

Campanian (Late Cretaceous) hexactinellid sponges from the white chalk of Mielnik (Eastern Poland)

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ABSTRACT:

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The taxonomic description of the Campanian (Upper Cretaceous) hexactinellid sponges from the white chalk of Mielnik, eastern Poland, is presented. The fauna comprises 19 species belonging to 15 genera, representing by the Hexactinosida and Lychniscosida. The species *Polyopesia macropora* is described as new. They represent a typical sponge assemblage of the North European Province. Most of the specimens are strongly phosphatized (85% of the material), less common are grey-beige, slightly phosphatized specimens (11%), and distinctly rarer are specimens infilled with white chalk (3%) and silicified specimens (1%). Phosphatization was the dominant fossilization process of the hexactinellid sponges in the white chalk of Mielnik.

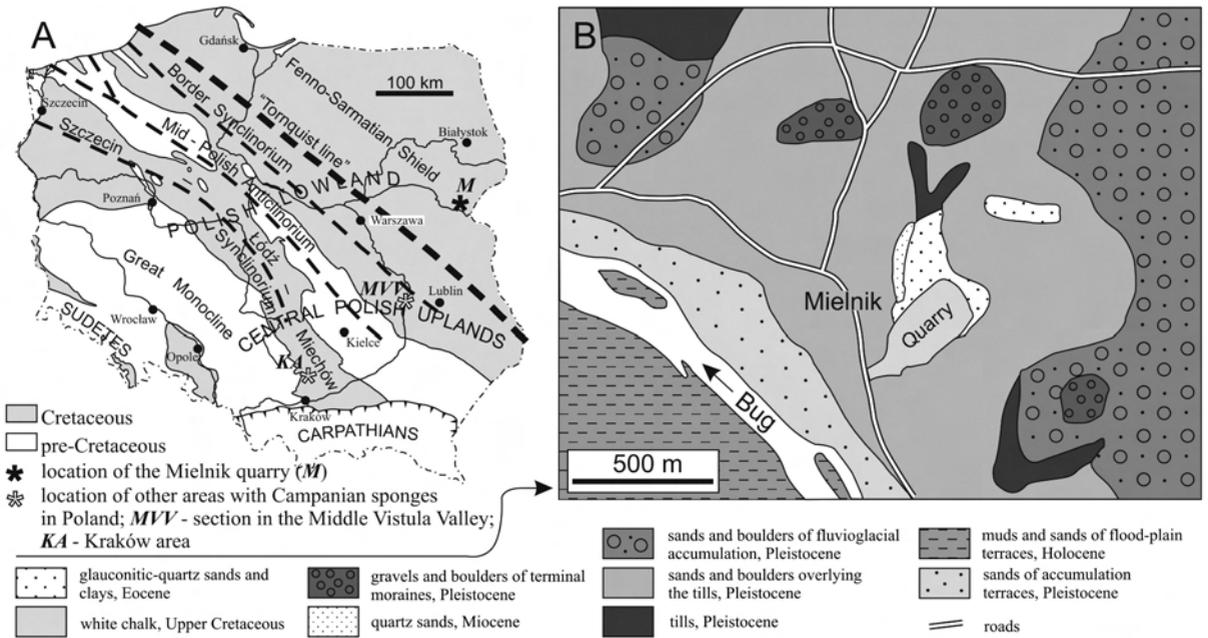
Key words: Hexactinellid sponges; Taxonomy; Phosphatization; Mielnik; Eastern Poland.

INTRODUCTION

The Upper Cretaceous chalk of Mielnik, eastern Poland (Text-fig. 1), is a richly fossiliferous succession. The best represented groups are foraminifera (Bieda 1958; Peryt 1981), brachiopods (Bitner and Pisera 1979), nannoplankton (Gaździcka 1981), endo- and epibionts on belemnite guards (Pugaczewska 1965; Radwański 1972), scalpellid cirripedes (Collins and Radwański 1982), and belemnites (Olszewska 1990a). The latter date the chalk as late Early-early Late Campanian and latest Campanian [=early Early Maastrichtian (Olszewska

1990a) according to the traditional boreal subdivision] (see comments on the Campanian/Maastrichtian boundary in e.g., Walaszczyk 2004; Machalski 2005).

The siliceous sponges are very rich in the Campanian and Maastrichtian (see Świerczewska-Gładysz 2006 and references therein), however, they have only rarely been described from the white chalk facies (Nestler 1961), in which they are usually associated with hardground zones (Reid 1962a). Similarly, the sponges from the Mielnik section have never been studied. This paper presents the hexactinellid sponges from the entire Mielnik section.

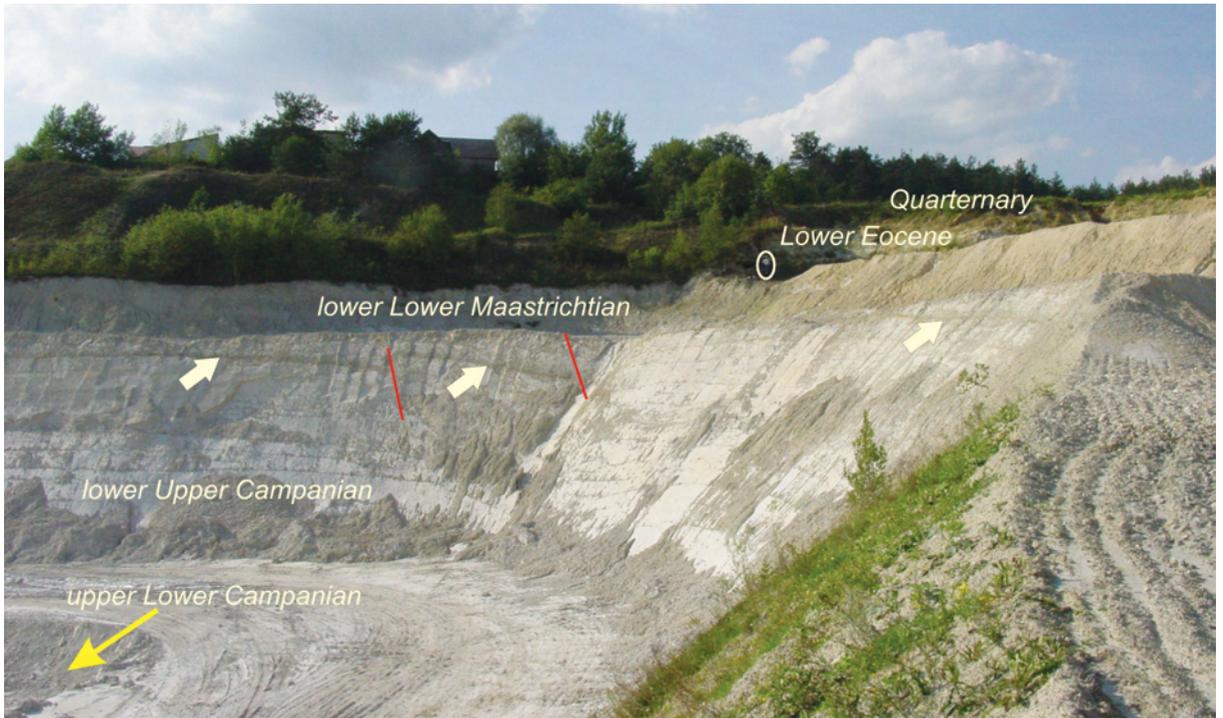


Text-fig. 1. Location of Mielnik. A – Tectonic sketch-map of Poland without the Cenozoic cover (explanations do not refer to Carpathian deposits); thick dashed line indicates the generalized outline of stable margins of the Fenno-Sarmatian (F-S) Shield (after Marcinowski and Radwański 1983, simplified); B – Geologic sketch-map of the study area with location of the Mielnik quarry in eastern Poland (after Zwierz 1954 and Staśkiewicz 1971, slightly modified)

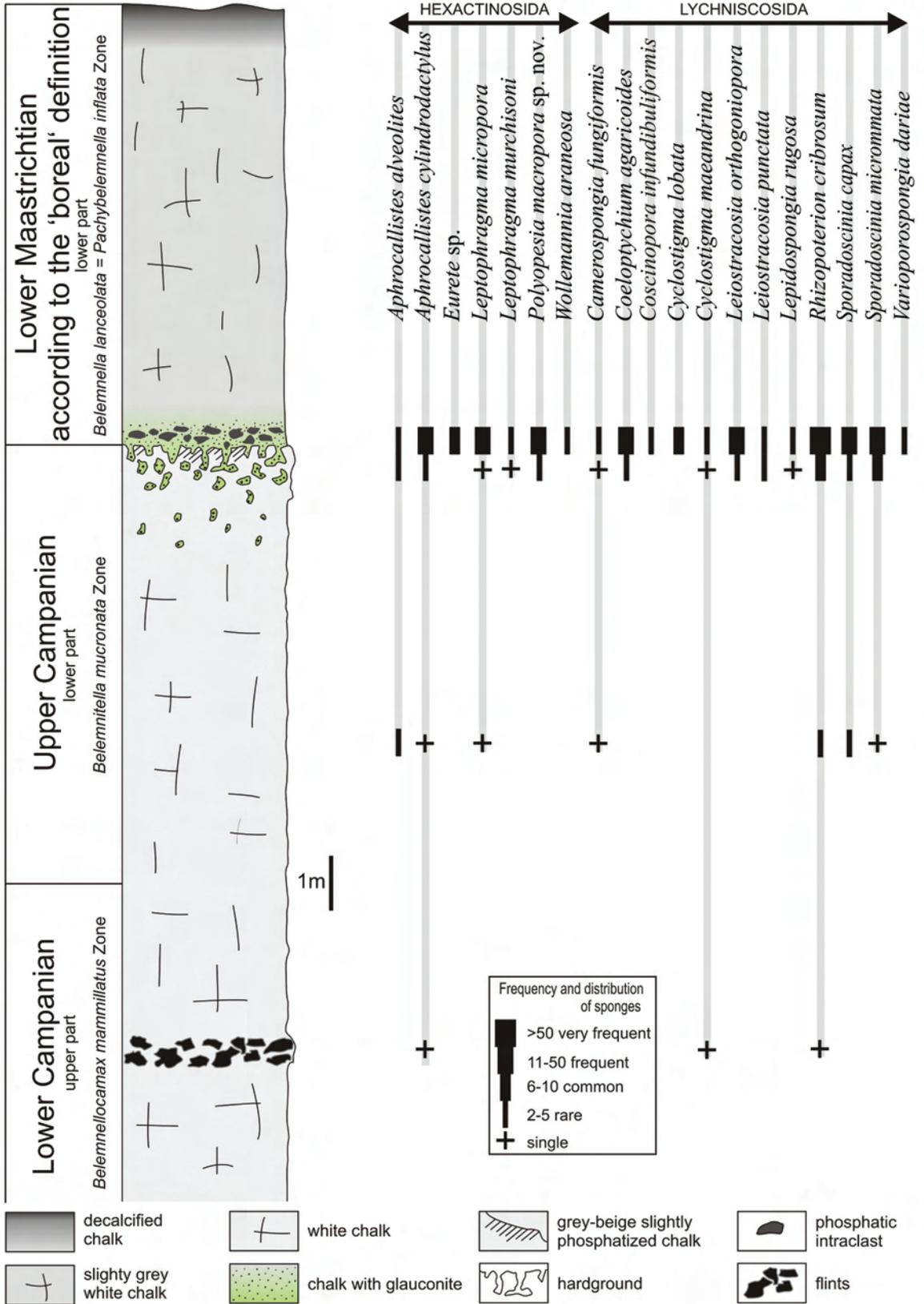
GEOLOGICAL SETTING

The Mielnik section (eastern Poland) is a working quarry where a c. 20 m thick succession of Campanian white chalk is exposed (Text-fig. 2). The homogeneous chalky succession is interrupted by two distinctive horizons: flints in its lower part and a hardground in its upper part (Text-fig. 3). The lower c. 6 m of the

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Text-fig. 2. Panoramic view of the NW and NE walls of the Mielnik quarry; arrows indicate the hardground (boundary between the lower part of Upper Campanian and lower Lower Maastrichtian), numerous black phosphorites occur above the hardground



Text-fig. 3. Geological section (stratigraphy after Olszewska 1990a) of the Campanian and Lower Maastrichtian deposits at Mielnik with distribution of sponge taxa

succession represents the late Early Campanian *Belemnellocomax mammillatus* Zone. The succeeding 7 m of chalk, capped by the hardground, represent the early Late Campanian *Belemnitella mucronata* Zone. The overlying, up to 8 m thick, greyish-white chalk is assigned to the latest Campanian [= early Early Maastrichtian *Belemnella lanceolata* Zone = *Belemnella (Pachybelemnella) inflata* Zone (Olszewska 1990a)]. The basal part of the *B. lanceolata* Zone, glauconitic chalk, directly above the hardground, contains numerous scattered black phosphatic intraclasts (Text-fig. 4). The intraclasts represent mostly phosphatized chalk fragments, with less numerous phosphatized remains of fossils including siliceous sponges, brachiopods, bivalves and infillings of belemnite alveoli. Some of the phosphatized clasts are covered by phosphatized stromatolites. The top of the Cretaceous strata is erosional and covered by Lower Eocene (Olszewska-Nejbort and Barski 2010) and Quaternary deposits.

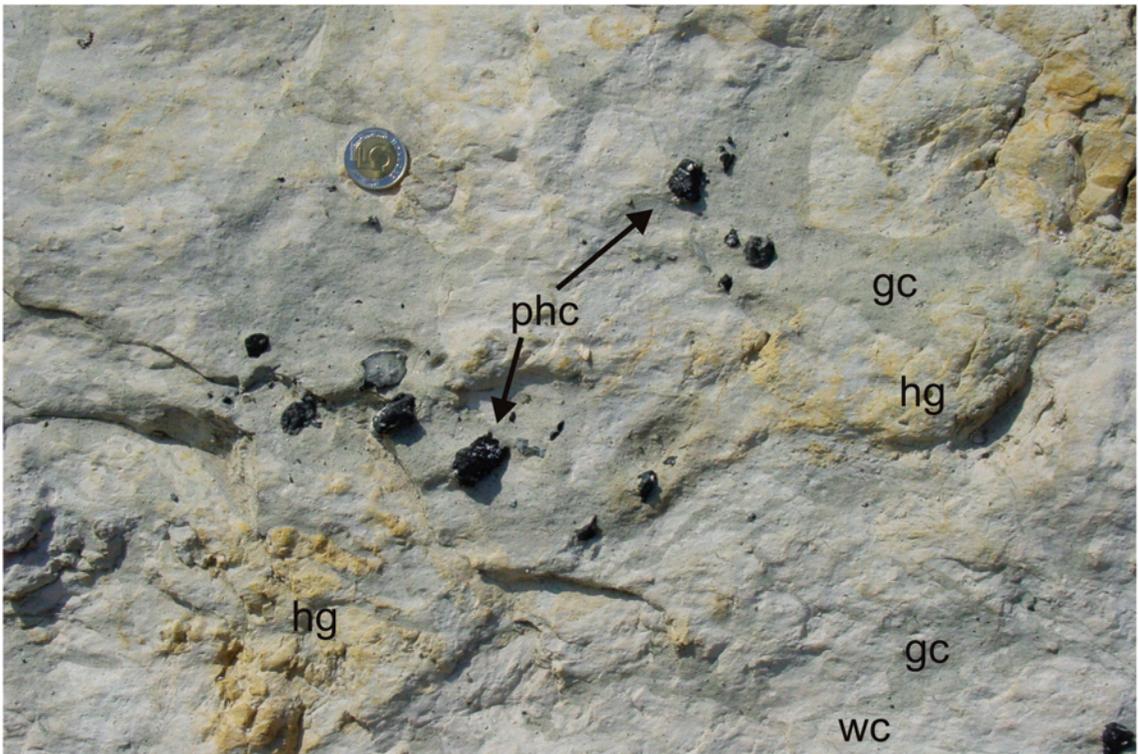
The correlation of the 'Boreal' base of the Maastrichtian Stage defined by belemnites (Christensen *et al.* 2000; Christensen 2001) with the Global Stratotype Section and Point (GSSP) at Tercis in southern France (Odin 2001; Odin and Lamaurelle 2001) is not clear (see Walaszczyk *et al.* 2002a, b, 2004; Machal-

ski 2005). Recent correlations based on inoceramid bivalves suggest that the base of the Maastrichtian lies higher than in the traditional 'Boreal' subdivision (see e.g., Walaszczyk 2004; Niebuhr *et al.* 2011). Herein, the traditional subdivision for Central Europe based on belemnites (compare Christensen *et al.* 2000) is applied because of the lack of inoceramids and ammonites in the Mielnik succession.

MATERIAL, REPOSITORIES AND METHODS OF STUDY

The collection of siliceous sponges comprises 348 specimens (341 specimens of hexactinellids and seven poorly preserved undeterminable lithistids). In most of the specimens the siliceous skeleton has been dissolved, hence the structure of the skeleton was determined from the shape and distribution of voids after the spicules. The macroscopic descriptions were supplemented by microscope and petrographic observations.

Polished thin sections were prepared from silicified sponges, sponges filled with white chalk and from phosphatized sponges (10 thin sections). The microscope observations were carried out in the Microscope Laboratory of the University of Warsaw using a Nikon



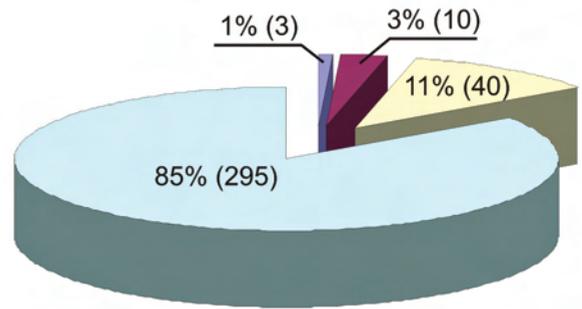
Text-fig. 4. Scattered black phosphorites in the horizon above the hardground; gc – green chalk with glauconite (lower Lower Maastrichtian), hg – grey-beige parts of hardground, slightly phosphatized chalk (Upper Campanian), phc – black phosphatized intraclast (Upper Campanian intraclasts redeposited to the Lower Maastrichtian), wc – white chalk (Upper Campanian)

SMZ 1000 stereoscope microscope and a Nikon ECLIPSE E600W POL optical microscope. Petrographic analyses were carried out under the Scanning Electron Microscope in the Microanalysis Laboratory of the University of Warsaw using a JEOL JSM-6380LA scanning electron microscope.

Most of the specimens investigated were collected by the authors, and are housed at the Geological Department of the Łódź University (collection UL XXII). The collection also contains the specimens donated by Prof. Andrzej Pisera.

