steiger, 1992
Fig. 8 A

1973. Hagiastrids gen. et sp. indet.: Foreman, pl. 5, figs 6-8.
1992. *Parapodocapsa furcata* Steiger: p. 62, pl. 17, figs 2-4.
1994. *Parapodocapsa furcata* Steiger: Jud, p. 90, pl. 15, fig. 13.
1995. *Parapodocapsa furcata* Steiger: Baumgartner *et al.*, p. 386, pl. 5396, figs 1-5.

Diagnosis: Test consists of cephalis, thorax, abdomen and three tube-like arms protruding out from the thorax. Cephalis and thorax are small, hemispherical in outer shape, porous. Abdomen spherical, with circular pores set in the hexagonal pore frames. The arms laying in a plane of abdomen which is perpendicular to axis of cephalis, thorax and abdomen. Arms are also covered by circular pores, set in the hexagonal pore frames. Arms slightly narrowing distally.
Material: Only one specimen has been found in the material investigated.
Remarks: Founded specimen is the most similar to form described by Foreman (1973) as Hagiastrids gen. et sp. indet. from the Lower Cretaceous deposits from the northern Pacific.
Range: Early Oxfordian in the Kraków Upland; the late Tithonian to the early Valanginian in the Tethyan region (Baumgartner *et al.*, 1995).

Family THEOPERIDAE Haeckel, 1881,
emend. Riedel, 1967, emend. Takemura, 1986

Genus *Artocapsa* Haeckel, 1881
Type species *Artocapsa fusiformis* Haeckel, 1887

Artocapsa (?) *amphorella* Jud, 1994
Fig. 8 B

1994. *Artocapsa* (?) *amphorella* Jud: p. 65, pl. 4, figs 9-10.

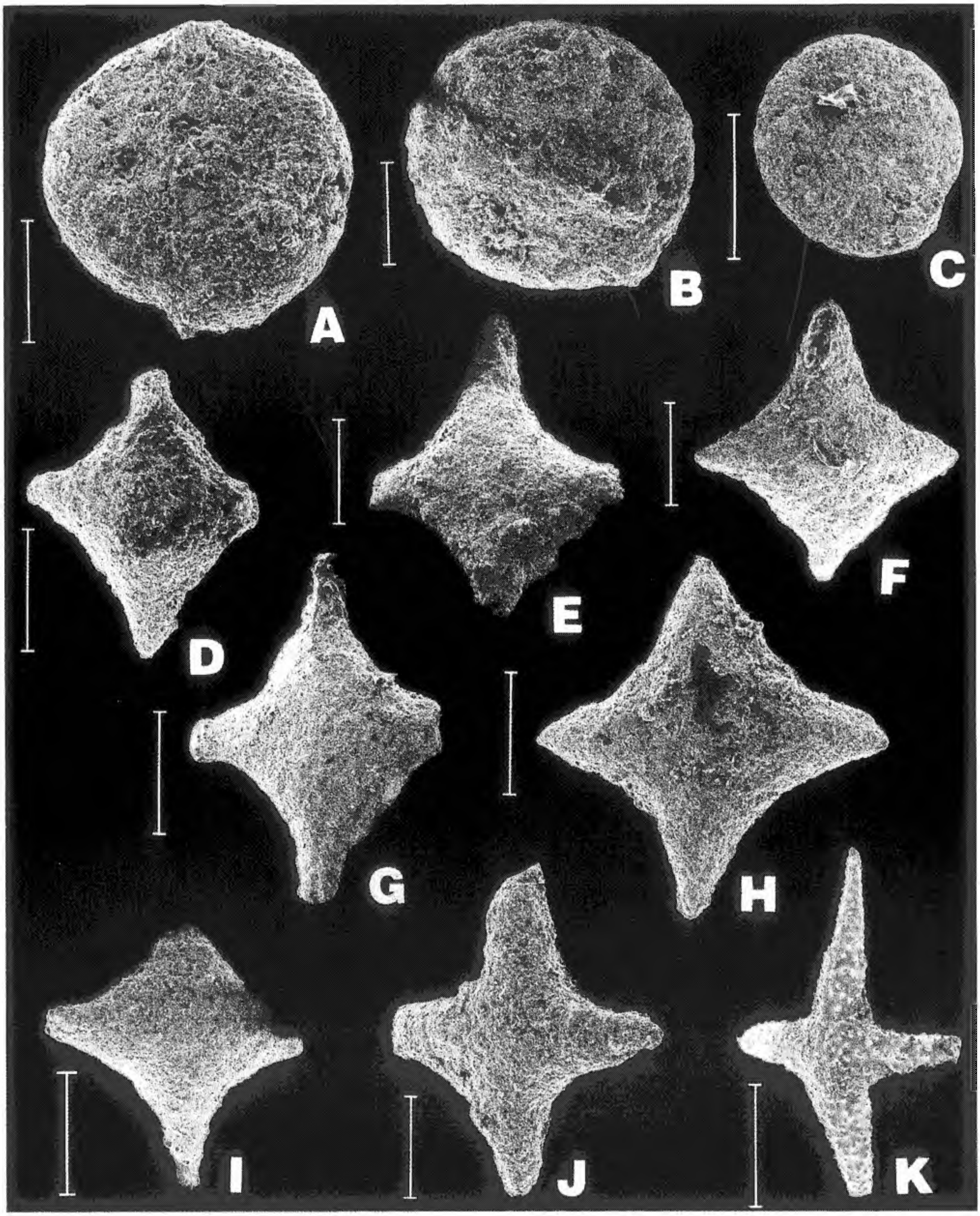

Fig. 7. SEM micrographs of Spumellaria. **A-C.** *Orbiculiforma* sp.; **D-K.** *Crucella theokaftensis* Baumgartner. Length of scale bar – 100 μm