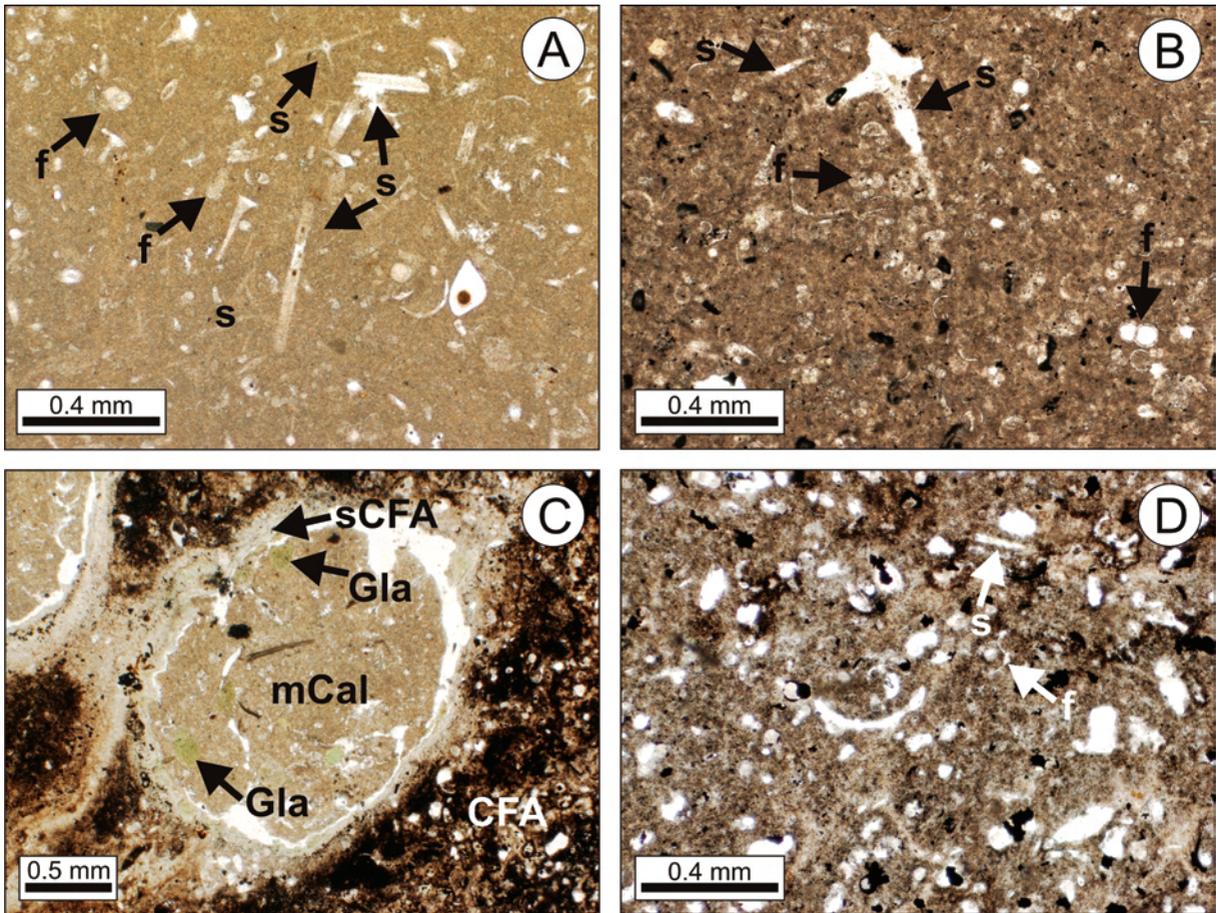
CHARACTERISTICS, DISTRIBUTION AND PETROGRAPHY OF THE MATERIAL

Most of the specimens (295 out of 348) are strongly phosphatized with a black enveloped core; 40

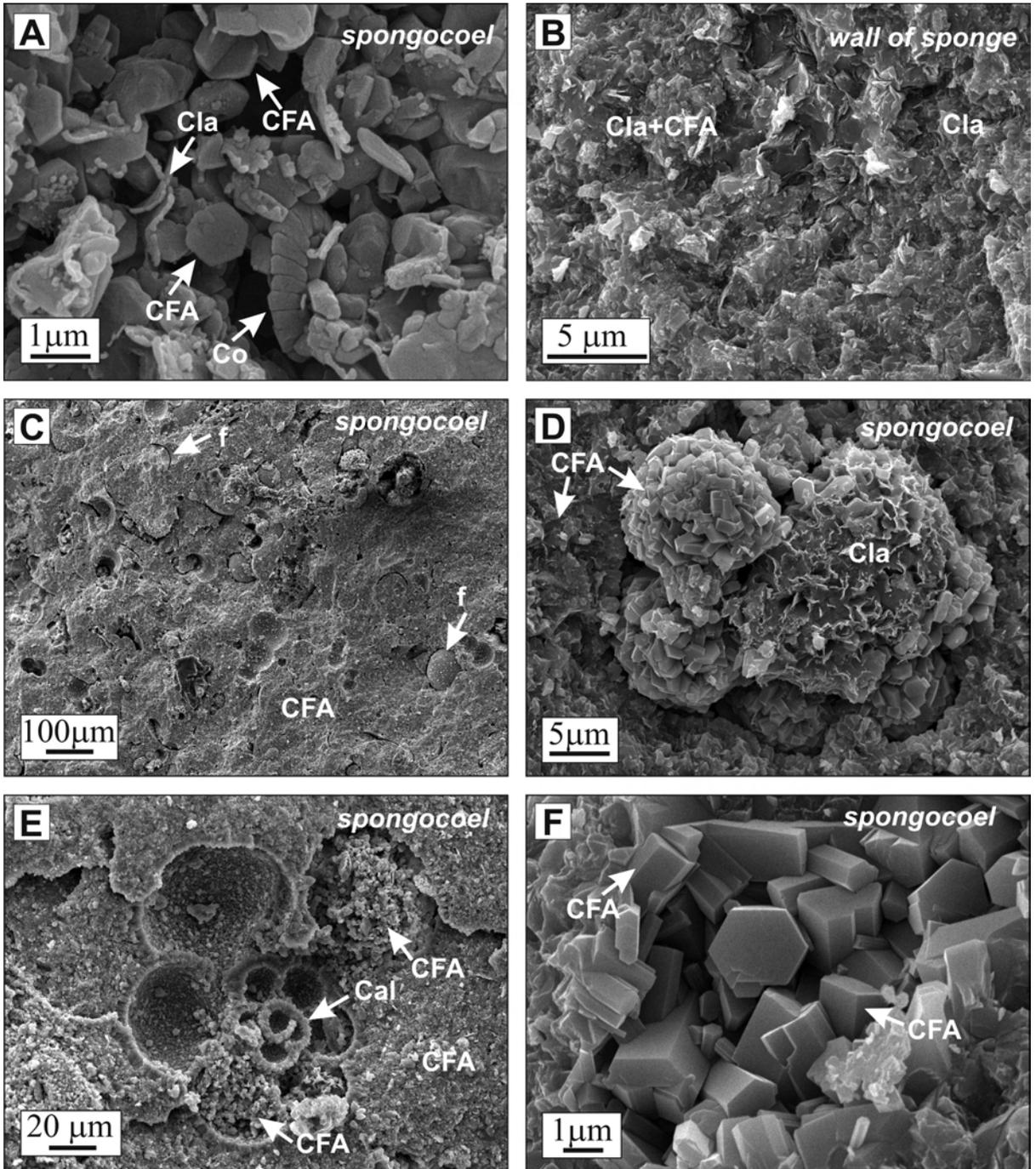


- silicified sponges
- sponges infilled with white chalk
- grey-beige slightly phosphatized sponges
- phosphatized black sponges

Text-fig. 5. Distribution of sponges with variable type of fossilization in Mielnik



Text-fig. 6. Characteristic microfacies from the Campanian and Lower Maastrichtian deposits at Mielnik. A – silicified wackestone with numerous sponge spicules (s) and calcite relicts of foraminifers (f); B – calcareous wackestone with rare empty voids after siliceous spicules (s) (large white field) and foraminifers (f); C – boring in black phosphatized (CFA) sponges (phosphatized wackestone) infilled with calcareous wackestone (mCal) with foraminifers and admixture of glauconite (Gla); wall of the boring with lining of phosphatized stromatolite (sCFA); D – phosphatized wackestone infilling the sponge spongocoel, white fields represent empty voids after microfossils, chiefly after foraminifers (f), spicules (s) and other non-determined particles



Text-fig. 7. SEM photomicrographs of phosphatized sponges. A – grey-beige slightly phosphatized sponge; spongocoel infilled with calcareous micrite and coccolith plates (Co), very fine francolite plates (CFA) and clay minerals (Cla); B–F – black phosphatized sponges; B – space of the wall infilled with mass of clay and phosphate (francolite) minerals; C – texture of material infilling the spongocoel; numerous empty voids after dissolved calcareous foraminifers (f); matrix and infillings of foraminiferal chambers are carbonate fluoroapatite (CFA); D – foraminifer chambers (in spongocoel space) infilled with francolite (CFA); foraminifer test is entirely dissolved; francolite intergrown and partly covered with clay minerals (Cla); E – another foraminifer (in spongocoel space) with relicts of calcite (Cal) chamber; chambers empty or infilled with francolite (CFA); foraminifer surrounded by phosphatized micrite; F – space in spongocoel infilled with hexagonal columnal francolite (CFA)

specimens are grey-beige in colour and slightly phosphatized; ten specimens are infilled with white chalk, and three specimens are silicified. (Text-fig. 5). Al-

though the siliceous sponges are present throughout the succession, the specimens from pure white chalk are impossible to determine because their siliceous

| Type of fossilization | Original sediment infilling the interspicular space and/or spongocoel | Depositional texture | Mineralogy of matrix support | Texture and fossilization processes |
|--|---|----------------------|---|---|
| Silicified sponges | Calcareous ooze composed mainly of coccolith plates and calcareous foraminifera | wackestone | Chalcedony | Silicified wackestone with sponge spicules and calcite relicts of foraminifera |
| Sponges infilled with white chalk | | | Calcite | Calcareous wackestone with empty spaces after sponge spicules and numerous foraminifer tests |
| Grey-beige slightly phosphatized sponges | | | Calcite-francolite | Calcareous-francolite wackestone with numerous foraminifer tests |
| Black phosphatized sponges | | | Francolite and francolite-clay minerals | Francolite and/or francolite-clay mineral wackestone with empty space after dissolved foraminifer tests |

Table 1. Summarized data on the texture, mineralogy and petrography of sponges with processes leading to their fossilization

skeleton was usually dissolved and the morphology of the sponges was also destroyed. The only exceptions are the silicified sponges. The empty voids after dissolved spicules in the phosphatized specimens are sometimes filled with glauconite or white chalk.

In the lower part of the section, particularly below the flint horizon, occur well-preserved specimens of the calcareous sponge *Porosphaera globularis* (Philips), which is not treated herein.

Black phosphatized sponges occur scattered in the black phosphorite horizon (Text-fig. 4) above the hardground, where they form about 5% of the black phosphorite intraclasts. The remaining intraclasts represent moulds of brachiopods, infillings of belemnite rostrum alveoli and numerous phosphatized chalk clasts. The intraclasts are rounded and were subject to intense boring (Text-fig. 6C). The siliceous skeletons of the sponges are dissolved. Voids after the spicules are usually filled with glauconite or white chalk. Because the porous walls of the sponges are less resistant to erosion than the material filling the canals, the deeper parts of the sponges and the projecting moulds after canals are visible on the destroyed outer surfaces of numerous specimens. The sponge infillings consist of phosphatized wackestone (Text-fig. 6D). The walls and spongocoels of the black sponges are infilled either with francolite (carbonate fluoroapatite) or with a mixture of francolite and clay minerals (Text-fig. 7B–F). Empty voids in the texture of the sponges are after dissolved calcite elements (e.g., foraminiferal tests) and siliceous spicules (Text-figs 6C, D; 7C–E); relicts of calcite are very rare (Text-fig. 7E).

Grey-beige phosphatized sponges are randomly distributed only in the grey-beige parts of the slightly phosphatized chalk of the hardground. They are well cemented and the morphology and voids after the dis-

solved skeleton are quite clearly visible. The wall and spongocoel of the sponges are infilled with calcareous mud consisting mainly of coccolith plates and very fine, but not very numerous francolite plates up to 1 µm in size (Text-fig. 7A). The sediment represents slightly phosphatized calcareous wackestone.

Sponges infilled with white chalk are dispersed almost throughout the section. Sometimes they are slightly limonitized and rusty in colour. Sponges of this group are poorly cemented. Their siliceous skeletons are completely dissolved. Voids after spicules are poorly visible. Their poorly preserved walls and spongocoels are infilled with typical calcareous wackestone (Text-fig. 6B).

Silicified sponges occur within the flint horizon in the lower part of the section (*Belemnellocomax mamillatus* Zone). They are preserved within larger, very hard, flint concretions. The black and grey flints with sponges are enveloped by white cores. Their walls and spongocoels are infilled by silicified, previously calcareous mud. Numerous relicts of calcitic foraminifers are visible in thin sections; sponge spicules (mainly of soft demosponges) are also present. This microfacies represents silicified wackestone (Text-fig. 6A).

The interspicular space (when visible) in the wall and spongocoel is infilled with wackestone with an admixture of foraminifera in every type of the fossilized sponges (Text-figs 6, 7). The difference is in the matrix support of the microfacies (Table 1). In the silicified sponges the matrix is composed of chalcedony, in the sponges infilled with white chalk it represents calcite micrite, in the grey-beige phosphatized sponges the matrix is composed of a mixed micrite mass consisting of calcite coccoliths and francolite plates, and in the black phosphatized sponges it comprises either francolite plates or a mixed clay minerals-francolite mass.

SYSTEMATIC ACCOUNT

(Ewa Świercewska-Gładysz)

Order Hexactinosida Schrammen, 1903

Family Euretidae Zittel, 1877

Genus *Wollemannia* Schrammen, 1912TYPE SPECIES: *Wollemannia araneosa* Schrammen, 1912.*Wollemannia araneosa* Schrammen, 1912
(Text-figs 8A; 9A, B)1912. *Wollemannia araneosa* nov. sp.; A. Schrammen, p. 247, text-pl. 10, figs 4–6; pl. 27, fig. 2; pl. 41, fig. 5.2010. *Wollemannia araneosa* Schrammen; E. Świercewska-Gładysz, p. 256, figs 3a, 4a, b (cum syn.).

TYPES: The lectotype, designated herein, is specimen no. K432-14, the original of Schrammen (1912, pl. 27, fig. 2), from the Lower Campanian (Quadratenkreide) of Oberg, Germany. It is housed in the Institute and Museum of Geology and Palaeontology of Göttingen University, Germany.

MATERIAL: 1 specimen from the hardground and 4 specimens from the phosphorite horizon.

DESCRIPTION: The only complete specimen is cone-shaped, 2 cm high and 3 cm wide (Text-fig. 8A). The remaining specimens are fragments from the phosphorite horizon, with the largest belonging to a sponge that was 4 cm in diameter. The wall thickness

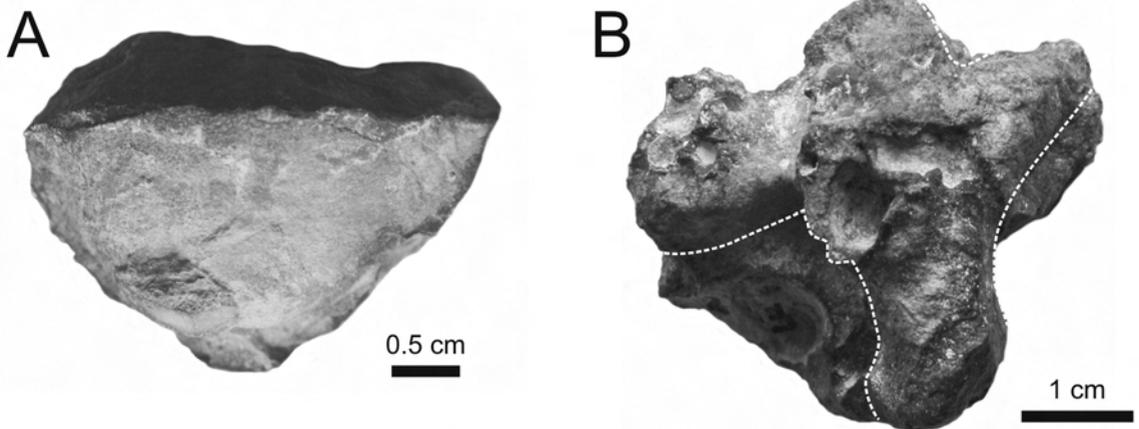
is 2–3 mm. Both surfaces are smooth, without canal openings. Transverse ripples, 1 mm wide, are present on the outer surface of one specimen. The dictyonal skeleton is very regular, with quadrangular or horizontal elongated rectangular meshes, 0.3 mm × 0.3–0.4 mm in size (Text-fig. 9A, B). The triangular meshes occur only locally in the subdermal part of the dictyonal skeleton. The skeleton is irregular in transverse section, with small quadrangular or triangular meshes, 0.15–0.2 mm in size. On both surfaces, secondary small hexactines form a single layer of dense network with quadrangular or triangular meshes, 0.05 mm in size. The skeleton is without canals.

REMARKS: The ripples (Text-fig. 9B) observed on the surface of one specimen probably resulted from the variable growth rate of the sponge. The remaining features are in accordance with the diagnosis of the species.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Coniacian and/or Santonian; Middle Vistula Valley, Upper Campanian–Lower Maastrichtian), northern Germany (Upper Campanian), eastern Ukraine (Lower Maastrichtian), ?France (Coniacian–Campanian).