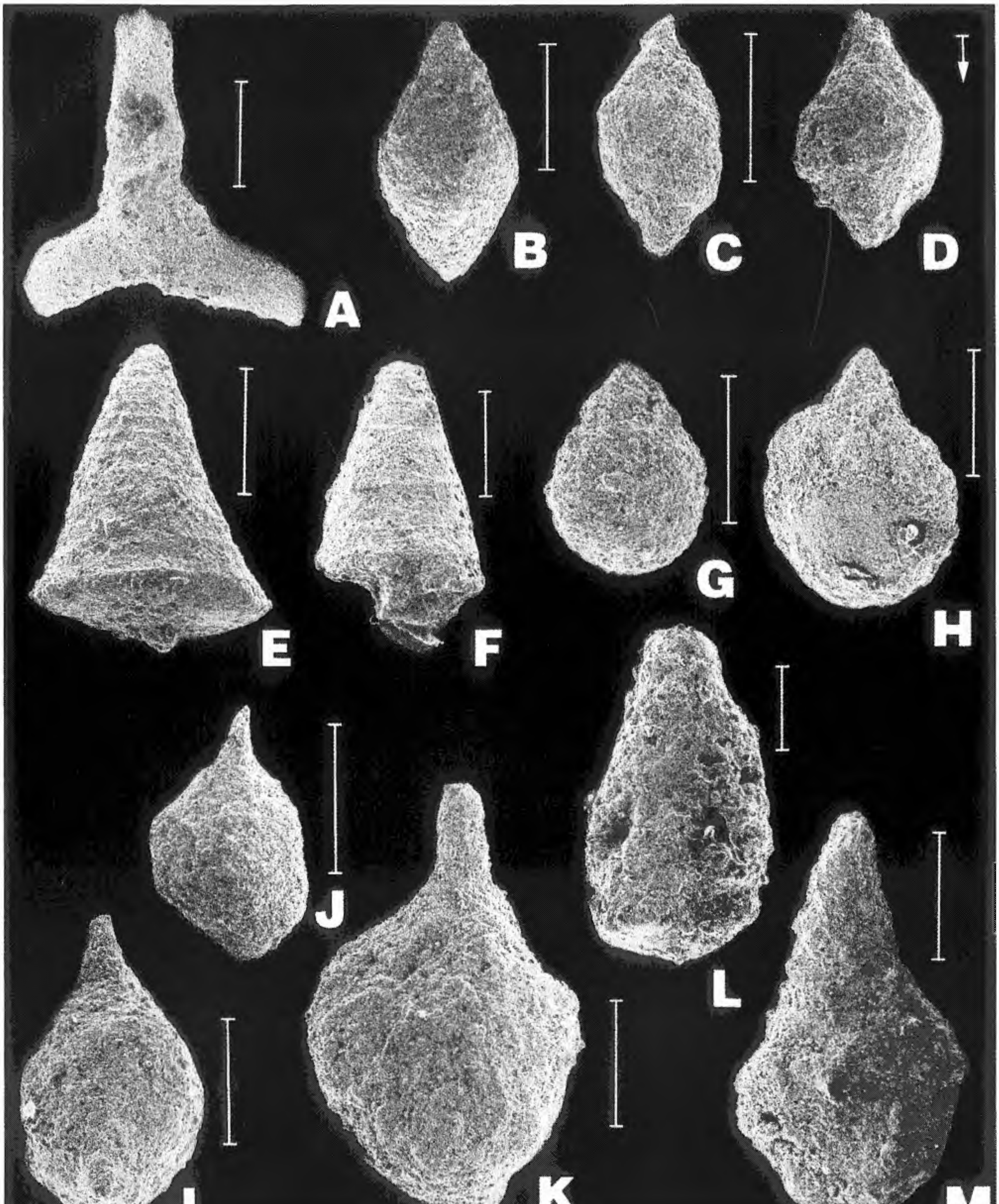

Fig. 8. SEM micrographs of Nassellaria. **A.** *Parapodocapsa furcata* Steiger; **B.** *Artocapsa* (?) *amphorella* Jud; **C, D.** *Cyrtocapsa mastoidea* Yao; **E, F.** *Dictyomitrella* (?) *kamoensis* Mizutani & Kido; **G.** *Zhamoidellum ovum* Dumitrica; **H.** *Obesacapsula morroensis* Pessagno; **I-K.** *Stylocapsa oblongula* Kocher; **L.** *Stichomitra* sp.; **M.** *Parahsuum* (?) *magnum* Takemura. Length of scale bar – 100 μm

1995. *Artocapsa* (?) *amphorella* Jud: Baumgartner *et al.*, p. 120, pl. 3924, figs 1-3.

Diagnosis: Test spindle-shaped, with unknown number of segments. Upper part of the test is conical. Starting from cephalis, the test increases rapidly in width. Lower part of the test decrease in width, become more oval, terminating into a small, conical, relatively short tube, which is always closed and prolonged into a short conical spine. Meshwork of the test is coarse and irregular.
Material: Two moderately preserved specimens.
Remarks: A number of segments in the specimens investigated are unknown (like in the holotype). Forms founded are most similar to *Artocapsa* (?) *amphorella* Jud illustrated by Baumgartner *et al.* (1995, pl. 3924, fig. 1). Spine terminating the tube are broken. Terminal tube very short.
Range: Early Oxfordian in the Kraków Upland; latest Tithonian to early late Berriasian in the Tethyan region (Baumgartner *et al.*, 1995).

Genus *Cyrtocapsa* Haeckel, 1881
Type species *Cyrtocapsa ovalis* Rüst, 1885

Cyrtocapsa mastoidea Yao, 1979
Fig. 8 C, D

1979. *Cyrtocapsa mastoidea* Yao: p. 36, pl. 8, figs 1-8.
1995. *Cyrtocapsa mastoidea* Yao: Baumgartner *et al.*, p. 168, pl. 3307, figs 1-3.

Diagnosis: Test consists of five segments. Cephalis is small and poreless. Thorax and abdomen are truncate-conical. Fourth segment is large and oval. Last segment is small and cylindrical. Segmental dividions are slightly emphase externally. Test with smooth surface, porous.
Remarks: According to description of holotype (Yao, 1979) cephalis posses short apical horn.
Material: 35 moderately to well-preserved specimens.
Range: Early Oxfordian in the Kraków Upland; early Bajocian to late Bajocian in the Tethyan region (Baumgartner *et al.*, 1995).

Genus *Dictyomitrella* Haeckel, 1881
Type species *Eucyrtidium articulatum* Ehrenberg, 1875, subsequent designation by Campbell (1954)

Dictyomitrella (?) *kamoensis* Mizutani & Kido, in: Kido *et al.*, 1982
Fig. 8 E, F

1981. "Dictyomitrella" sp. A: Mizutani *et al.*, p. 197, fig. 2a.
1982. *Dictyomitrella* (?) *kamoensis* Mizutani & Kido: Kido *et al.*, pl. 2, figs 9-11.
1995. *Dictyomitrella* (?) *kamoensis* Mizutani & Kido: Baumgartner *et al.*, p. 188, pl. 4014, figs 1-4.

Diagnosis: Test multi-segmented, conical to sub-cylindrical, with six to nine segments. Cephalis poreless without horn. Thorax and abdomen separated by one row of pores. Abdomen and post-abdominal chambers truncate-conical to cylindrical toward distal part of the test, with tetragonally-arranged two rows of circular pits. Abdomen and post-abdominal chambers separate each other by nodose circumferential ridge with two rings of single pores situated just below and just above the ridge.
Material: 15 poorly preserved specimens.
Remarks: Because of poor state of specimens preservation, perforation of the tests is not visible.
Range: Early Oxfordian in the Kraków Upland; early Bajocian to early Callovian in the Tethyan region (Baumgartner *et al.*, 1995).

Family SPONGOCAPSULIDAE Pessagno, 1976

Genus *Obesacapsula* Pessagno, 1977a
Type species *Obesacapsula morroensis* Pessagno, 1977a

Obesacapsula morroensis Pessagno, 1977a
Fig. 8 H

1977. *Obesacapsula morroensis* Pessagno: p. 87, pl. 11, figs 5-8.
1997. *Obesacapsula morroensis* Pessagno: Hull, p. 94, pl. 36, fig. 10.

Diagnosis: Test is multi-segmented. Cephalis, thorax, abdomen and following post-abdominal segments (2–3) forming a wide conical proximal portion of the test. Last segment large, globular, forming about three-quarter of the test. It may possess tubular cylindrical extension.
Material: Five poorly preserved specimens.
Remarks: Specimens investigated vary in outer shape of proximal portion of the test. All specimens lacking terminal tube.
Range: Early Oxfordian in the Kraków Upland; latest Bajocian to early Barremian in the Tethyan region (Baumgartner *et al.*, 1995).

Family SETHOCAPSIDAE Haeckel, 1881

Genus *Stylocapsa* Principi, 1909, emend. Tan, 1927
Type species *Stylocapsa exagonata* Principi, 1909

Stylocapsa oblongula Kocher, 1981
Fig. 8 I–K

1981. *Stylocapsa oblongula* Kocher: p. 97, pl. 16, figs 27-29.
1995. *Stylocapsa oblongula* Kocher: Baumgartner *et al.*, p. 532, pl. 3059, figs 1-5.

Diagnosis: Test two-segmented, ellipsoidal with slender apical horn. Cephalis is not marked in external outline, partly incased in horn. Thorax is spherical and inflated. Wall of thorax thin, with small rounded pores set in hexagonal pore frames.
Material: 15 poorly preserved specimens.
Remarks: Specimens investigated vary in length of apical horn and outer shape of thorax. Perforation of the thorax wall is not visible because of poor state of test's preservation.
Range: Early Oxfordian in the Kraków Upland; middle Bathonian to early Oxfordian in the Tethyan region (Baumgartner *et al.*, 1995).

Family WILLIRIEDELLIDAE Dumitrica, 1970

Genus *Zhamoidellum* Dumitrica, 1970
Type species *Zhamoidellum ventricosum* Dumitrica, 1970

Zhamoidellum ovum Dumitrica, 1970
Fig. 8 G

1970. *Zhamoidellum ovum* Dumitrica: p. 79, pl. 9, figs 52a-b, 53, 54.
1995. *Zhamoidellum ovum* Dumitrica: Baumgartner *et al.*, p. 656, pl. 4079, figs 1-6.

Diagnosis: Test generally oval in outer shape, consists of three segments. Cephalis poreless, partly encased in thick thoracic wall. Thorax porous, with lower part depressed into abdominal cavity. Abdomen large and oval possesses thick wall.
Material: Twelve poorly preserved specimens.
Range: Early Oxfordian in the Kraków Upland; mid- late Oxfordian to late Kimmeridgian in the Tethyan region (Baumgartner *et al.*, 1995).