Genus *Eurete* Semper, 1868TYPE SPECIES: *Eurete simplicissimum* Semper, 1868.*Eurete* sp.
(Text-figs 8B; 9C)

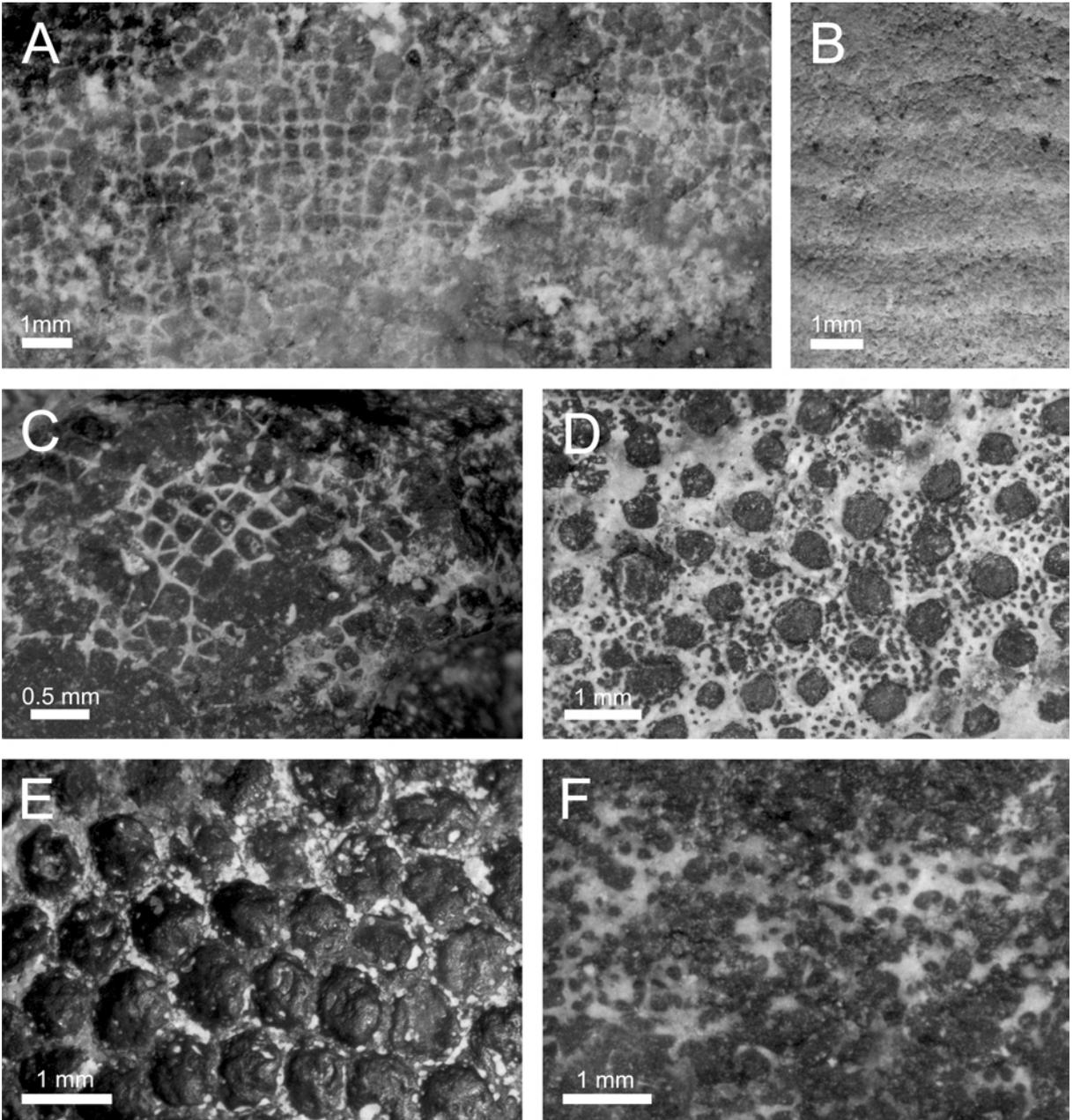
MATERIAL: 7 specimens from the phosphorite horizon.

Text-fig. 8. A – *Wollemannia araneosa* Schrammen, 1912; lateral view; M152; phosphorite horizon; B – *Eurete* sp.; fragment with divided tubes; M269; phosphorite horizon. A, B – Upper Campanian specimens redeposited to lower Lower Maastrichtian deposits

DESCRIPTION: The sponge body is composed of dichotomously dividing tubes, about 10 mm in diameter (Text-fig. 8B). The wall is 1–2 mm thick. The dictyonal skeleton within the central part of the wall is regular, with rectangular meshes, 0.2×0.3 mm in size (Text-fig. 9C). The skeleton is irregular in transverse section, with quadrangular and triangular meshes, 0.2 mm in size. On both surfaces the skeleton is dense,

with smaller (about 0.1 mm) triangular meshes and multiradiate nodes. Some nodes are thickened and spherical. No canals are developed within the dictyonal skeleton.

REMARKS: Features of the skeleton in the specimens studied show some resemblance to *Eurete formosum* Reid, 1959, a common species from the Campanian



Text-fig. 9. A–B – *Wollemannia araneosa* Schrammen, 1912; A – glauconitized subdermal skeleton; M152; phosphorite horizon; B – voids after secondary network on dermal surface; M153; hardground horizon; C – *Eurete* sp.; transverse cross-section; note glauconitized dictyonal skeleton; M272; phosphorite horizon; D – *Aphrocallistes cylindrodactylus* Schrammen, 1912; M177; phosphorite horizon; E, F – *Aphrocallistes alveolites* (Roemer, 1841); M141; phosphorite horizon; E – outer surface with canal openings; F – mono-layered network between canals; B – Upper Campanian; A, C–F – probable Upper Campanian specimens redeposited to Lower Maastrichtian deposits

and Maastrichtian of the Middle Vistula Valley. Unfortunately, the specimens are too poorly preserved to allow for unequivocal determination.

OCCURRENCE: Poland (Mielnik, Upper Campanian).

Family Aphrocallistidae Gray, 1867

Genus *Aphrocallistes* Gray, 1858

TYPE SPECIES: *Aphrocallistes beatrix* Gray, 1858.

Aphrocallistes alveolites (Roemer, 1841)

(Text-figs 9E, F; 10A–C)

1841. *Scyphia alveolites* N.; F.A. Roemer, p. 8, pl. 3, fig. 6.

2006. *Aphrocallistes alveolites* (Roemer); E. Świerczevska-Gładysz, p. 245, figs 11a–f, 12a.

2006. *Aphrocallistes alveolites* (Roemer); C. Helm and R. Kosma, pp. 204–227, figs 2–6 (cum syn.).

TYPES: The holotype, by monotypy, is specimen no. 511 (old number 121), housed in the Museum in Hildesheim, Germany, and figured by Roemer (1841, pl. 3, fig. 6), from the Upper Cretaceous (Quadraten-Senon) of Peine, Germany.

MATERIAL: 3 specimens from the chalk, 2 specimens from the hardground and 3 specimens from the phosphorite horizon.

DESCRIPTION: Six specimens are fragments of flattened branches, 10 mm × 15–20 mm in diameter, reaching up to 30 mm in length (Text-fig. 10C). The apex of one of them shows traces of dichotomous branching, in which one of the branches is broken off, whereas the second has the form of a rounded, blind swelling. The remaining two specimens are bell-shaped. The better preserved specimen is 54 mm high and 40 mm wide (Text-fig. 10A, B). Its wider apex is terminated by a slightly convex sieve plate with rounded, densely distributed pores, 1.2–1.8 mm in diameter. The wall thickness in all of the specimens is 2–4 mm. The wall is completely pierced by straight, perpendicular canals, opening onto both wall surfaces by polygonal canal openings, 0.7–0.9 mm in diameter, separated by very thin (about 0.1 mm) skeletal bands. The canal openings are regularly distributed in a honeycomb pattern, 120–130/cm² (Text-fig. 9E). The skeleton is poorly visible on the surface. In the central part of a barrier separating neighbouring canals occur small hexactines forming a mono-layered net-

work with triangular meshes, 0.1–0.3 mm in size (Text-fig. 9F).

REMARKS: According to Helm and Kosma (2006), the body of *Aphrocallistes alveolites* is composed of star-like-arranged branches which creep on the bottom. From these irregularly ramified branches grow upwards bowl-like extensions. The shape of the specimens studied indicates that most of them represent the stolon-like branched tubes, whereas only two correspond to the bowl-like extensions. In German specimens of *A. alveolites* (see Helm and Kosma 2006, figs 2–4), the bowl-like branches terminate in flat or concave sieve plates. In our specimen, as in the specimens from the Middle Vistula Valley (Świerczevska-Gładysz 2006, fig. 11E, F), the sieve plate is slightly convex.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Lower Campanian–Upper Maastrichtian; Kraków area, Lower and Upper Campanian), northwest Germany (Campanian; Rügen, Lower Maastrichtian), Russia (Volgograd region, Coniacian; Ulyanovsk region, Santonian–Campanian), Ukraine (southern Donbass region, Upper Campanian; west Podillia, Lower and Upper Maastrichtian).

Aphrocallistes cylindrodactylus Schrammen, 1912
(Text-figs 9D; 10D–F)

1912. *Aphrocallistes cylindrodactylus* nov. sp.; A. Schrammen, p. 220, text-fig. 1; text-pl. 11, fig. 6.

2010. *Aphrocallistes cylindrodactylus* Schrammen; E. Świerczevska-Gładysz, pp. 262, 263, figs 8a–d, 9a (cum syn.).

TYPES: The lectotype, designated herein, is the original of Schrammen (1912, text-fig. 1) from the Lower Campanian (Quadraten-Kreide) of Oberg, Germany. Study of the Schrammen Collection is in progress and this specimen has not so far been found (personal communication Mike Reich, Institute and Museum of Geology and Palaeontology of Göttingen University).

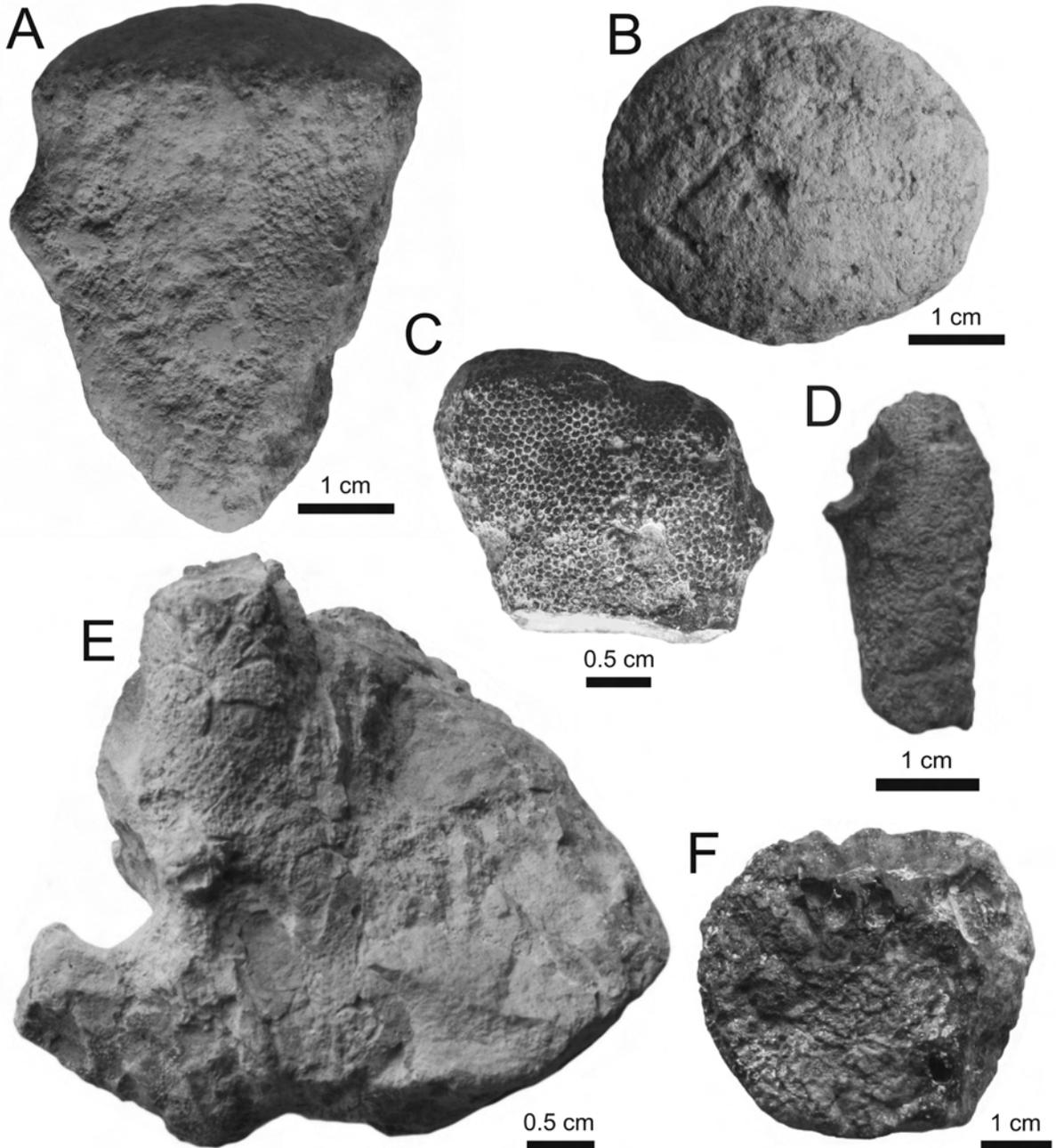
MATERIAL: 1 specimen from the chalk, 1 specimen from the flint horizon, 4 specimens from the hardground and 18 specimens from the phosphorite horizon.

DESCRIPTION: The material includes broken fragments of lateral lobes, up to 52 mm in size (Text-fig. 10E), and cylindrical branches, 9–22 mm in diameter and 26–40 mm long (Text-fig. 10D). Some of the branches are divided dichotomously. The wall, 1.5–2.5

mm thick, is pierced by straight, perpendicular canals. The outer surface has round canal openings, about 0.5 mm in diameter, separated by skeletal bands 0.3–0.5 mm wide. They are densely and evenly distributed, 150–200/cm². On one branch occurs an additional osculum, 1 mm wide. The cup-like sieve plate that closes the terminal aperture of the sponges is preserved only as a void on a single specimen (Text-fig. 10F). The

sieve plate pores are irregular, reaching 3 mm in size. The skeleton is composed of hexactines, forming a dense network with small triangular meshes, 0.1–0.2 mm in size, (Text-fig. 9D). A thick cortex with small round pores occurs on the dermal surface.

REMARKS: Although the Mielnik material lacks complete specimens, the preserved fragments indicate



Text-fig. 10. A–C – *Aphrocallistes alveolites* (Roemer, 1841); A – apical part of branch with sieve plate; M147; chalk; B – the same specimen, lateral view of branch; C – fragment of stolon-like branch; M143; phosphorite horizon; D–F – *Aphrocallistes cylindrodactylus* Schrammen, 1912; D – lateral view of lobe with broken branch; M149; hardground horizon; E – single branch; M141; phosphorite horizon; F – imprint of sieve plate; M57; phosphorite horizon; A, B, D – Upper Campanian; C, E–F – Upper Campanian specimens redeposited to Lower Maastrichtian deposits

that the sponges possess the star-like lobes, with lateral branches of variable length protruding from them (Text-fig. 10E). Such a morphology is typical of representatives of this species.

OCCURRENCE: Poland (Mielnik, upper Lower Campanian to Upper Campanian; Kraków area, Coniacian and/or Santonian; Middle Vistula Valley, Upper Campanian–uppermost Maastrichtian; Łódź area, Campanian), northern Germany (Campanian), Ukraine (Upper Maastrichtian), England (Campanian–Maastrichtian), and Northern Ireland (Campanian).

Family Craticulariidae Rauff, 1893
Genus *Leptophragma* Zittel, 1877

TYPE SPECIES: *Scyphia purchisoni* Goldfuss, 1831.

Leptophragma purchisoni (Goldfuss, 1831)
(Text-figs 11A; 12A)

1831. *Scyphia Munchissonii* nobis; A. Goldfuss, p. 219, pl. 65, fig. 8.

1877. *Leptophragma Murchisoni* Goldf.; K.A. Zittel, p. 48, pl. 3, fig. 1.

2006. *Leptophragma purchisoni* (Goldfuss); E. Świerczewska-Gładysz, pp. 238–240, figs 7a, b, 8d, e (cum syn.).

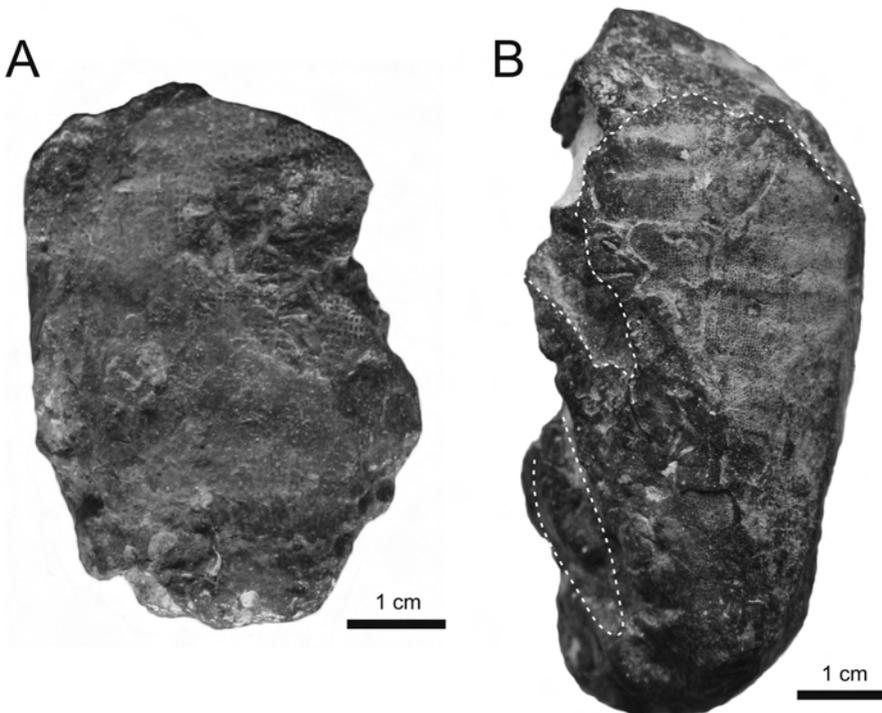
TYPES: The holotype is specimen no. StIPB-Goldfuss 453a, b, c, the original of Goldfuss (1831, pl. 65, fig. 8) from the Upper Campanian of Darup, Westphalia, Germany. The specimen is housed in the Goldfuss Collection of Bonn University (Rheinische Friedrich-Wilhelms Universität, Paläontologisches Institut, Goldfuss Museum), Bonn, Germany.

MATERIAL: 1 specimen from the hardground and 4 specimens from the phosphorite horizon.