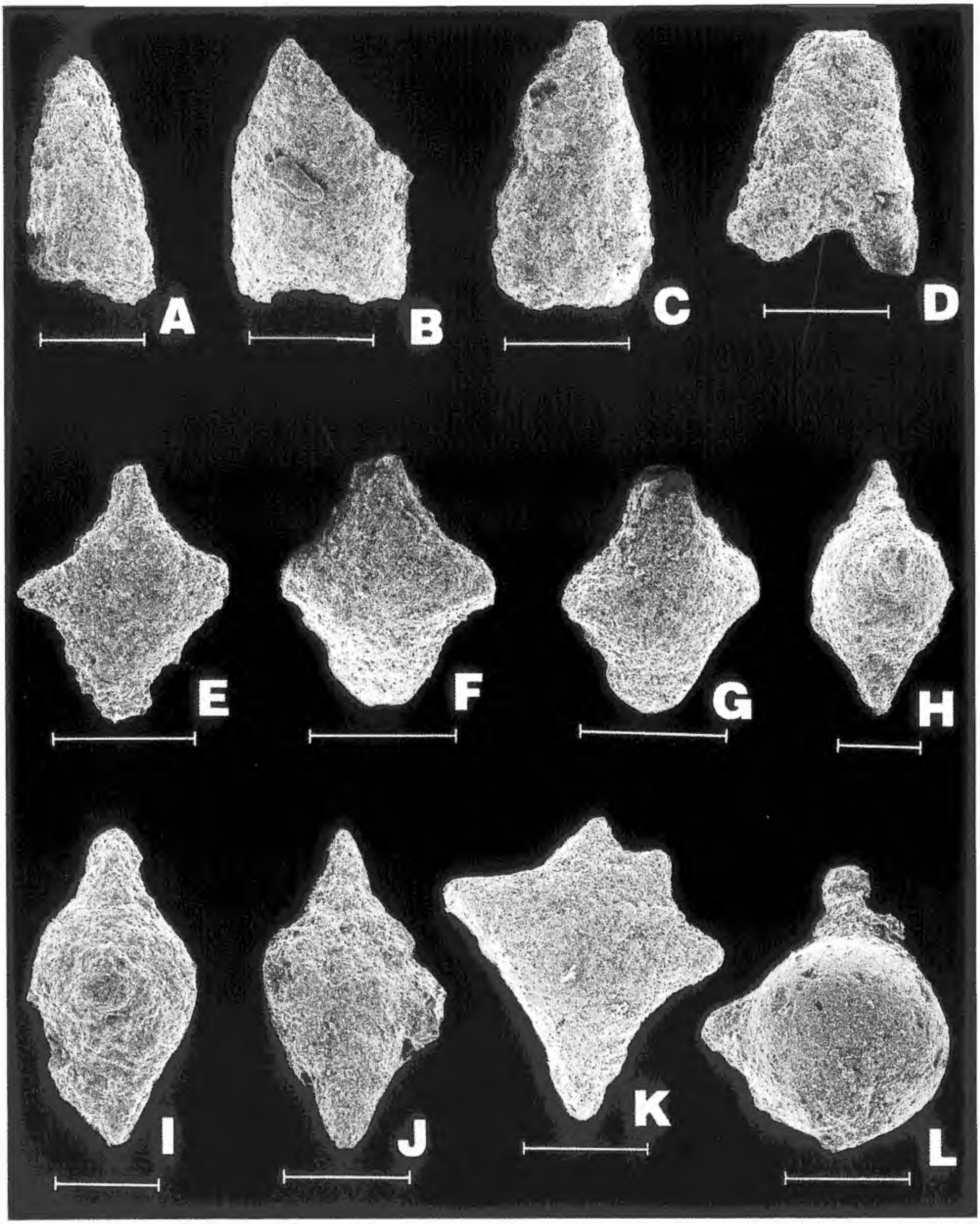

Fig. 9. SEM micrographs of Nassellaria. **A-C.** *Hsuum* sp.; **D.** *Crolanium* sp.; **E-J.** *Dibolachras* sp.; **K.** *Podocapsa amphitreptera* Foreman; **L.** *Podocapsa* sp. Length of scale bar – 100 μm

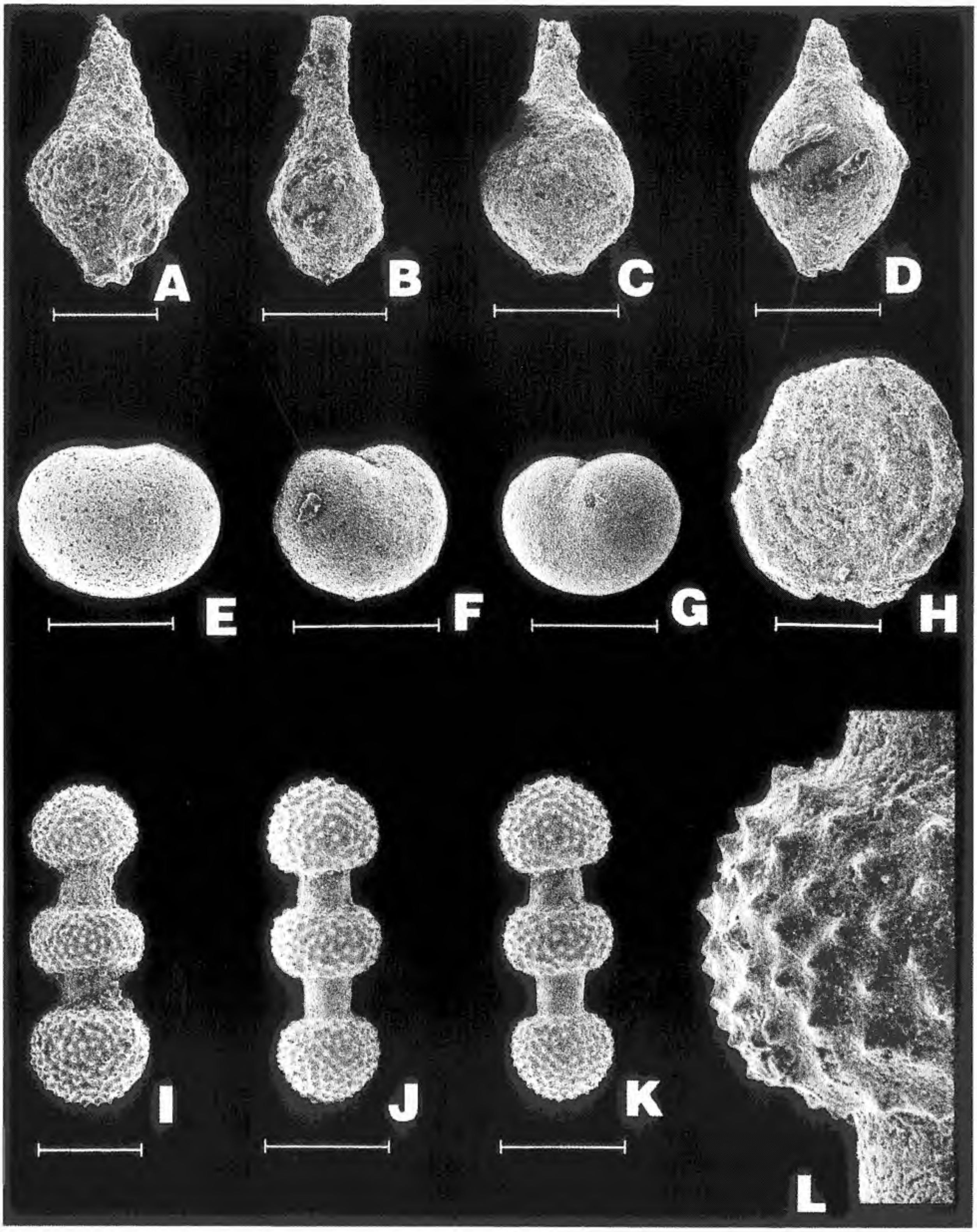

Fig. 10. SEM micrographs of Nassellaria, Foraminifera and sponge spicules. **A-C.** *Syringocapsa vicetina* (Squinabol); **D.** *Syringocapsa* sp.; **E-G.** Rhax; **H.** *Spirillina gracilis* Terquem; **I-L.** Criccorhabd. Length of scale bar – 100 μm

Family ARCHAEODICTYOMITRIDAE Pessagno, 1976

Genus *Hsuum* Pessagno, 1977a, emend. Takemura, 1986
Type species *Hsuum cuestaense* Pessagno, 1977a

Hsuum sp.
Fig. 9 A–C

Diagnosis: Test multicyrtoid, conical without strictures. cephalis and thorax together trapezoidal. Abdomen and post-abdominal chamber posses massive, continuous to discontinuous diverging costae.
Material: Twelve poorly preserved specimens.
Range: Early Oxfordian in the Kraków Upland.

Genus *Stichomitra* Cayeux, 1897
Type species *Stichomitra costata* Cayeux, 1897, subsequent designation by Chediya, 1959

Stichomitra sp.
Fig. 8 L

Diagnosis: Test multi-segmented, with upper part conical and cylindrical lower one. Strictures between adjacent segments are slightly visible.
Material: Three poorly preserved specimens.
Range: Early Oxfordian in the Kraków Upland.

Family XITIDAE Pessagno, 1977b

Genus *Crolanium* Pessagno, 1977b
Type species *Crolanium triquetrum* Pessagno, 1977b

Crolanium sp.
Fig. 9 D

Material: One poorly preserved specimen.
Remarks: Only distal part of the test is present. This part of the test possesses three tubular feet, which permit recognition of this genus.
Range: Early Oxfordian in the Kraków Upland.

Family PSEUDODICTYOMITRIDAE Pessagno, 1977

Genus *Parahsuum* Yao, 1982
Type species *Parahsuum simplum* Yao, 1982

Parahsuum (?) *magnum* Takemura, 1986
Fig. 8 M

1986. *Parahsuum* (?) *magnum* Takemura: p. 49, pl. 5, figs 12-15.
1995. *Parahsuum* (?) *magnum* Takemura: Baumgartner *et al.*, p. 380, pl. 3072, figs 1-4.

Material: Nine poorly preserved specimens.
Remarks: These specimens have been assigned to *Parahsuum* (?) *magnum* based on outer shape of the test, which is conical in the apical part and more cylindrical distaly. In distal part of the tests circumferential ridges are visible. Tests also possess rectangular or rounded-pointed and tetraradiate apical horn.
Range: Early Oxfordian in the Kraków Upland; late Aalenian to early Bathonian in the Tethyan region (Baumgartner *et al.*, 1995).

Family AMPHIPYNDACIDAE Riedel, 1967

Genus *Dibolachras* Foreman, 1973
Type species *Dibolachras tytthophora* Foreman, 1973

Dibolachras sp.
Fig. 9 E–J

Material: 35 poorly preserved specimens.
Remarks: Because all tests founded are poorly preserved, the features of this group are difficult to define. Generally, each test possesses three chambers, terminal tube and only two arms.
Range: Early Oxfordian in the Kraków Upland.