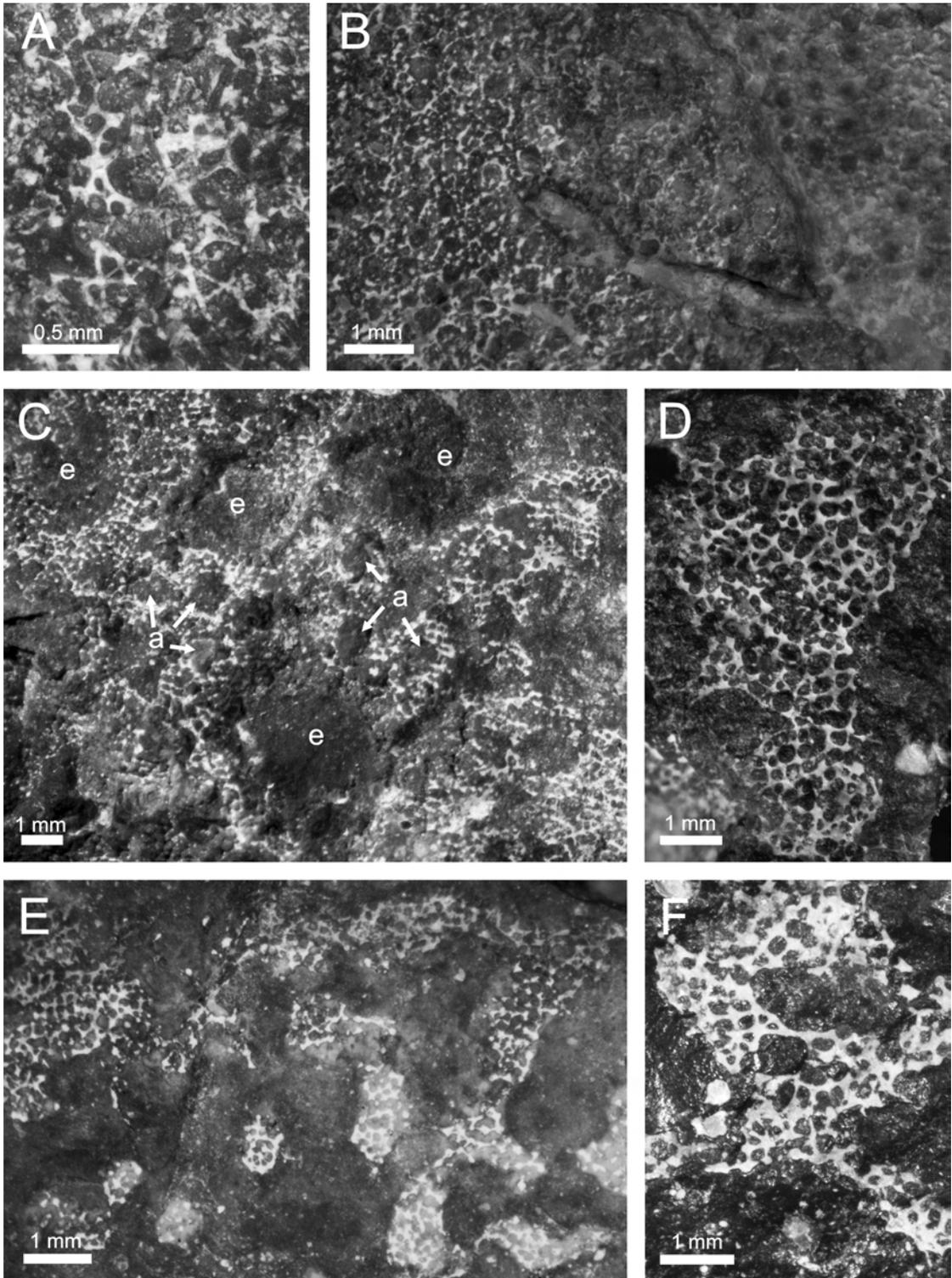
DESCRIPTION: This is a cup-shaped sponge (Text-fig. 11A) with a wall 2 mm thick. The largest, almost complete specimen is 56 mm high. The inner surface is covered with round canal openings, 0.3–0.4 mm in diameter. They are regularly distributed in horizontal and vertical rows, 200–250/cm². On the inner surface there is a dense network with triangular meshes, 0.15–0.2 mm in size (Text-fig. 12A). On the worn outer surface, there are canal openings; the hexactines are poorly visible. The size and distribution of the canal openings are similar to those on the inner surface.

REMARKS: The specimens studied show all the features characterizing *L. purchisoni*.

The incorrect spelling *Munchissonii* by Goldfuss (1831), in honour of Roderick Murchison, was corrected by Zittel (1877) when he placed the species in the genus *Leptophragma*.



Text-fig. 11. A – *Leptophragma purchisoni* (Goldfuss, 1831); lateral view; M247; phosphorite horizon; B – *Leptophragma micropora* Schrammen, 1912; lateral view of cup-like specimens with folded wall; visible narrow side of fold; M30; phosphorite horizon; A, B – Upper Campanian specimens redeposited to Lower Maastrichtian deposits



Text-fig. 12. A – *Leptophragma murchisoni* (Goldfuss, 1831), cross-section parallel to surface; dictyonal skeleton with canals; M247; phosphorite horizon; B – *Leptophragma micropora* Schrammen, 1912; subgastral part of glauconitized dictyonal skeleton with aporhyses (to the left) and voids of outer surface with canal openings (to the right); M206; phosphorite horizon; C–F – *Polyopesia macropora* sp. nov.; C – dermal surface of dictyonal skeleton with large openings of epirhyses (e) and accessory apertures of aporhyses (locally note subdermal part of dictyonal skeleton); paratype, M55; phosphorite horizon; D – the same specimen, subdermal part of dictyonal skeleton; E – transverse cross-section through wall; note glauconitized dictyonal skeleton and labyrinth-shaped aporhyses; holotype, M131; phosphorite horizon; F – dermal surface of glauconitized dictyonal skeleton with thickened rays of hexactines; paratype, M130; phosphorite horizon; A–F – Upper Campanian specimens redeposited to Lower Maastrichtian deposits

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Campanian–Upper Maastrichtian; Kraków area, Lower and Upper Campanian; Łódź area, Campanian), southern England (Cenomanian; Upper Coniacian–Campanian), France (Coniacian), Ukraine (Cenomanian, Campanian–Maastrichtian), northwest Germany (Campanian).

Leptophragma micropora Schrammen, 1912
(Text-figs 11B; 12B)

1912. *Leptophragma micropora* nov. sp.; A. Schrammen, pp. 237, 238, pl. 32, figs 4, 5; pl. 43, fig. 2; text-pl. 9, fig. 1.

2010. *Leptophragma micropora* Schrammen; E. Świerczewska-Gładysz, p. 262, figs 6e, 7f (cum syn.).

TYPES: The lectotype, designated herein, is specimen no. K432-7, the original of Schrammen (1912, pl. 32, fig. 4), from the Campanian (Quadratenkreide) of Oberg, Germany. It is housed in the Institute and Museum of Geology and Palaeontology of the University of Göttingen.

MATERIAL: 1 specimen from the hardground and 14 specimens from the phosphorite horizon.

DESCRIPTION: The specimens are thin-walled, 1–2 mm thick, cup-shaped, up to 65 mm in height and about 60 mm in diameter (Text-fig. 11B). The wall of the largest specimens is folded. The stalk is not preserved. The round canal openings on the outer surface are very small, 0.2–0.3 mm in diameter. They are densely distributed, 400–420/cm², in vertical rows and in indistinct horizontal rows. On the inner surface the canal openings are similar in size or somewhat larger, up to 0.4 mm, and less densely packed, about 360/cm². A dense network with small rounded meshes occurs on both surfaces (Text-fig. 12B). In the subdermal part there is an irregular skeleton with triangular and quadrangular meshes, 0.1–0.2 mm in size. The canal arrangement and dictyonal skeleton is not visible within the wall.

REMARKS: The specimens studied correspond fully to the diagnosis of *L. micropora*; they are particularly similar to specimens from the Middle Vistula Valley.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Coniacian and/or Santonian, Upper Campanian; Middle Vistula Valley, Upper Campanian–Upper Maastrichtian), northern Germany (San-

tonian–Campanian), eastern Ukraine (Lower Maastrichtian), England (Upper Coniacian–Santonian), ?Russia (Saratov area, Lower Santonian).

Family Cribrospongiidae Roemer, 1864
Genus *Polyopesia* Schrammen, 1902
emended Schrammen, 1912; emended Reid, 1961

TYPE SPECIES: *Polyopesia angustata* Schrammen, 1902.

Polyopesia macropora sp. nov.
(Text-figs 12C–F; 13)

HOLOTYPE: Specimen no. UL XXII M131, illustrated in Text-figs 12E and 13B.

TYPE LOCALITY: Mielnik, eastern Poland.

TYPE HORIZON: *Belemnella lanceolata* Zone = *Belemnella (Pachybelemnella) inflata* Zone of the lower Lower Maastrichtian in the traditional ‘Boreal’ subdivision. Specimens from the type horizon were probably redeposited from Upper Campanian deposits.

ETYMOLOGY: *macr* (gr.) – large, *porus* (latin) – pore; referring to the large canal openings on their dermal surface.

MATERIAL: 3 specimens from the hardground and 11 from the phosphorite horizon.

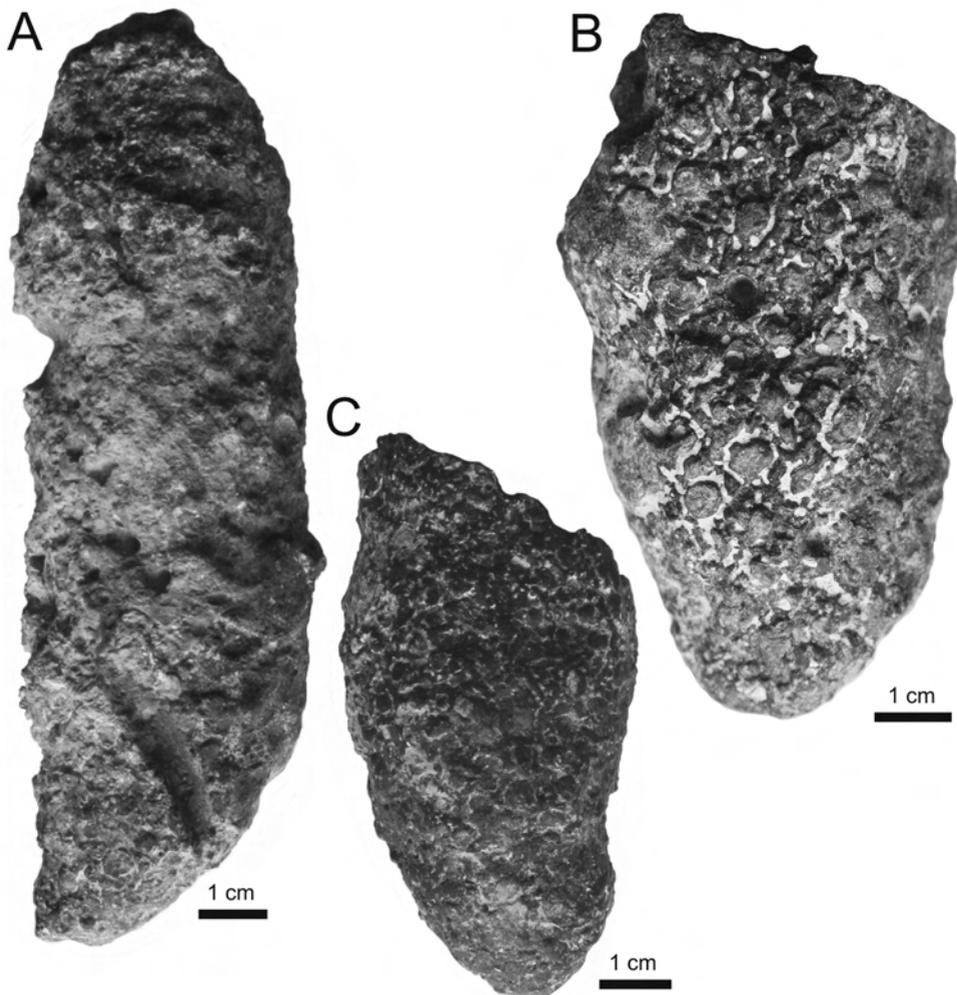
DIAGNOSIS: Conical or cylindrical sponges with thick wall, up to 11 mm thick, with very large, rounded or oval canal openings, 3–7 mm in size, on outer surface, arranged without a clear order, in 3–8 mm intervals. Canal openings surrounded by small, rounded, accessory apertures of aporhyses. Diplorhysis with labyrinth-like aporhyses and straight epirhyses terminated blindly or connected with poorly developed diagonal canals directly below gastral surface. Dictyonal skeleton quite regular, with meshes 0.2–0.25 mm in size. Dictyonal cortex not developed.

DESCRIPTION OF THE HOLOTYPE: The specimen is narrow conical, broken in its upper part, about 90 mm high and 55 mm in diameter (Text-fig. 13B). The wall is 10 mm thick. On its outer surface there occur rounded canal openings, 4–7 mm in diameter. They are irregularly distributed, up to 8 mm apart. The canal openings are not visible on the internal surface.

The epirhyses are straight, perpendicular to the wall, with poorly visible terminations. The aporhyses lead to irregular chambers within the wall (Text-fig. 12E). The chambers are interconnected and comprise diagonal passages, from which the canals with small openings on the dermal surface run out. The accessory apertures of the aporhyses are round, 0.7–1.5 mm in diameter; 7–9 apertures surround the canal openings. The dictyonal skeleton within the wall is quite regular, with a prevalence of square meshes, 0.2–0.25 mm in size. Locally, especially in the subdermal and subgastral part, the skeleton is less regular with square and triangular meshes. A relatively irregular network with thickened rays of hexactines is present on both surfaces. The dictyonal cortex is not developed.

INTRASPECIFIC VARIABILITY: These are conical or nearly cylindrical sponges, with the upper edge straight or bent slightly inwards, up to 130 mm high

and 55 in diameter (Text-fig. 13A, C). Their lower part is sometimes asymmetrically curved, probably without the stalk. The smallest specimens (30 mm in height) possess vestiges of rhizoidal processes. The wall is 8–11 mm thick. The canal openings on the outer surface are usually rounded, rarely oval (Text-fig. 12C). On some specimens the canal openings are smaller, 3–4 mm in diameter, and more dense than in the holotype, distributed every 4–6 mm. The epirhyses are straight, perpendicular to the wall, typically terminating blindly. Sporadically, epirhyses are connected with poorly developed diagonal canals running below the gastral surface. The aporhyses always form a complex labyrinth with large irregular chambers that can fill the entire wall thickness. On well preserved fragments of the outer surface, the accessory aporhyses apertures occur on the apical part of small papillae. The dictyonal skeleton (Text-fig. 12C, D, F) is weakly variable.



Text-fig. 13. A–C – *Polyopsia macropora* sp. nov., Upper Campanian specimens redeposited to Lower Maastrichtian deposits; A – lateral view; paratype, M130; phosphorite horizon; B – lateral view; holotype, M131; phosphorite horizon; C – lateral view; paratype, M55; phosphorite horizon

DISCUSSION: In comparison to other species of the genus, *P. macropora* is characterized by extremely large canal openings on the outer surface and a great thickness of the wall. In *P. levis* (Schrammen, 1912), from the Campanian of Germany and the Campanian–Lower Maastrichtian of the Middle Vistula Valley, the canal openings are 1–2 mm in diameter and its wall is 4 mm thick. Similarly, in *P. angustata* Schrammen, 1902, from the Campanian of Germany and from the Santonian of Poland, the canal openings on the outer surface are up to 3 mm in diameter and its wall is up to 4–5 mm thick. The state of preservation of the specimens studied does not allow comparison of the internal parts with those of other representatives of the genus *Polyopesia*.

OCCURRENCE: Poland (Mielnik, Upper Campanian).

Order Lychniscosida Schrammen, 1903
Family Callodictyidae Zittel, 1878
Genus *Cyclostigma* Schrammen, 1912

TYPE SPECIES: *Plocoscyphia acinosa* Schrammen, 1902.

Cyclostigma lobata Schrammen, 1912
(Text-figs 14A, B; 15A)

1912. *Cyclostigma lobata* nov. sp.; A. Schrammen, pp. 304, 305, text-fig. 4.
2006. *Cyclostigma lobata* Schrammen; E. Świerczevska-Gładysz, p. 268, figs 32f, g; 33b; 34f.

TYPES: The holotype, by monotypy, is the original of Schrammen (1912, text-fig. 4) from the Upper Campanian of Ahlten, near Misburg, Germany. The specimen is housed in the Schrammen Collection, Institute and Museum of Geology and Palaeontology of the Göttingen University, Göttingen, Germany. Study of the Schrammen Collection is still in progress, and the specimen has not yet been found (personal communication Mike Reich, Institute and Museum of Geology and Palaeontology of Göttingen University).

MATERIAL: 6 specimens from the phosphorite horizon.

DESCRIPTION: The specimens are irregularly shaped fragments, up to 65 mm long and 54 mm wide (Text-fig. 14A, B). Most of the fragments are flattened and their thickness does not exceed 35 mm. They are built of thin-walled (1–1.5 mm thick) tubes, 4–6 mm

in diameter. The tubes divide and fuse again. The cavaedia between the tubes are usually narrower than the tubes, 2–4 mm wide. The tube openings on the sponge surface are round or oval. The margins of some neighbouring tubes are fused. The dictyonal skeleton is regular, with square or rectangular meshes, 0.2–0.3 mm in size (Text-fig. 15A). Locally the regular orientation of lychniscs is disturbed and small triangular meshes appear in the network. The cortex on the external parts of the tubes is not preserved. The canals in the dictyonal skeleton are not developed.

REMARKS: The known specimens of *C. lobata* have an irregularly bulbous form with longitudinal lobes. Although the specimens studied are only fragments (mainly of lateral lobes), their macroscopic structure fully corresponds to the species diagnosis. They also closely resemble specimens from the Maastrichtian of the Middle Vistula Valley (central Poland). The asymmetric pattern of the tubes on one specimen may indicate that one surface of this lobe touched the bottom sediment. The lack of any traces of secondary hexactines on the specimens studied is most probably the result of their poor preservation.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Maastrichtian), northwest Germany (Campanian).

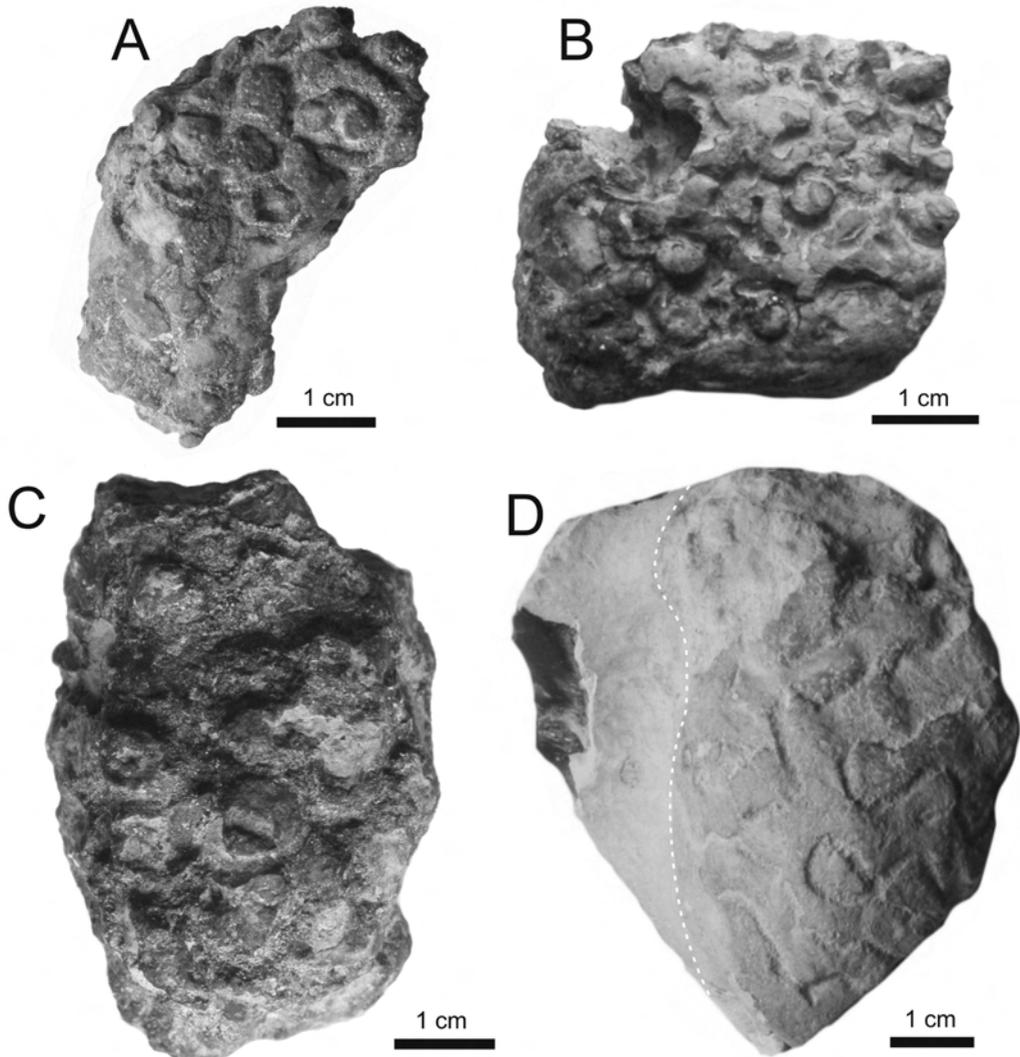
Cyclostigma maeandrina Schrammen, 1912
(Text-figs 14C, D; 15B, C)

1912. *Cyclostigma maeandrina* nov. sp.; A. Schrammen p. 304, text-pl. 14, fig. 4; pl. 40, fig. 6.
2006. *Cyclostigma maeandrina* Schrammen; E. Świerczevska-Gładysz, pp. 267, 268, figs 32e; 33c, d; 34a, b.

TYPES: The lectotype, designated herein, is specimen no. K432-317, the original of Schrammen (1912, pl. 40, fig. 6), from the Lower Campanian (Quadraten-Kreide) of Oberg, Germany. It is housed in the Institute and Museum of Geology and Palaeontology of Göttingen University, Germany.

MATERIAL: 1 specimen from the flint horizon, 1 specimen from the hardground and 3 specimens from the phosphorite horizon.

DESCRIPTION: These are cosh- or club-shaped sponges, exceeding 60 mm in height and 40–45 mm in diameter (Text-fig. 14C, D). The sponge body comprises thin-walled, divided and anastomosed tubes,

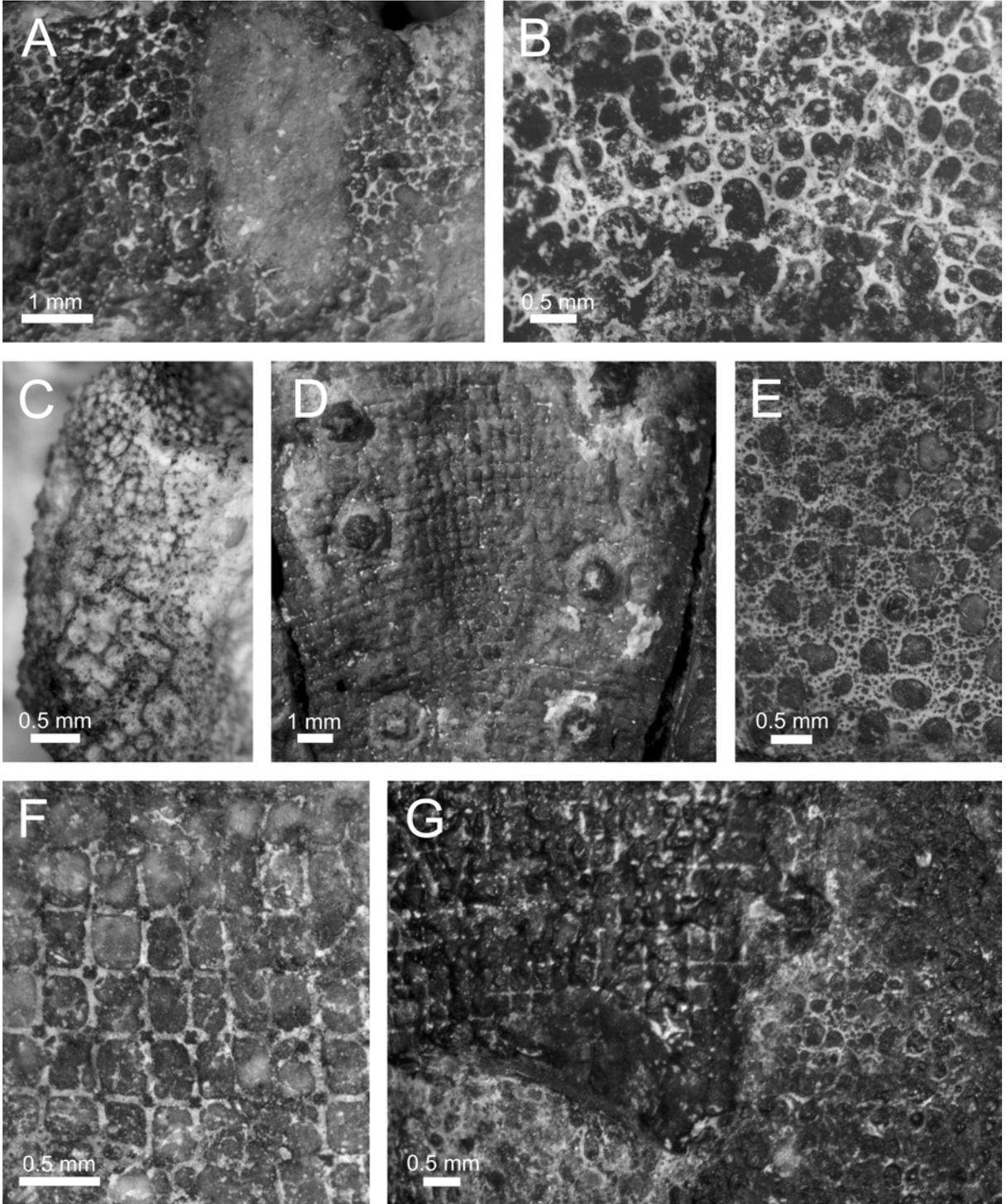


Text-fig. 14. A, B – *Cyclostigma lobata* Schrammen, 1912; A – fragment of apical part with eroded walls of tubes and with projecting infillings of tubes; M283; phosphorite horizon; B – lateral flat lobe with eroded walls of tubes and with projecting infillings of tubes; M22; phosphorite horizon; C, D – *Cyclostigma maeandrina* Schrammen, 1912; C – lower part of sponge with eroded walls of tubes and with projecting infillings of tubes; M150; phosphorite horizon; D – upper part of specimen with destroyed surface; visible patterns of tubes and cavaedia inside the specimen; M164; flint horizon; A–C – Upper Campanian specimens redeposited to Lower Maastrichtian deposits; D – upper Lower Campanian

7.5–9 mm in diameter. In the lower part, the tubes have a more regular, radial arrangement. On the outer surface, the ends of the tubes are free, with rounded openings. Sporadically, the margins of neighbouring tubes are fused. The cavaedial spaces between the tube openings, 3–7 mm in size, form a system of intercanals of similar diameters to those of the tubes. The canals do not occur in the dictyonal skeleton (Text-fig. 15B, C). The skeleton within the wall is regular, with quadrangular and rectangular meshes, $0.25\text{--}0.3 \times 0.3\text{--}0.35$ mm. On the dermal surface, variably orientated lychniscs with thickened beams form a layer with rounded meshes, 0.2–0.3 mm in size. Above them,

secondary hexactines form a layer, 0.5 mm thick, of an irregular, dense network with triangular meshes, 0.1 mm in size. The skeleton on the gastral surface is not preserved.

REMARKS: According to Schrammen (1912) and Reid (2004), “ostia” on the dermal surface are characteristic of the genus *Cyclostigma* Schrammen. In the case of *C. maeandrina*, the synapticular cortex is poorly developed and small pores observed on the dermal surface are narrowed meshes of the network (see also Świerczewska-Gładysz 2006). Due to the variable orientation of the lychniscs, these pores have a



Text-fig. 15. A – *Cyclostigma lobata* Schrammen, 1912; longitudinal cross-section through cavaedia (in centre) and wall of adjacent tubes; note glaucinitized dictyonal skeleton; M22; phosphorite horizon; B, C – *Cyclostigma maeandrina* Schrammen, 1912; B – cross-section parallel to surface of tube; note glaucinitized dictyonal skeleton from central part of tube wall; M150; phosphorite horizon; C – secondary hexactines on dermal surface (top of photograph) and lychnises of dictyonal skeleton (lower part of photograph); M164; flint horizon; D–G – *Coeloptychium agaricoides* Goldfuss, 1826; phosphorite horizon; D – fragment of lower surface of discoidal part of specimen; note oscula and voids after subdermal part of dictyonal skeleton; M70; E – the same specimen, glaucinitized cortex on dermal surface (lower surface of fold); F – glaucinitized dictyonal skeleton from central part of fold; M64; G – glaucinitized dictyonal skeleton (left upper part of photograph) and cortex on dermal surface (the right and lower left part of photo) of conical part of specimen; M65; A, B, D–G – Upper Campanian specimens redeposited to Lower Maastrichtian deposits; C – upper Lower Campanian

variable size and are irregularly distributed. Fragments of secondary network comprising small hexactines are preserved only on the dermal surface of one specimen, preserved within a flint.

OCCURRENCE: Poland (Mielnik, upper Lower Campanian, Upper Campanian; Middle Vistula Valley, Campanian–Lower Maastrichtian), northwest Germany (Campanian), England (Upper Coniacian–Santonian).

Family Coeloptychidae Roemer, 1864

Genus *Coeloptychium* Goldfuss, 1826

TYPE SPECIES: *Coeloptychium agaricoides* Goldfuss, 1826.

Coeloptychium agaricoides Goldfuss, 1826
(Text-figs 15D–G; 16A–D)

1826. *Coeloptychium agaricoides* nobis; A. Goldfuss, p. 20, pl. 9, fig. 20.
 1841. *Coeloptychium decimum*; F.A. Roemer, p. 10, pl. 4, fig. 3.
 1876. *Coeloptychium decimum*; K. Zittel, pp. 62–65, pl. 1, fig. 6, 7; pl. 3, fig. 2.
 1912. *Coeloptychium decimum*; A. Schrammen, p. 329.
 1933. *Coeloptychium decimum* Roemer; F. Bieda, p. 35.
 1933. *Coeloptychium rude* Seebach.; F. Bieda, p. 36, pl. 3, fig. 3.
 1968. *Coeloptychium decimum* Roemer; H. Hurcewicz, pp. 82, 83, pl. 18, figs 1, 2.
 1977. *Coeloptychium decimum* Roemer; Z.I. Khmilevsky, p. 43.
 1992. *Coeloptychium agaricoides* Goldfuss; D. Mehl, p. 120, pl. 19, figs 1–4 (cum syn.).

TYPES: The holotype, by monotypy, is specimen no. StIPB-Goldfuss 116, the original of Goldfuss (1826, pl. 9, fig. 20); re-illustrated by Mehl (1992, pl. 19, fig. 1), from the Campanian of Coesfeld, Westphalia, Germany. It is housed in Bonn University (Rheinische Friedrich-Wilhelms Universität, Paläontologisches Institut, Goldfuss Museum), Bonn, Germany.

MATERIAL: 2 specimens from the hardground and 46 specimens from the phosphorite horizon.

DESCRIPTION: The preserved fragments of the disc-like part allow estimation of the sponge diameter as about 80–90 mm (Text-fig. 16A–C). The flat,

undivided disc margin, 15 mm wide, slopes slightly inwards. The upper surface of the disc is flat. The radially distributed folds on the lower surface, 5–7 mm wide, are separated by slightly narrower grooves. The primary folds (about 9–10) are dichotomously divided. The rounded or oval openings, 1–1.5 mm in diameter, are irregularly spaced (every 1.5–5 mm) on the fold ridges (Text-fig. 15D). The lower part has the shape of an empty cone, up to 53 mm high and 27 mm in diameter (Text-fig. 16D). Small, parietal oscula, 2–3 mm in diameter, are present on the conical surface. They are irregularly distributed or arranged in indistinct vertical rows. The spaces between the oscula are 7–15 mm. The dictyonal skeleton is very regular, with square or rectangular meshes, 0.3 mm × 0.3–0.4 mm in size (Text-fig. 15F, G). Synapticules are present in some places in the network. The skeleton is less regular, with smaller meshes, in the subdermal part. The upper part of the disc is covered by a siliceous synapticular membrane, composed of radial bands with larger, round or oval meshes, 0.4–0.8 mm in diameter, above the grooves and finely porous bands on the fold ridges. The dense synapticular membrane encases the disc margin. The synapticular cortex, with numerous rounded or irregular pores, covers the surface of the lower part of the disc and both surfaces of the conical part (Text-fig. 15E). Canals are not developed in the dictyonal skeleton.

REMARKS: According to Mehl and Niebuhr (1995), all known species of the genus *Coeloptychium* Goldfuss are morphotypes of a single species *C. agaricoides* Goldfuss. The differences in the structure of some of the species distinguished are actually insignificant and their concept is thus fully justified. Polish specimens from both Mielnik and the Kraków region (see Bieda 1933; Hurcewicz 1968) correspond more closely to *C. decimum* Roemer. They are characterized by numerous oscula situated not only on the lower part of the disc but also on the stalk.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Lower and Upper Campanian), Ukraine (Lower Campanian), northwest Germany (Campanian), England (Campanian, Maastrichtian) and Northern Ireland (Campanian).

Family Camerospongiidae Schrammen, 1912

Genus *Camerospongia* D'Orbigny, 1849

TYPE SPECIES: *Scyphia fungiformis* Goldfuss, 1831.

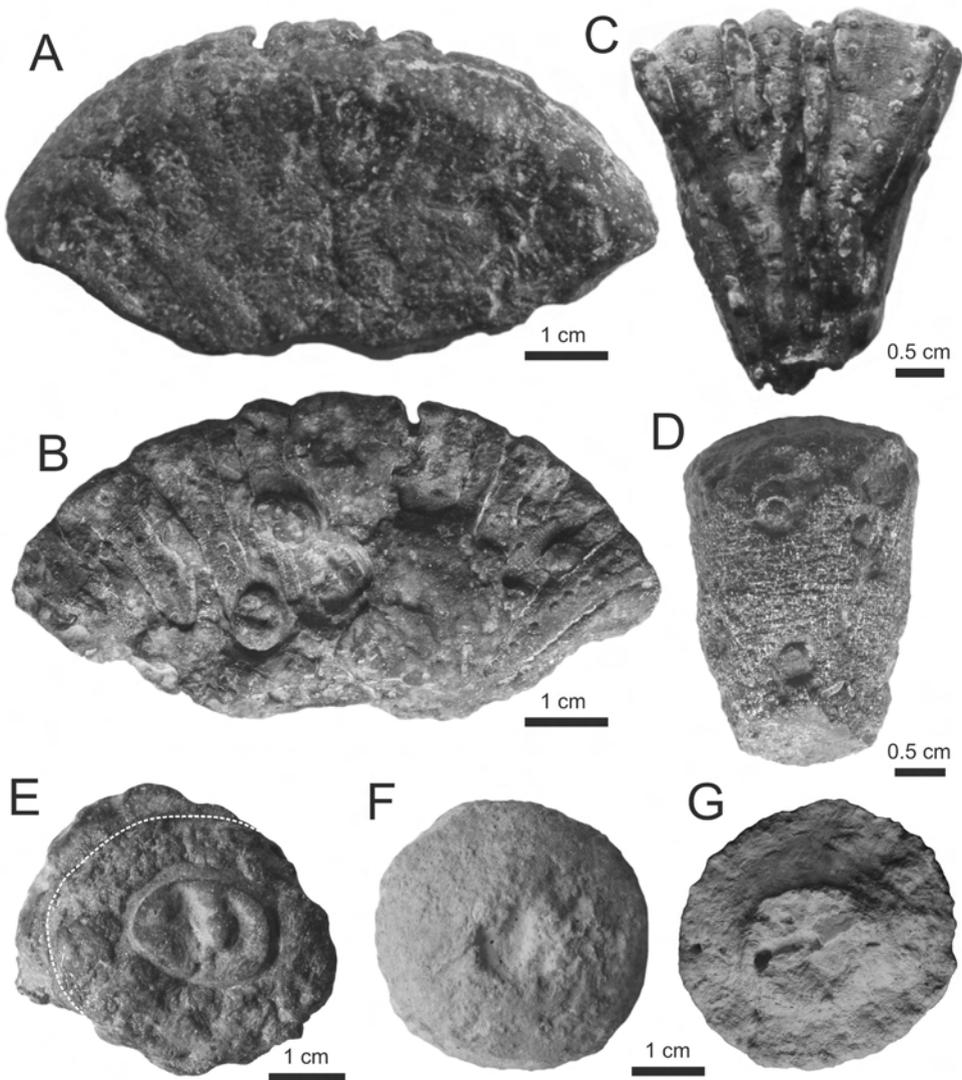
Camerospongia fungiformis (Goldfuss, 1831)
(Text-fig. 16E–G)

1831. *Scyphia fungiformis* nobis; A. Goldfuss, p. 218, pl. 65, figs 4a–c.
1980. *Camerospongia capitata* (Smith); J. Małecki, p. 423, pl. 8, figs 2a–c.
1991. *Camerospongia fungiformis* (Goldfuss); R. Tarkowski, p. 93, pl. 4, figs 5, 6.
1992. *Camerospongia fungiformis* (Goldfuss); D. Mehl, p. 111 (cum syn.).
2001. *Camerospongia fungiformis* (Goldfuss); F. Wiese and C. Wood, fig. 3k.