Genus *Podocapsa* Rüst, 1885, emend. Foreman, 1973
Type species *Podocapsa Guembelii* Rüst, 1885

Podocapsa amphitreptera Foreman, 1973
Fig. 9 K

1973. *Podocapsa amphitreptera* Foreman: p. 267, pl. 13, fig. 11.
1998. *Podocapsa amphitreptera* Foreman: Zügel, p. 25-26, fig. 7, pl. 4, figs 12-14.

Material: Only one specimen has been found in the material investigated.
Remarks: Although this specimen is poorly preserved with indistinct meshwork we assigned it to species *Podocapsa amphitreptera* because it possesses test of three segments with small cephalis and thorax, large, globose abdomen with terminal tube, and three conical wings extent outward the abdomen.
Range: Early Oxfordian in the Kraków Upland; mid-late Oxfordian to earliest Hauterrivian in the Tethyan region (Baumgartner *et al.*, 1995).

Podocapsa sp.
Fig. 9 L

Material: Only one specimen has been found in the material investigated.
Remarks: This form is very poorly preserved. The visible features are very big spherical abdomen and remnants of tubular wings.
Range: Early Oxfordian in the Kraków Upland.

Genus *Syringocapsa* Neviani, 1900
Type species *Theosyringium robustum* Vinassa, 1901

Syringocapsa vicetina (Squinabol), 1914
Figs. 10 A–C

1914. *Theosyringium vicetinum* Squinabol: p. 281, pl. 20, fig. 10.
1994. *Syringocapsa vicetina* (Squinabol): Jud, p. 112, pl. 22, figs 15-16.
1995. *Syringocapsa vicetina* (Squinabol): Baumgartner *et al.*, p. 552, pl. 5409, figs 1-5.

Material: Fifteen poorly preserved specimens.
Remarks: Specimens have been assigned to *Syringocapsa vicetina* based on the outer shape of the tests. Cephalis and thorax form together smooth, elongate cone. Abdomen inflated, with terminal tube. Pores of the meshwork circular to oval differ in dimensions.
Range: Early Oxfordian in the Kraków Upland; latest Tithonian to late Valanginian in the Tethyan region (Baumgartner *et al.*, 1995).

Syringocapsa sp.
Fig. 10 D

Material: Only one specimen has been found in the material investigated.
Remarks: Form differs from *Syringocapsa vicetina* by having upper part of the test (cephalis and thorax) short.
Range: Early Oxfordian in the Kraków Upland.

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REFERENCES

Alperin, M. I., 1993. Radiolarios de un testigo cuaternario del talud continental arentino, interpretación paleoclimática. *Revista de la Asociacion Geologica Argentina*, 48: 85–91.

Anderson, O. R., Bennett, P. & Bryan, M., 1989. Experimental and observational studies of radiolarian physiological ecology: 3. Effects of temperature, salinity and light intensity on the growth and survival of *Spongaster tetras tetras* maintained in laboratory culture. *Marine Micropaleontology*, 14: 275–282.

Baumgartner, P. O., 1980. Late Jurassic Hagiastridae and Patulibracchidae (Radiolaria) from the Angolis Peninsula (Peloponnesus, Greece). *Micropaleontology*, 26: 274–322.

Baumgartner, P. O., 1984. A Middle Jurassic–Early Cretaceous low latitude radiolarian zonation based on unitary association and age of Tethyan radiolarites. *Eclogae Geologicae Helvetiae*, 77: 729–841.

Baumgartner, P. O., 1992. Lower Cretaceous radiolarian biostratigraphy and biogeography off Northwestern Australia (ODP Sites 765 and 766 and DSDP Site 261), Argo Abyssal Plain and Lower Exmouth Plateau. In: Gradstein, F. M., Ludden, J. N., *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, 123, pp. 299–342.

Baumgartner, P. O., 1993. Early Cretaceous radiolarians of the Northeast Indian Ocean (Leg 123: Sites 765, 766 and DSDP Sire 261): The Antarctic-Tethys connection. *Marine Micropaleontology*, 21: 329–352.

Baumgartner, P. O., O'Dogherty, L., Gorican, S., Dumitrica-Jud, R., Dumitrica, P., Pillevuit, A., Urquhart, E., Matsuoka, A., Danelian, T., Bartolini, A., Carter, E. S., De Wever, P., Kito, N., Marcucci M. & Steiger, T., 1995. Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and species. In: Baumgartner, P. O., *et al.* (eds), Middle *Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology, Mémoires de Géologie (Lausanne)*, 23, pp. 37–685.

Blueford, J. R. & King, C., 1983. Distribution of Spongodiscid-type radiolarians in modern sediments. *American Association of Petroleum Geologists Bulletin*, 67: 425.

De Wever, P., 1981. Hagiastridae, Patulibracchiidae et Spongodiscidae (Radiolaires Polycystines) du Lias de Turquie. *Revue de Micropaléontologie*, 24: 27–50.

Dumitrica, P., 1970. Cryptocephalic and cryptothoracic Nassellaria in some Mesozoic deposits of Romania. *Revue roumaine de geologie, geophysique et geographie, Serie de Geologie*, 14: 1–124.

Empson-Morin, K. M., 1984. Depth and latitude distribution of Radiolaria in Campanian (Late Cretaceous) tropical and subtropical oceans. *Micropaleontology*, 30: 87–115.

Foreman, H. P., 1973. Radiolaria from DSDP Leg 20. In: Heezen, B. C., Mac Gregor, J. D. *et al.* (eds), *Initial Reports of the Deep Sea Drilling Project*, 20, pp. 249–305.