2010. *Camerospongia fungiformis* (Goldfuss); E. Świerczewska-Gładysz, p. 272, fig. 13e, f.

TYPES: The holotype, by monotypy, is specimen no. StIPB-Goldfuss 449, the original of Goldfuss (1831, pl. 65, figs 4a–c), from the Campanian of Coesfeld, Westphalia, Germany. It is housed in the Bonn University (Rheinische Friedrich-Wilhelms Universität, Paläontologisches Institut, Goldfuss Museum), Bonn, Germany.

MATERIAL: 1 specimen from the chalk, 1 specimen from the hardground and 3 specimens from the phosphorite horizon.



Text-fig. 16. A–D – *Coeloptychium agaricoides* Goldfuss, 1826; A – fragment of disoidal part; view of upper surface; M64; phosphorite horizon; B – the same specimen, view of lower surface; C – fragment of disoidal part; view of lower surface; M70; phosphorite horizon; D – lower conical part; M18; phosphorite horizon; E–G – *Camerospongia fungiformis* (Goldfuss, 1831); E – upper surface view; M183; phosphorite horizon; F – view of upper surface; M151; chalk; G – the same specimen, view of lower surface; A–E – Upper Campanian specimens redeposited to Lower Maastrichtian deposits; F, G – Upper Campanian

DESCRIPTION: The species is spherical or almost hemispherical with a deep central cavity, up to 35 mm high and 30–45 mm in diameter (Text-fig. 16E–G). Its upper part is convex or slightly flattened, covered by a thick membrane. There is a round or oval opening, 10–20 mm wide, on the summit. The lower part possesses radial, irregular ribs or papilliform outgrowths that run to the base of the stalk. The outgrowths are small and blindly terminated. The voids after dictyonal skeleton are poorly preserved. What is visible are only small fragments of the subdermal network with rectangular meshes, 0.3–0.35 mm in size, and a finely-porous cortex on the dermal surface.

REMARKS: The lower part uncovered by the membrane is best visible in the specimen infilled with white chalk. In comparison to other material of *C. fungiformis*, the specimens studied are relatively flat and the papilliform processes seem to be poorly developed. The observed differences may, however, be the result of compaction.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Coniacian and/or Santonian; Opole area, Turonian), Spain (Aptian); France (Albian), northern Germany (Campanian), England (Upper Coniacian–Santonian).

Family Ventriculitidae Smith, 1848
Genus *Rhizopoterion* Zittel, 1877

TYPE SPECIES: *Scyphia cervicornis* Goldfuss, 1826.

Rhizopoterion cribrosum (Phillips, 1829)
(=*Ventriculites radiatus* Mantell, 1822 *sensu*
Schrammen, 1912)
(Text-figs 17A, B; 18A, B)

1829. *Spongia cribrosa*; J. Phillips, pl. 1, fig. 7.
1837. *Scyphia longiporata* m.; G.G. Pusch, p. 7, pl. 2, fig. 3.
1883. *Ventriculites cribrosus* Phillips; G.J. Hinde, p. 113, pl. 26, fig. 2, 2a.
2006. *Rhizopoterion cribrosum* (Phillips); E. Świerczewska-Gładysz, pp. 252–254, figs 18a–d; 19; 20a–f (cum syn.).
2010. *Rhizopoterion cribrosum* Schrammen; E. Świerczewska-Gładysz, pp. 272, 273, fig. 14a.

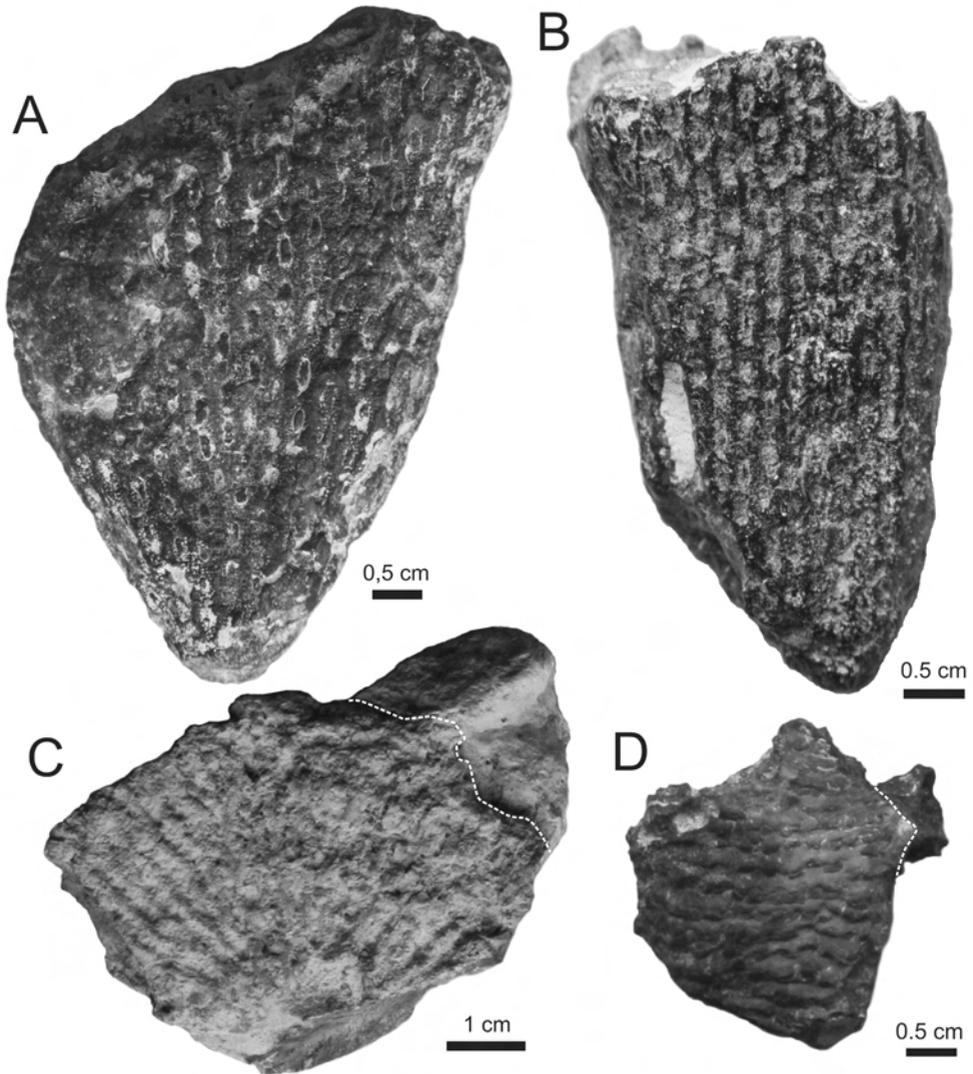
TYPE: The holotype, by monotypy, is the original of Phillips (1829, pl. 1, fig. 7). Phillips (1829) stated that the specimen originated from the White Chalk of Danes Dyke, Yorkshire, England. The section exposed at this locality is Santonian; the famous Flamborough

Sponge Beds, which crop out farther to the west, are Lower Campanian (see Mortimore *et al.* 2001, figs 5.19, 5.31). The specimen described by Phillips (1829) probably came from the Flamborough Sponge Beds. The original of Phillips cannot be located in the Phillips Collection in the Oxford University Museum of Natural History (personal communication Paul Jeffery, Oxford University Museum of Natural History); the present location of the specimen is unknown.

MATERIAL: 1 specimen from the flint horizon, 3 specimens from the chalk, 8 specimens from the hardground and 109 specimens from the phosphorite horizon.

DESCRIPTION: The species is trumpet- or funnel-shaped, with a short massive stem (Text-fig. 17A, B) and long rhizoids. The largest incomplete specimen in the material studied is 70 mm high. The wall is usually 5–7 mm thick, rarely up to 10 mm thick. The outer surface is covered with longitudinal elliptical canal openings, 1.5–2 mm × 3–4 mm in size, distributed in quincunx (Text-fig. 18A). The openings occur on the bottoms of shallow furrows that are separated by sinusoidal ribs, 1.5 mm wide. The transverse skeletal bands between the canal openings are 1–2 mm wide. In some of the specimens they can be of the same height as the ribs; in this case the furrows are less distinct. On the internal surface, the canal openings are less regularly distributed in quincunx. In the lower part of the sponges they are longitudinally elliptical, 1.2–1.5 × 2–2.5 mm in size. In the upper part, the elliptical or round canal openings are usually large, 2–3 mm in diameter. The dictyonal skeleton is irregular, with rectangular or quadrangular meshes, 0.3–0.4 mm in size (Text-fig. 18B). In the subdermal and gastral part there is a network with numerous synapticules. Both surfaces are covered with synapticular cortex, less developed on the gastral surface. Single siliceous filaments running across the canal openings are visible on the dermal surface of well-preserved specimens. The epirhyses are long, straight and parallel to the wall, terminating blindly under the surface of the inner side. The aporhyses are straight at the beginning, then run diagonally downwards and connect with the system of longitudinal canals running inside the wall (Text-fig. 18B). A thin synapticular membrane covers the canal walls.

REMARKS: *R. cribrosum* dominates (in abundance) the sponge assemblage from the phosphorite horizon in Mielnik. This taxon also dominated selected beds in the Middle Vistula Valley section (see Świerczewska-Gładysz 2006). The actual dominance of this species in a living assemblage could have been lower. Taking into account the fact that these sponges could have grown



Text-fig. 17. A, B – *Rhizopoterion cribrosum* (Phillips, 1829); A – lateral view of funnel-like morphotype (stalk not preserved); M144; phosphorite horizon; B – lateral view of incomplete trumpet-like morphotype; M17; phosphorite horizon; C–D – *Lepidospongia rugosa* Schlüter, 1870; C – lateral view; M200; hardground horizon; D – fragment of inner surface; M236; phosphorite horizon; A, B, D – Upper Campanian specimens redeposited to Lower Maastrichtian deposits; C – Upper Campanian

to over 20 cm in height, it cannot be excluded that some fragments may derive from the same individual.

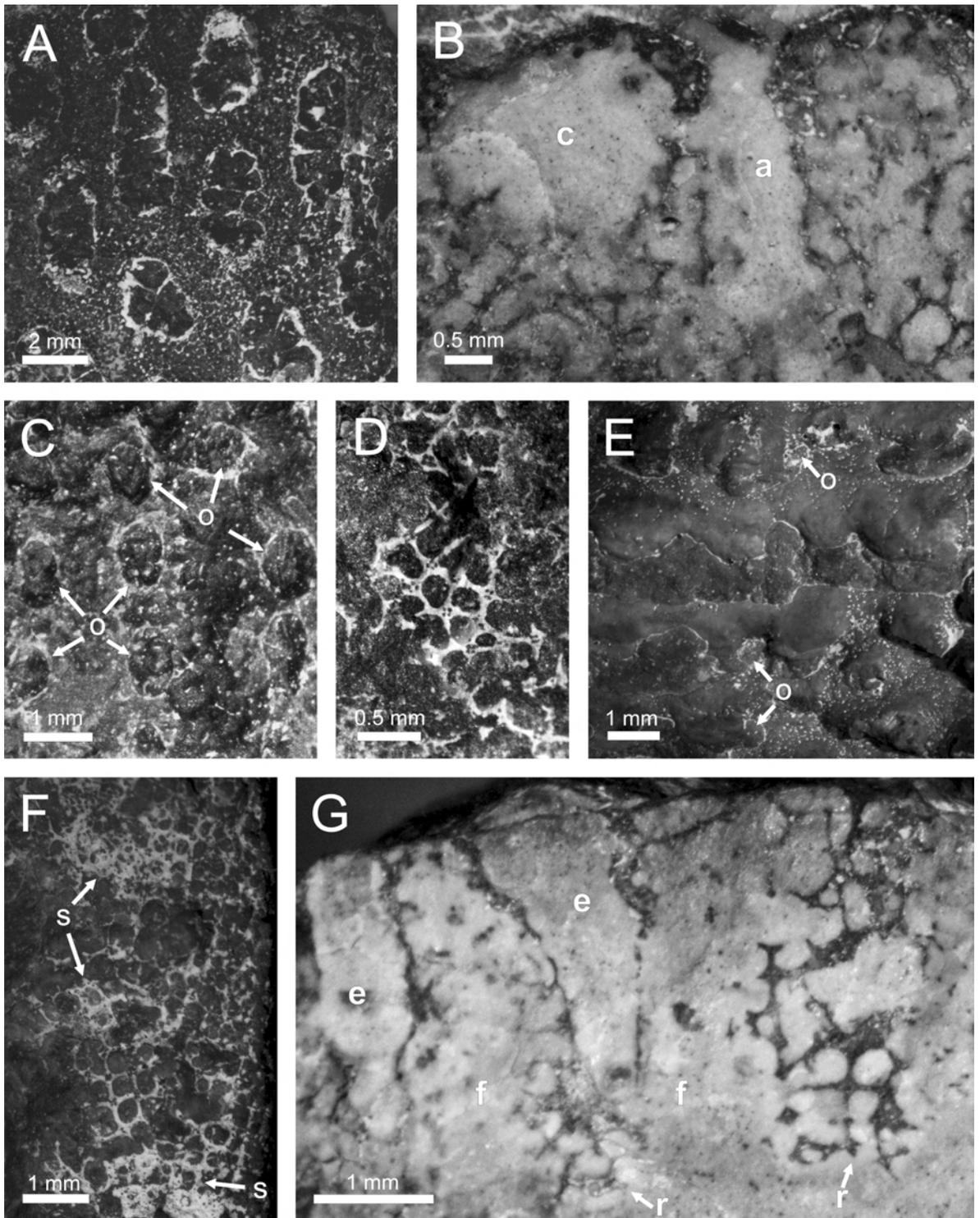
According to Reid (1962b), the species *Scyphia oeynhausii* Goldfuss, 1831 is the junior synonym of *Rhizopoterion cribrosum* (Phillips, 1829), which was wrongly identified by Schrammen (1912), with *Ventriculites chonoides* (Mantell, 1815) (= *V. radiatus* Mantell, 1822). Some specimens described as *S. oeynhausii* Goldfuss and *V. radiatus* Mantell from the Turonian of localities in Germany and Poland (Opole area) were included by Ulbrich (1974) in *Rhizopoterion cribrosum*, but the taxonomic position of these specimens remains problematic and requires further investigation.

OCCURRENCE: Poland (Mielnik, upper Lower to

Upper Campanian; Kraków area, Coniacian–Upper Campanian; Upper Middle Vistula Valley, Campanian–Lower Maastrichtian; Opole area, Turonian), northern Germany (Turonian–Campanian), England (Upper Coniacian–Maastrichtian), Northern Ireland (Santonian–Campanian), Isle of Rügen (Lower Maastrichtian), Ukraine (Crimea, Maastrichtian; northern Donbass region, Maastrichtian), Russia (Saratov area, Lower Santonian), ?France (Turonian).

Genus *Lepidospongia* Roemer, 1864

TYPE SPECIES: *Lepidospongia denticulata*, Roemer, 1864.



Text-fig. 18. A, B – *Rhizopoterion cribrosum* (Phillips, 1829); A – outer surface with voids after dermal cortex and siliceous filaments running across canal openings; M108; phosphorite horizon; B – transverse section through the wall; note voids glauconitized dictyonal skeleton and aporhyse (a) connected with longitudinal canal (c); M162; phosphorite horizon; C, D – *Leiostracosia punctata* Schrammen, 1902; C – outer surface with canal openings (o); M354; phosphorite horizon; D – the same specimen with glauconitized dictyonal skeleton; E, F – *Lepidospongia rugosa* Schlüter, 1870; E – inner surface with casts of siliceous plates; locally visible canal openings (o); M236; phosphorite horizon; F – the same specimen, longitudinal section through wall; visible glauconitized dictyonal skeleton with synapticles (s) in walls of epirhysses; G – *Leiostracosia orthogoniopora* (Defretin-Lefranc, 1960); transverse section through wall with furrows (f) and ribs (r) on inner surface; visible epirhysses (e) within glauconitized dictyonal skeleton of ribs; M26; phosphorite horizon; A–G – Upper Campanian specimens redeposited to Lower Maastrichtian deposits

Lepidospongia rugosa Schlüter, 1870
(Text-figs 17C, D; 18E, F)

1870. *Lepidospongia rugosa* Schlüter; C.A. Schlüter, p. 140.
 1872. *Lepidospongia rugosa* Schlüter; C.A. Schlüter, pp. 27, 28, pl. 1, figs 1–4.
 non 1980. *Lepidospongia rugosa* Schlüter: J. Malecki, p. 414, pl. 1, fig. 6 [= *Laocoetis virgatula* (Schrammen, 1912)].
 2006. *Lepidospongia rugosa* Schlüter; E. Świerczevska-Gładysz, p. 256, fig. 22a, b (cum. syn.).

TYPES: The holotype, by monotypy, is specimen StIPB-Schlüter 115, the original of Schlüter (1872, pl. 1, figs 1–4), from the Upper Campanian (Mukronaten-Kreide) of the Coesfeld-Osterwick area, Westphalia, Germany. It is housed in the Bonn University (Rheinische Friedrich-Wilhelms Universität, Paläontologisches Institut), Bonn, Germany.

MATERIAL: 1 specimen from the hardground and 2 specimens from the phosphorite horizon.

DESCRIPTION: The most complete specimen has the form of a wide cone, 43 mm in height (Text-fig. 17C), with a wall 4.5–5.5 mm thick. The external surface bears longitudinal, dichotomously bifurcating ribs, ca. 2 mm wide. The deep furrows between the ribs are 1 mm in width. The rounded or oval canal openings, are usually 1 mm × 1–1.5 mm in size, and arranged on the bottoms of the furrows. The gastral surface bears non-porous siliceous plates, 1–2 mm wide (Text-figs 17D, 18E). The plates form horizontal, wavy belts, of which the higher overlaps the lower one. Single canal openings, about 0.5 mm in diameter, are visible in places where the plates are partly destroyed. The straight long canals are perpendicular to the wall (Text-fig. 18F). The canal walls are covered with a thin synapticular membrane. The dictyonal skeleton is regular, with square or trapezoidal meshes, 0.25–0.3 mm in size (Text-fig. 18F). The fine-porous synapticular cortex is well developed on the dermal surface.

REMARKS: Four specimens have been assigned to *L. rugosa*, however, the diagnostic plates on the gastral side are only clearly visible on one specimen.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Campanian and Upper Maastrichtian; Kraków area, Campanian), northwest Germany (Campanian), England (Campanian, Maastrichtian) and Northern Ireland (Campanian).

Genus *Leiostracosia* Schrammen, 1902

TYPE SPECIES: *Leiostracosia punctata* Schrammen, 1902.

Leiostracosia punctata Schrammen, 1902
(Text-figs 18C, D; 19A)

1902. *Leiostracosia punctata* Schrm. n. sp.; A. Schrammen, p. 12, pl. 3, fig. 3.
 1912. *Leiostracosia punctata* Schrammen; A. Schrammen, p. 285, text-pl. 14, fig. 12; pl. 35, figs 1, 2.
 1962. *Leiostracosia punctata* Schrammen; L. Lagneau-Hèranger, p. 97, text-pl. 14, fig. 2.
 2006. *Leiostracosia punctata* Schrammen; E. Świerczevska-Gładysz, pp. 260–262, figs 27e, f, 28a–c.

TYPES: The holotype by monotypy is the original of Schrammen (1902, pl. 3, fig. 3) from the Campanian of Misburg, Germany. This specimen, no. 158, is housed in the Roemer Museum in Hildesheim, Germany.

MATERIAL: 3 specimens from the hardground and 4 specimens from the phosphorite horizon.

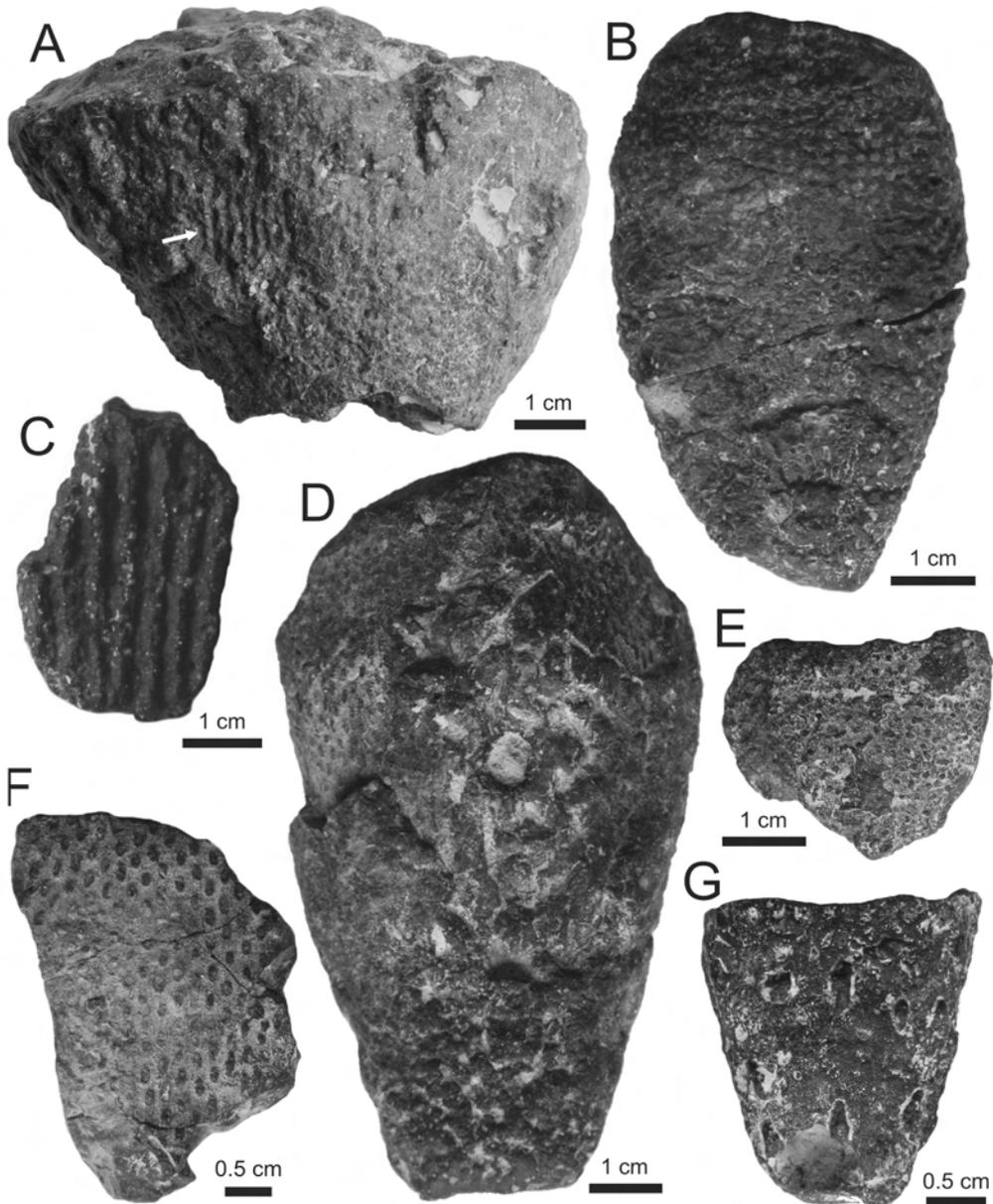
DESCRIPTION: The specimens studied are fragments of thin-walled (2.5–4 mm thick), funnel-shaped sponges. The cone-shaped upper parts are up to 54 mm in height and 75 mm in diameter (Text-fig. 19A). The narrow conical to cylindrical lower parts are up to 85 mm high. Their external surface is covered by very small rounded canal openings, 0.5 mm in diameter (Text-fig. 18C). Their upper part is covered with rounded, or rarely slightly oval canal openings, 0.8–1 mm in size, arranged in longitudinal and less distinct, horizontal rows. The longitudinal flat skeletal bands separating them are 1 mm wide. The transverse bands are of similar width or slightly narrower. The inner surface bears radial ridges and furrows, 1 mm wide. The rounded canal openings, about 1 mm in diameter, lie on the bottoms of the furrows and similarly as on the external surface are arranged in horizontal rows. The canals are perpendicular to the wall and are distributed in independent longitudinal series. The long epirhyses terminate below the ridges of the inner surface. The aporhyses are shorter than the epirhyses, and terminate below the longitudinal skeletal bands of the dermal surface. An indistinct indication of a synapticular cortex is present on the dermal surface. The dictyonal skeleton of the subdermal part is irregular, with quadrangular meshes, 0.2–0.4 mm in size. Within the

wall, the lychniscs form more regular network with rectangular or quadrangular meshes, 0.25–0.3 mm × 0.3–0.4 mm in size (Text-fig. 18D). The gastral surface is without a cortex.

REMARKS: The specimens studied are characterized by rounded canal openings, arranged in regular vertical and horizontal rows on both surfaces, features typical of *L. punctata*. The diameter of the canal openings

on the external surface is slightly larger than in specimens from Germany, but corresponds to the values observed in specimens from the Middle Vistula Valley.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Campanian–Lower Maastrichtian), France (Albian), northwest Germany (Campanian), England (Santonian).



Text-fig. 19. A – *Leiostracosia punctata* Schrammen, 1902; lateral view; locally visible voids of inner surface with ribs and furrows (pointed by arrow); M354; phosphorite horizon; B, C – *Leiostracosia orthogoniopora* (Defretin-Lefranc, 1960); B – lateral view; M26; phosphorite horizon; C – fragment of inner surface; M218; phosphorite horizon; D–F – *Sporadoscimia capax* Hinde, 1883; D – lateral view; M80; phosphorite horizon; E – fragment of outer surface; M23; phosphorite horizon; F – imprint of inner surface; M41; phosphorite horizon; G – *Varioporospongia dariae* Świerczewska-Gładysz, 2006; fragment of lower part of specimen; M29; phosphorite horizon; A–G – Upper Campanian specimens redeposited to Lower Maastrichtian deposits

Leiostracosia orthogoniopora (Defretin-Lefranc,
1960)
(Text-figs 18G; 19B, C)

1960. *Porocylus orthogonioporus* nov. sp.; S. Defretin-Lefranc, pp. 69, 70, text-fig. 20; pl. 6, figs 1–2.

2006. *Leiostracosia orthogoniopora* (Defretin-Lefranc); E. Świerczewska-Gładysz, pp. 262, 263, figs 27a, b; 28d–j; 29 (cum syn.).

TYPES: The holotype, by original designation, is specimen no. MGL 6128-A, the original of Defretin-Lefranc (1960, pl. 6, figs 1, 2), from the *Micraster cortestudinarium* Zone, Coniacian, of Lezennes, France. The specimen is housed in the Musée d'Histoire naturelle de Lille (Museum Gosselet), France.

MATERIAL: 3 specimens from the hardground and 21 specimens from the phosphorite horizon.

DESCRIPTION: The species is cone- or cup-like with a thin stalk. The wall is relatively thick, 5–7 mm. The largest, nearly completely preserved specimen is 74 mm high and 42 mm in diameter (Text-fig. 19B). The outer surfaces of the lower parts of specimens bear canal openings that are rounded or even longitudinally oval, about 1 mm in diameter. In the upper part the canal openings are in the shape of irregular rectangles, up to 2.5 mm in diameter. They are transversely longitudinal and arranged in longitudinal rows, separated by flat skeletal bands, 1–2 mm wide. The transverse bands are narrower, up to 1 mm wide. On the internal surface the small round canal openings are located in longitudinal deep grooves, 1–2 mm wide (Text-fig. 19C). The ridges between grooves are of the same width or slightly narrower, 1–1.5 mm wide. The dictyonal skeleton is regular, with quadrangular or longitudinally rectangular meshes, 0.25–0.30 mm × 0.25–0.35 mm in size (Text-fig. 18G). The dense synapticular cortex is developed on the dermal surface. The synapticular membrane covers the walls of the epirhyses. The gastral surface and the walls of the aporhyses are without cortex. The diploporal canalization with cylindrical canals is perpendicular to the wall (Text-fig. 18G). The canals are arranged in longitudinal series—long epirhyses terminate below ridges on the gastral surface, whereas short aporhyses terminate under longitudinal skeletal bands of the dermal surface.

REMARKS: The external surfaces of the specimens studied are usually poorly preserved. Because of that, the cortex and the quadrangular canal openings characteristic of *L. orthogoniopora* are only rarely visible.

Typically, a subdermal skeleton (glauconitized or preserved as voids) is visible on the outer surface of the specimens, cut by epirhyses, with a rounded outline. Due to the poor state of preservation, some features of the internal surface, such as canalization on the bottom of the furrows and the siliceous filament running from the ray of gastral lychnics, are also rarely visible.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Maastrichtian), France (Coniacian), Ukraine (Podillia, Upper Maastrichtian).

Genus *Sporadoscinia* Pomel, 1872

TYPE SPECIES: *Scyphia retiformis* Roemer, 1841.

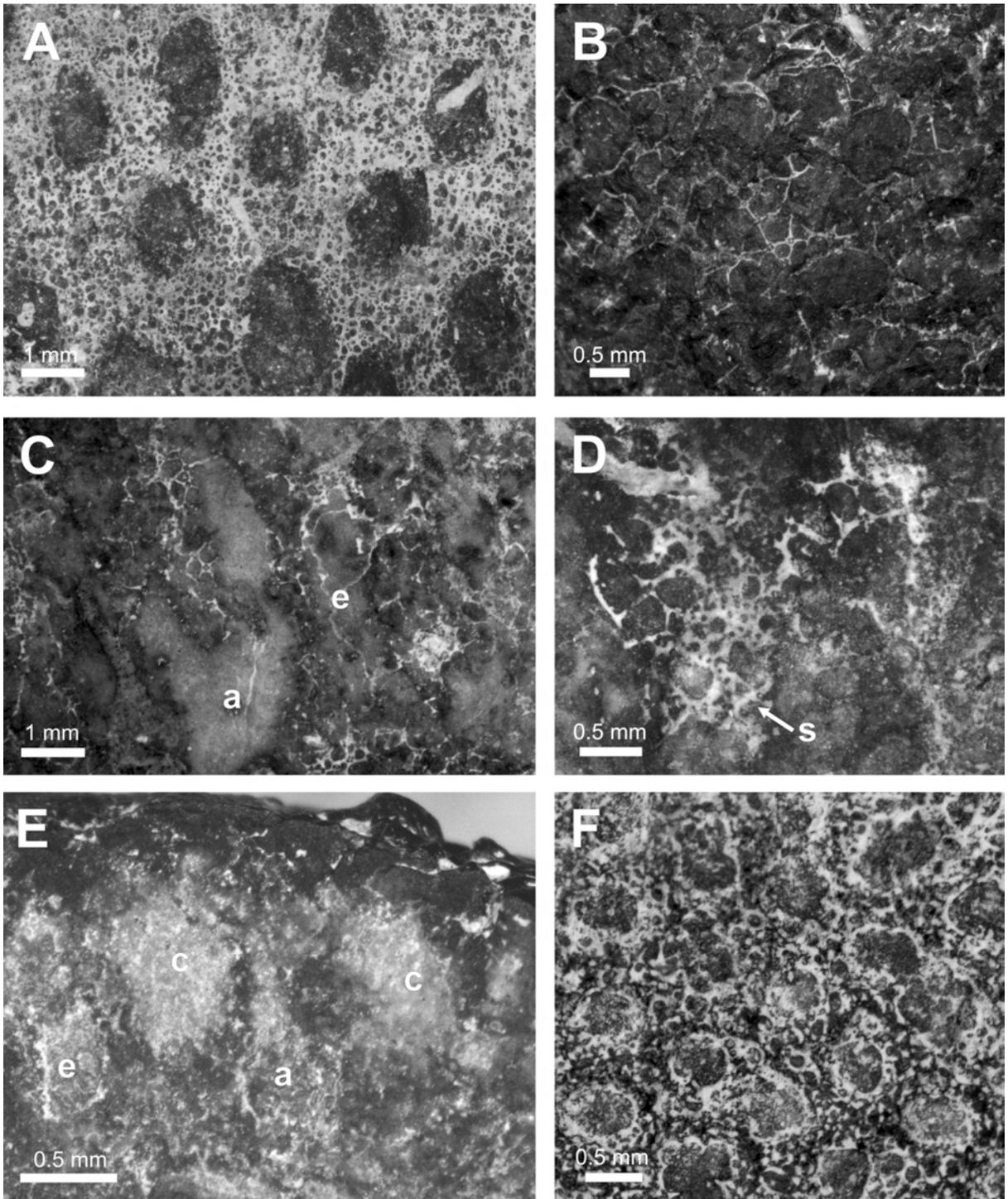
Sporadoscinia capax Hinde, 1883
(Text-figs 19D–F; 20A, B)

1883. *Sporadoscinia capax* n. sp.; G.J. Hinde; pp. 116, 117, pl. 26, figs 4, 4a, 4b.
?1889. *Sporadoscinia capax* Hinde; E. Dunikowski, p. 81, pl. 4, fig. 5.
1912. *Sporadoscinia teutoniae* nov. sp.; A. Schrammen, p. 283, pl. 38, figs 1–3.
?1933. *Sporadoscinia* aff. *capax* Hinde; F. Bieda, pp. 31, 32, pl. 1, fig. 4.
?1960. *Sporadoscinia capax* Hinde; S. Defretin-Lefranc, pp. 74, 75, pl. 7, fig. 7.
1960. *Sporadoscinia teutoniae* Schrammen; S. Defretin-Lefranc, p. 73, pl. 7, figs 3, 4.
1962. *Sporadoscinia teutoniae* Schrammen; L. Lagneau-Hèrenger, p. 96, text-pl. 14, fig. 5.
1974. *Sporadoscinia teutoniae* Schrammen; H. Ulbrich, p. 63, pl. 15, fig. 3.

TYPES: The holotype, by monotypy, is the specimen P.1755, illustrated by Hinde (1883, pl. 26, figs 4, 4a, 4b), from the Lower Chalk (South of England, locality unknown), England. The specimen is housed in the Natural History Museum, London.

MATERIAL: 3 specimens from the hardground and 21 specimens from the phosphorite horizon.

DESCRIPTION: These are conical to tubular sponges (Text-fig. 19D), up to 100 mm high and 60 mm in diameter, with 2.5–3.5 mm thick walls. The outer surface is covered with transversely elliptical, rarely rounded or irregular, canal openings, 1–2 mm in size



Text-fig. 20. A, B – *Sporadoscimia capax* Hinde, 1883; A – glauconitized cortex on gastral surface with canal openings; M1; phosphorite horizon; B – section parallel to surface; note glauconitized dictyonal skeleton and canals; M28; phosphorite horizon; C, D – *Sporadoscimia micrommata* (Roemer, 1841); C – transverse section through the wall; note glauconitized dictyonal skeleton with epirhyses (e) and dividing aporhyses (a); M166; phosphorite horizon; D – the same specimen, glauconitized dictyonal skeleton with synapctic membrane around canals (s); E – *Varioporospongia dariae* Świerczewska-Gładysz, 2006; transverse section through wall; note epirhyse (e) and aporhyse (a) running to system of internal chambers (c); M29; phosphorite horizon; F – *Coscinopora infundibuliformis* Goldfuss 1826; glauconitized cortex on dermal surface with canal openings (note locally lychniscs of subdermal skeleton); M208; phosphorite horizon; A–F – Upper Campanian specimens redeposited to Lower Maastrichtian deposits

(Text-fig. 19E). In the lower part, which gradually passes into the thin stalk, the canal openings may be longitudinally elongated. Evenly spaced canal openings (60/cm²) are separated by flat skeletal bands, 0.7–0.9 mm wide. In the lower part, where the skeletal bands are widest, the spacing of the canal openings is only 25/cm². On the inner surface the canal openings are organized in alternating patterns, 24/cm² (Text-fig. 19F, 20A). The openings are oval, 1 mm × 1.5–2.5 mm in diameter. The long straight canals are perpendicular to the wall and terminate blindly below the opposite surface. The dictyonal skeleton is irregular, with rectangular, trapezoidal or triangular meshes, 0.2–0.35 mm in size (Text-fig. 20B). The thick, fine-porous synapticular cortex (Text-fig. 20A) occurs on the gastral surface. It is finer on the dermal surface.

REMARKS: According to Reid (1968a), *Sporadoscinia teutoniae* Schrammen, 1912 is the junior synonym of *S. capax*. The shape and distribution of the canal openings on both surfaces in the types of both species support this statement. *S. capax* seems to be a common Late Cretaceous species, but some of the published specimens are poorly preserved and consequently their determination is uncertain (see synonymy). The pattern of canals within the wall of *S. capax* is a disputable issue. In the species diagnosis, and in some descriptions, this feature has been omitted. According to Ulbrich (1974), the epirhyses surrounded by branching aporhyses pass into chambers running below the gastral surface. In the material from Mielnik such chambers were not observed and the pattern of canals corresponds to the description presented by Schrammen (1912).

OCCURRENCE: Poland (Mielnik, Upper Campanian; ?Kraków area, Lower Campanian), northwest Germany (Campanian), France (Albian, Coniacian), England (Cenomanian, Santonian and Maastrichtian).

Sporadoscinia micrommata (Roemer, 1841)
(Text-figs 20C, D; 21)

1841. *Scyphia micrommata* N.; F.A. Roemer, p. 7, pl. 2, fig. 11 *partim*.