Garlicka, I., 1976. Stratigraphic position of the lower boundary of a horizon with *Colomisphaera fibrata* (Nagy) in the Jurassic sequence at Zalas (Kraków region). *Biuletyn Instytutu Geologicznego*, 295: 273–284.

Garlicka, I. & Tarkowski, R., 1980. Biostratigraphy and microfacies development of the Lower and Middle Oxfordian at Zalas near Kraków. *Bulletin de l'Académie Polonaise des Sciences, Série des sciences, Sciences de la Terre*, 28: 59–68.

Giżejewska, M. & Wieczorek, J., 1976. Remarks on the Callovian and Lower Oxfordian of the Zalas Area (Kraków Upland, Southern Poland). *Bulletin de l'Académie Polonaise des Sciences, Série des sciences, Sciences de la Terre*, 24: 167–175.

Holzer, H. L., 1980. Radiolaria aus Atzrückstanden des Malm und der Unterkreide der Nordlichen Kalkalpen (Osterreich). *Annalen des Naturhistorischen Museums in Wien*, 83: 153–167.

Hull, D. M., 1995. Morphologic diversity and paleogeographic significance of the family Parvicingulidae (Radiolaria). *Micropaleontology*, 41: 1–48.

Hull, D. M., 1997. Upper Jurassic Tethyan and Southern Boreal radiolarians from western North America. *Micropaleontology*, 43 (suplement 2): 1–202.

Jud, R., 1994. Biochronology and systematics of Early Cretaceous Radiolaria of the Western Tethys. *Mémoires de Géologie (Lausanne)*, 19: 1–147.

Kido, S., Kawaguchi, I., Adachi, M. & Mizutani, S., 1982. On the *Dictyomitrella* (?) *kamoensis – Pantanellium foveatum* assemblage in the Mino Area, Central Japan. (in Japanese). In: Nakaseko, K. (ed.), *Proceedings of the First Japanese Radiolarian Symposium, News of Osaka Micropaleontologists, Special Volume*, 5, pp. 195–210.

Kiessling, W., 1999. Late Jurassic Radiolarians from the Antarctic Peninsula. *Micropaleontology*, 45 (suplement 1): 1–96.

Kocher, R. N., 1981. Biochronostratigraphische Untersuchungen oberjurassischer radiolarien führender Gesteine, insbesondere der Südalpen. *Mitteilungen aus dem geologischen Institut der Eidgenossischen Technischen Hohschule und der Universität Zürich, Neue Folge*, 234: 1–184.

Matyja, B. A. & Tarkowski, R., 1981. Lower and Middle Oxfordian ammonite biostratigraphy at Zalas in the Kraków Upland. *Acta Geologica Polonica*, 31: 1–14.

Mizutani, S., Hattori, I., Adachi, M., Wakita, K., Okamura, Y., Kido, S., Kawaguchi, I. & Kojima, S., 1981. Jurassic formations in the Mino Area, Central Japan. *Proceedings of the Japan Academy, series B*, 57: 194–199.

Muzavor, S. N. X., 1977. *Die oberjurassische Radiolarienfauna von Oberaudorf am Inn.* Inaugural-Dissertation zur Erlangung des Doktorgrades des Fachbereiches Geowissenschaften der Ludwig-Maximilians-Universität zur München, 163 pp.

Pessagno, E. A., 1973. Upper Cretaceous Spumellariina from Great Valley Sequence, California Coast Ranges. *Bulletin of American Paleontologists*, 63: 49–102.

Pessagno, E. A., 1977. Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. *Micropaleontology*, 23: 56–113.

Pessagno, E. A. & Blome, C. D., 1986. Faunal affinities and tectonogenesis of Mesozoic rocks in the Blue Mountain Province of eastern Oregon and western Idaho. In: Vallier, T. L. & Brooks, H. C. (eds), *Geology of the Blue Mountain region of*

Oregon, Idaho and Washington: Biostratigraphy and Paleontology. U. S. Geological Survey Professional Papers, 1435, pp. 65–78.

Roemer, F., 1870. *Geologie von Oberschlesien*. Wrocław, 587 pp.

Różycki, S. Z., 1953. Upper Dogger and Lower Malm of the Kraków–Częstochowa Jurassic Belt. *Prace Instytutu Geologicznego*, 17: 1–412.

Siemiradzki, J., 1891. Fauna kopalna warstw oxfordzkich i kimerydzkich w okręgu krakowskim i przyległych częściach Królestwa Polskiego. (in Polish). *Pamiętniki Akademii Umiejętności, Wydział Matematyczno-Przyrodniczy*, 18: 1–92.

Siemiradzki, J., 1899. Monographische Beschreibung der Ammonitengattung Perisphinctes. *Palaeontographica*, 45: 297–352.

Squinabol, S., 1914. Contributo alla conoscenza dei Radiolarii fossili del Veneto, Appendice – Di un genere di Radiolari caratteristico del Secondario. *Memorie dell'Instituto Geologico della R. Università di Padova*, 2: 249–306.

Steiger, T., 1992. Systematik, stratigraphie und Palökologie der Radiolarien des Oberjura-Unterkreiden-Grenzbereiches im Osterhorn-Tirolikum (Nördliche kalkalpen, Salzburg und Bayern). *Zitteliana*, 19: 3–188.

Takemura, A., 1986. Classification of Jurassic Nassellarians (Radiolaria). *Palaeontographica, Abteilung A: Päozoologie-Stratigraphie*, 195: 29–74.

Taketani, Y. 1982. Cretaceous radiolarian biostratigraphy of the Urakawa and Obira areas, Hokkaido. *Science Reports of the Tohoku University, Sendai, Series 2, Geology*, 52: 1–75.