1968. *Sporadoscinia micrommata* Roemer; H. Hurcewicz, p. 83–85 (cum syn.).

TYPES: The holotype, by monotypy, is the original of Roemer (1841, pl. 2, fig. 11), from the Campanian of Coesfeld, Westphalia, Germany. This specimen, no. 520 (old number 147), is housed in the Roemer Museum in Hildesheim, Germany.

MATERIAL: 2 specimens from the chalk, 6 specimens from the hardground and 6 specimens from the phosphorite horizon.

DESCRIPTION: These are cup-shaped sponges, up to 115 mm high and 80 mm in diameter (Text-fig. 21), with a thin stalk. The wall is 4–5 mm thick. On the outer surface there occur horizontally elongated elliptical or lentoid canal openings, 1.2–2 mm in length and 0.7–1 mm wide. Thin skeletal bands between the canal openings are up to 0.5 mm wide. The canal openings are densely and evenly spaced, 25–45/cm². On the inner side, the canal openings are round or slightly elongated, 1 mm × 1–1.2 mm in diameter, distributed in quincunx, about 25/cm². On the dermal surface the canal openings directly connect to 1 or 2 long blind epirhyses, 0.5–1 mm in diameter. Straight or divided aporhyses terminate below the dermal surface (Text-fig. 20C). Inside the wall the canals are arranged in relatively regular vertical series. The skeleton structure is similar to that of *S. capax* (Text-fig. 20D).

REMARKS: The features of the external surface, characteristic of *S. micrommata* are clearly seen in the specimens from the hardground. In specimens from the phosphorite horizon only small fragments of the outer surface are preserved, containing a hitherto undescribed pattern of canals in the form of longitudinal series.

Among the specimens from the Campanian of the Kraków area, referred to *S. micrommata* by Hurcewicz (1968), there is one specimen (no. UL III/210) that is distinctly different from the remaining ones. Its external side bears longitudinal rows of small, rounded canal openings, a feature characteristic of *S. venosa* Schrammen, 1912.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Lower and Upper Campanian), northwest Germany (Campanian), England (Santonian–Maastrichtian).

Genus *Varioporospongia* Świerczewska-Gładysz, 2006

TYPE SPECIES: *Varioporospongia dariae* Świerczewska-Gładysz, 2006.

Varioporospongia dariae Świerczewska-Gładysz, 2006
(Text-figs 19G; 20E)

2006. *Varioporospongia dariae* sp. n.; E. Świerczewska-Gładysz, pp. 264, 265, figs 30a–f; 31.

TYPES: The holotype, by original designation, is the original of Świerczewska-Gładysz (2006, pl. 30A), from the Upper Maastrichtian of Kazimierz, Middle Vistula Valley, Poland. This specimen, no. UL XX 7/67, is housed in the Geological Laboratory of Łódź University.

MATERIAL: 4 specimens from the phosphorite horizon.

DESCRIPTION: These are conical sponges with walls 3–5 mm thick. The largest fragment (lower part of the sponge) measures 31 mm in height and 26 mm in diameter (Text-fig. 19G). The canal openings on the external surface are longitudinally oval, 1.5–2 × 2–4 mm in diameter. These openings are arranged sparsely, without any particular pattern. The canal openings on the inner surface are longitudinally oval, 1 × 2.5 mm in diameter, and regularly arranged. The diporhysal canalization is composed of blindly wide epirhyses. The aporhyses run to irregular chambers, 1–3 mm in size, situated in the central part of the wall (Text-fig. 20E). Short canals running from the chambers directly through the wall form additional small, 0.5–1 mm, round openings on the dermal surface. The accessory openings are randomly spaced. The thick, synapticular cortex occurs on both surfaces. Only single voids after lychniscs are visible inside the wall.

REMARKS: In specimens from the Middle Vistula Val-

ley, the chambers occurring within the wall to which the aporhyses run, reach 5 mm in diameter; they are thus much larger than the chambers observed in the specimens studied. These differences may be the result of intraspecific variability, but might also result from the fact that in the Middle Vistula Valley material, the measurements were made in the upper parts of the sponges. The specimens from Mielnik are only fragments of the lower parts, where the chambers could have been smaller.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Middle Vistula Valley, Upper Maastrichtian).

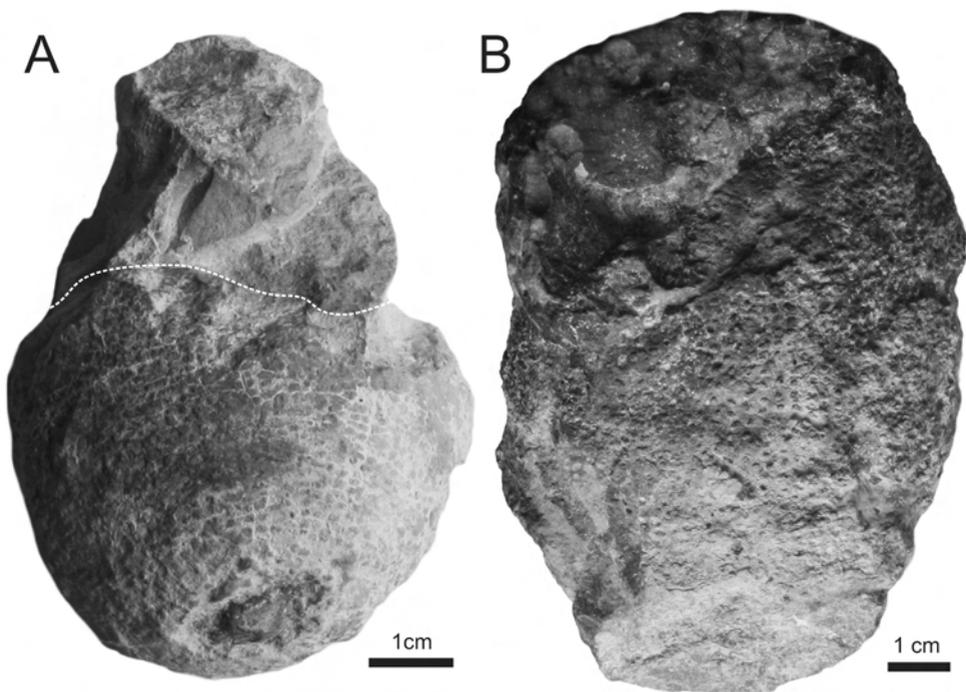
Genus *Coscinopora* Goldfuss, 1826

TYPE SPECIES: *Coscinopora infundibuliformis* Goldfuss, 1826.

Coscinopora infundibuliformis Goldfuss, 1826
(Text-fig. 20F)

1826. *Coscinopora infundibuliformis* nobis; A. Goldfuss, p. 30, pl. 9, fig. 16; pl. 30, fig. 10.

2010. *Coscinopora infundibuliformis* Goldfuss; E. Świerczewska-Gładysz, pp. 274, 275, figs 14B, 15A (cum syn.).



Text-fig. 21. A, B – *Sporadoscinia micrommata* Roemer, 1841; A – lateral view; M84; hardground; Upper Campanian; B – lateral view of specimen with eroded wall; visible casts of canals; M94; phosphorite horizon; Upper Campanian specimen redeposited to Lower Maastrichtian deposits

TYPES: The lectotype, designed herein, is the original of Goldfuss (1826, pl. 30, fig. 10), from the Campanian of Coesfeld, Westphalia, Germany. This specimen, no. StIPB-Goldfuss 112b, is housed in Bonn University (Rheinische Friedrich-Wilhelms Universität, Paläontologisches Institut, Bonn, Germany).

MATERIAL: 2 specimens from the phosphorite horizon.

DESCRIPTION: The specimens studied are platy-like fragments derived from thin-walled (2.5 mm thick), cup-shaped sponges. The largest fragment is 2.5 cm high. The outer-surface canal openings are rounded and measure about 0.5 mm in diameter. They are regularly distributed in quincunx, 100–120/cm². Dermal surfaces are covered by very thick, finely-porous cortex (Text-fig. 20F). In places, where the cortex is destroyed, small fragments of the subdermal skeleton with longitudinally rectangular meshes, 0.2–0.25 × 0.35–0.4 in size, are visible. The inner surface and the patterns of canals inside the wall are not visible.

REMARKS: The specimens have been attributed to *C. infundibuliformis* on the basis of the skeleton type and character of the canal openings on the dermal surface.

OCCURRENCE: Poland (Mielnik, Upper Campanian; Kraków area, Coniacian/Santonian, Lower and Upper Campanian; Opole area, Upper Turonian–Lower Coniacian), France (Coniacian), northern Germany (Campanian), England (Upper Coniacian–Campanian).

REMARKS

The black phosphatized sponges were reburied, and/or transported and incorporated in the lower Lower Maastrichtian deposits covering the hardground. The occurrence of other phosphatized black elements, such as alveoli of *Belemnitella* guards (probably *Belemnitella mucronata*) suggests a Late Campanian age of the phosphatized deposits. The phosphatized sponges above the hardground are presumably also of Late Campanian age.

The sponge species occurring in the Mielnik section are typical of the sponge assemblages from the Upper Cretaceous of Europe (Table 2). In particular, they are well-known in the Campanian deposits of Germany (e.g., Schrammen 1902, 1912; Ulbrich 1974; Gasse *et al.* 1988; Mehl 1992). Only *Polyopesia macropora* is described as a new species herein. Most of the species described from Mielnik are also known in the Campanian deposits of the Middle Vistula River Valley (Świerczewska-Gładysz 2006) and of the Kraków area (Bieda 1933; Hurcewicz

| | Sponge taxa | Apt | Alb | Cen. | Tur. | Con. | Sant. | Camp. | Maast. | |
|---|--|-----|------|------|------|-------------|--------------|----------------|-----------|-----|
| HEXACTINOSIDA | <i>Aphrocallistes alveolites</i> (Roemer, 1841) | | | | | R | R | E,I,G,U,R,V,K | G,U,V | |
| | <i>Aphrocallistes cylindrodactylus</i> Schrammen, 1912 | | | | | ////// | | E,I,G,V,L | E,U,V | |
| | <i>Eurete</i> sp. | | | | | | | | | |
| | <i>Leptophragma micropora</i> Schrammen, 1912 | | | | | E | //////E,G,?R | G,V,K,L | U,V | |
| | <i>Leptophragma muchisoni</i> (Goldfuss, 1831) | | | E,U | | E,F | E | E,G,U,V,K,L | U,V | |
| | <i>Polyopesia macropora</i> sp. n. | | | | | | | | | |
| <i>Wollemannia araneosa</i> Schrammen, 1912 | | | | | | F?////// | F? | F?,G,V | U,V | |
| LYCHNISCOSIDA | <i>Camerospongia fungiformis</i> (Goldfuss, 1831) | S | F | | G,O | E | E | G | | |
| | <i>Coeloptychium agaricoides</i> Goldfuss, 1826 | | | | | | | E,I,G,U,K | E | |
| | <i>Coscinopora infundibuliformis</i> (Goldfuss, 1826) | | | | O | F,E,O////// | E | E,G,K | | |
| | <i>Cyclostigma lobata</i> Schrammen, 1912 | | | | | | | G | V | |
| | <i>Cyclostigma maeandrina</i> Schrammen, 1912 | | | | | E | E | G,V | V | |
| | <i>Leiostracosia punctata</i> Schrammen, 1902 | | F | | | | | E | G,V | V |
| | <i>Leiostracosia orthogoniopora</i> (Defretin-Lefranc, 1960) | | | | | F | | | | U,V |
| | <i>Lepidospongia rugosa</i> Schlüter, 1870 | | | | | | | | E,I,G,K,V | E,V |
| | <i>Rhizopoterion cribrosum</i> (Phillips, 1829) | | | | ?F | K////// | E,I | E,I,G,V,L,K,?R | E,G,U,V | |
| | <i>Sporadoscina capax</i> Hinde, 1883 | | F,?U | E | | F | E | G,?K | E | |
| | <i>Sporadoscina micrommata</i> Roemer, 1841 | | | | | | E | E,G,K | E | |
| | <i>Varioporospongia dariae</i> Świerczewska-Gładysz, 2006 | | | | | | | | | V |

Table 2. Stratigraphic distribution of sponges recognized in the studied succession, as reported from various areas of Europe; E – England (after Reid 1968a; Wiese and Wood 2001), F – France (after Defretin-Lefranc 1960; Lagneau-Hérenge 1962), G – Germany (after Schrammen 1910–12; Nestler 1961; Ulbrich 1974; Wiese and Wood 2001), I – Northern Ireland (after Reid 1968a), V – Middle Vistula River Valley, Poland (after Świerczewska-Gładysz 2006), K – Kraków area, Poland (after Bieda 1933; Hurcewicz 1968), O – Opole area, Poland (after Tarkowski 1991), R – Saratov region, Russia (after Sinzov 1871–72), S – Spain (after Hérenge 1942), U – Ukraine (after Dunikowski 1889; Khmilyevsky 1974, 1977, 1978, 1979; Świerczewska-Gładysz 2006); white bar with oblique black line represent probable stratigraphic range of sponges redeposited to Upper Santonian deposits in the Kraków area in southern Poland (after Olszewska-Nejbert and Świerczewska-Gładysz 2009;

1968). Nine species: *Wollemannia araneosa*, *Aphrocallistes alveolites*, *Aphrocallistes cylindrodactylus*, *Leptophragma murchisoni*, *Leptophragma micropora*, *Cyclostigma maeandrina*, *Leiostracosia punctata*, *Lepidospongia rugosa* and *Rhizopoterion cribrosum* occur in the Upper Campanian siliceous chalk of the Middle Vistula Valley section. Four species: *Coeloptychium agarioides*, *Coscinopora infundibuliformis*, *Sporadoscinia capax* and *Sporadoscinia micrommata*, which are not recognized in the Upper Campanian of the Middle Vistula Valley section, are known from the Campanian deposits of the Kraków area. Only three species from the Upper Campanian of Mielnik: *Cyclostigma lobata*, *Leiostracosia orthogoniopora*, and *Varioporospongia dariae* appeared in Poland in the Maastrichtian of the Middle Vistula Valley section. The species *Camerospongia fungiformis* was also not described from Campanian localities in Poland. This species occurs in redeposited assemblage of sponges in the Santonian deposits of the Kraków area (Świerczewska-Gładysz 2010).

The original material infilling the bodies of all the sponges from Mielnik was calcareous ooze containing coccoliths and foraminifera. This suggests that all the sponges inhabited a similar environment.

Only the post-mortem histories of the sponges buried in the coccolith ooze were subjected to different geochemical conditions. In the entire section composed of white chalk and flints, the Hexactinellida are rare and poorly preserved. Phosphatization seems to be the most favourable process for the fossilization of the Hexactinellida in the “white chalk” environment. However, in comparison with occurrences of phosphatized sponges in Upper Cretaceous deposits elsewhere in Poland (compare Hurcewicz 1988; Świerczewska-Gładysz and Olszewska-Nejbert 2006; Olszewska-Nejbert and Świerczewska-Gładysz 2009; Świerczewska-Gładysz 2010), the abundance of phosphatized sponges in the phosphorite horizon at Mielnik is low. This suggests that hexactinellids were not particularly numerous biotic elements during the time of “white chalk” sedimentation in the Mielnik area.

Numerous assemblages of similar or the same age (Late Campanian) are known from the siliceous chalk of Piotrawin quarry, in the Middle Vistula Valley, a region situated relatively close to Mielnik (Świerczewska-Gładysz 2006). The taxonomic variability of hexactinellid sponges recorded in the Piotrawin section is also higher than in Mielnik. In the upper part of the succession (“*Inoceramus*” *inkermanensis* Zone after Walaszczyk 2004) 14 Hexactinosida and 10 Lychniscosida occur, whereas in the Mielnik section 7 and 12 species are recognized respectively.

The extant rare Hexactinosida and the relict Lych-

niscosida preferred deeper parts of the seas, especially the bathial zone (e.g., Ijima 1927; Koltun 1967; Vacelet 1969; Tabachnick 1988; Van Soest and Stenotoft 1988; Duplessis and Reisswig 2004; Janussen and Tendal 2007). A more abundant shelf assemblage of hexactinosan sponges has been reported only from offshore British Columbia (Krautter *et al.* 2001, 2006; Conway *et al.* 2004, 2007; Cook *et al.* 2008). They are very rare in shallower seas (Finks and Rigby 2004) and occur in specific environmental conditions close to the oceanic one (Leys *et al.* 2004; Whitney *et al.* 2005). It is therefore assumed that the fossil hexactinellids are indicators of a calm deep-water palaeoenvironment (e.g., Reid 1968b; Pisera 1997; Pisera and Busquets 2002; Krautter 1997, 1998). During the Late Cretaceous, the present Middle Vistula Valley area was situated in the Danish-Polish Trough, the deepest part of the epicontinental sea (Hakenberg and Świdrowska 1998), where the deep water Hexactinellida had favourable conditions in which to live. Not only the sponges (Świerczewska-Gładysz 2006), but also the molluscs (Pozaryski 1960; Abdel-Gawad 1986) indicate a deep-water environment (the depths of the outer shelf) in Late Campanian times. In comparison to the Middle Vistula Valley area, sedimentation of calcareous mud (white chalk) in the Mielnik area took place in a shallower sea (e.g., Olszewska 1990b). Less favourable shallower conditions were presumably the main cause of the lower abundance and lower species diversity of the hexactinellids in the Mielnik area.

CONCLUSIONS

1. Almost all the sponges (98% of the specimens determined) belong to the orders Lychniscosida (74%) and Hexactinosida (24%). The remaining sponges (undetermined) belong to the Lithistida (2%).
2. Twelve hexactinosid species and 19 lychniscosid species were distinguished. The new species *Polyopesia macropora* was described. The entire sponge assemblage includes representatives typical of the European epicontinental seas in the Late Cretaceous.
3. 85% of the sponge specimens (black sponges), are strongly phosphatized and 11% are slightly phosphatized (grey-beige sponges). Only 4% of the specimens are preserved as a result of some other fossilization process, such as silicification or infilling with white chalk. Phosphatization was the dominant fossilization process of the sponges in the white chalk of Mielnik.

4. All the black phosphatized sponges and clasts were destroyed and rounded during redeposition (reburial or/and local transport) in the sedimentary environment of the Maastrichtian chalk with glauconite. These redeposited black phosphatized sponges probably derived from the Upper Campanian.
5. A low abundance and lower taxonomic variability of the hexactinellid sponges is noted in the Upper Campanian white chalk of Mielnik in comparison to the Upper Campanian siliceous chalk of the Middle Vistula Valley section. This can be attributed to the shallower (but not extremely shallow) water environment of “white chalk” deposition being less favourable for hexactinellid sponges than the deeper-water environment of “siliceous chalk” deposition.

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