Thurow, J., 1988. Cretaceous Radiolarians of the North Atlantic Ocean: ODP Leg 103 (Sites 638, 640 and 641) and DSDP Legs 93 (Site 603) and 47B (Site 398). In: Boillot, G., Winterer, E. L. *et al.* (eds), *Proceedings of the Ocean Drilling Program, Scientific Results*, 103, pp. 379–418.

Trammer, J., 1982. Lower and Middle Oxfordian sponges of the Polish Jura. *Acta Geologica Polonica*, 32: 1–39.

Vishnevskaya, V., 1993. Jurassic and Cretaceous radiolarian biostratigraphy in Russia. In: Bluefort, J. & Murchey, B. (eds), *Radiolaria of giant and subgiant fields in Asia. Micropaleontology Special Publication*, 6, pp. 175–200.

Vishnevskaya, V., 1997. New Mesozoic Boreal radiolarian finding from Russia. *Abstract Book of Eight meeting of the International Association of Radiolarian Paleontologists (Interrad VIII), Paris*: p. 130.

Widz, D., 1991. Les Radiolaires du Jurassique supérieur des radiolarites de la zone des Klippes de Pieniny (Carpathes occidentales, Pologne). *Revue de Micropaléontologie*, 34: 231–260.

Wójcik, K., 1910. Bat, kelowej i oksford okręgu krakowskiego. *Rozprawy Polskiej Akademii Umiejętności*, 50: 181–242.

Yao, A., 1979. Radiolarian fauna from the Mino Belt in the northern part of the Inuyama Area, Central Japan, Part II: Nassellaria I. *Journal of Geosciences, Osaka City University*, 22: 21–72.

Zügel, P., 1998. Radiolaria from the Nusplingen Lithographic Limestone (Late Kimmeridgian, SW Germany). *Stuttgart Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie)*, 268: 1–43.

Żytko, K., Zając, R., Gucik, S., Ryłko, W., Oszczypko, N., Garlicka, I., Nemčok, J., Eliáš, M., Menčik, E. & Stránik, Z., 1988. Map of the tectonic elements of the Western Outer Carpathians and their Foreland. In: Poprawa, D. & Nemčok, J. (eds), *Geological Atlas of the Western Outer Carpathians and their Foreland*. Państwowy Instytut Geologiczny, Warszawa.

Streszczenie

WCZESNOOKSFORDZKIE PROMIENICE Z KAMIENIOŁOMU W ZALASIE, WYŻYNA KRAKOWSKA, POLSKA POŁUDNIOWA

Hanna Górka & Marta Bąk

W artykule przedstawiono analizę mikropaleontologiczną promienic (Radiolaria) występujących w utworach dolnego oksfordu na Wyżynie Krakowskiej w kamieniołomie w Zalasie (Fig. 1).

Próba do badań została pobrana z warstwy zielonoszarych margli zaliczanych do podpoziomu amonitowego *cordatum* (Matyja & Tarkowski, 1981) (Fig. 2). Promienice współwystępują w próbie ze sklerami gąbek typu Criccorhabd i Rhax oraz licznymi okazami bentonicznej otwornicy z gatunku *Spirillina gracillis* Terquem.

Promienice w badanych utworach są na ogół słabo zachowane. Oznaczono 25 taksonów promienic, w tym 16 należących do rzędu Nassellaria oraz 9 należących do rzędu Spumellaria (Fig. 3–10). Pod względem liczebności okazów w zespole dominują spumellarie z rodzajów *Cavaspongia*, *Paronaella*, *Orbiculiforma*, *Angulobracchia* i *Crucella*. Licznie występują także nassellarie z rodzajów *Cyrtocapsa* i *Dibolachras*.

Wiek badanego zespołu określono na wczesny oksford na podstawie korelacji z podpoziomem amonitowym *cordatum* (wczesny oksford).

Badany zespół promienic posiada cechy przydatne do analizy paleoekologicznej. Są to: 1. przewaga ilościowa w zespole form o szkielecie gąbczastym; 2. niewielki udział przedstawicieli rodzin Williriedellidae, Xitidae oraz Spongocapsulidae; 3. całkowity brak przedstawicieli rodzajów *Parvicingula*, *Praeparvicingula* i *Mirifusus*.

Promienice o szkielecie gąbczastym są szczególnie częste w wodach chłodnych i płytkich oraz w zbiornikach o zmiennym zasoleniu (Alperin, 1993; Empson-Morin, 1984; Blueford & King, 1983; Anderson *et al.*, 1989). Formy te występują także licznie w jurze w strefie borealnej (Vishnevskaya, 1997). Duża liczebność tej grupy promienic w badanym zespole (ponad 62% wszystkich szkieletów) świadczy o borealnym charakterze fauny promienic. Ponadto w zespole nie występują przedstawiciele rodzin Pantanellidae i Parvicingulidae co dodatkowo potwierdza borealny typ fauny.

W badanym zespole występują także taksony charakterystyczne dla rejonu Tetydy. Są to przede wszystkim przedstawiciele rodzin Williriedellidae, Xithidae, Syringocapsidae i Spongocapsulidae. Oznacza to iż badany obszar pozostawał w strefie wpływu zarówno morza borealnego jak i Tetydy.

W zespole brak również takich rodzajów charakterystycznych dla obszaru Tetydy jak *Mirifusus* i *Ristola*. Ich nieobecność dodatkowo potwierdza przewagę borealnego typu fauny radiolariowej. Formy te preferowały głębsze środowiska życia, zatem ich brak dodatkowo świadczy o płytkim środowisku.