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SERPUKHOVIAN (EARLY CARBONIFEROUS) RUGOSA (ANTHOZOA) FROM THE LUBLIN BASIN, EASTERN POLAND

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Abstract: Sixteen rugose coral species, two known previously, nine new, three left in open nomenclature, and two identified as *affinis*, are described from the early Serpukhovian strata of the Lublin area, eastern Poland. Rugose corals of that age here are described for the first time from Poland. New genera include *Birkenmajerites*, *Chelmia* and *Occulogermen*. New species include: *Axisvacuus tenerus*, *Birkenmajerites primus*, *Chelmia radiata*, *Nervophyllum lukoviensis*, *Occulogermen luciae*, *Rotiphyllum plumeum*, ?*Sochkineophyllum symmetricum*, *Zaphrentites rotiphylloides* and, *Zaphrufimia anceps*. A brief analysis of the taphonomy, possible relationships and geographical connections of the corals described here to rugose coral faunas from adjacent areas also is included.

Key words: Early Serpukhovian, Rugosa (Anthozoa), taxonomy, palaeogeography, taphonomy.

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INTRODUCTION

Carboniferous deposits in the Lublin area (eastern Poland) have been described in detail by several authors (see Geological setting) with the most important data concerning their biostratigraphy being summarized by Skompski (1996, 1998). Previous studies dealing with rugose corals from late Viséan (Brigantian) strata are restricted to the paper by Fedorowski (1968) and the monograph by Khoa (1977). In the present account, all of the specimens collected by Dr. Łucja Musiał from the Pendleian (*Eumorphoceras* E1 Biozone) deposits are described. All of these corals came from drill cores. Thus, they are very limited in number and their preservation is not good in all cases. However, their occurrence fills the gap both geographically and stratigraphically between the mainly late Serpukhovian (*Eumorphoceras* E2 Biozone) Rugosa, known from the Upper Silesia Basin (Schindewolf, 1942, 1952; Weyer, 1974, 1977; Fedorowski, 2009a, 2010, 2012; Fedorowski and Machłajewska, 2014), related to the Western European faunas, and the much more complete Eastern European faunas (Viséan and Serpukhovian), best known from the Donets Basin. The unique character of the coral fauna from the Lublin Basin legitimizes the introduction of several new taxa, based on very few specimens or even a single specimen. However, all these new taxa appear so distant morphologically from the existing, comparable taxa that their separate taxonomic status is obvious. The alternative of leaving these forms in open nomenclature would not change the situation, but would make comparison to faunas elsewhere more difficult.

Diagnoses of the taxa described here start from a subfamily/family name in the case of genera and a generic name in the case of species. This method prevents repetition of all characters diagnostic for a subfamily/family or a genus and restricts a given diagnosis to characters, typical for the particular taxon being diagnosed. Also, following Hudson (1936) and Fedorowski (1997), only the cardinal and counter septa are considered to be the protosepta. All other major septa, including the alar and counter-lateral septa, are considered to be the metasepta.

The term “primary septa” refers to the innermost parts of septa, secreted prior to the secretion of the sclerenchymal sheets of septa. That same term was used by Carruthers (1908, 1910) for the protosepta. However, Carruthers’ terminology has not been used for many decades, being replaced by the term protosepta.

MATERIAL AND METHODS

The rugose corals described in this paper were collected from the following deep exploration wells: Łuków IG-4, Rudno IG-1, Parczew IG-3, Cyców IG-1, Chełm IG-2, Hostynne IG-1 and Telatyn IG-1.

The state of preservation of the corals varies. Many of them are compressed, several squeezed to an extent that makes identification of them either impossible or highly speculative. Such specimens were not accepted as study material, despite the fact that they were considered in the study of some details and are illustrated in the Taphonomy sec-

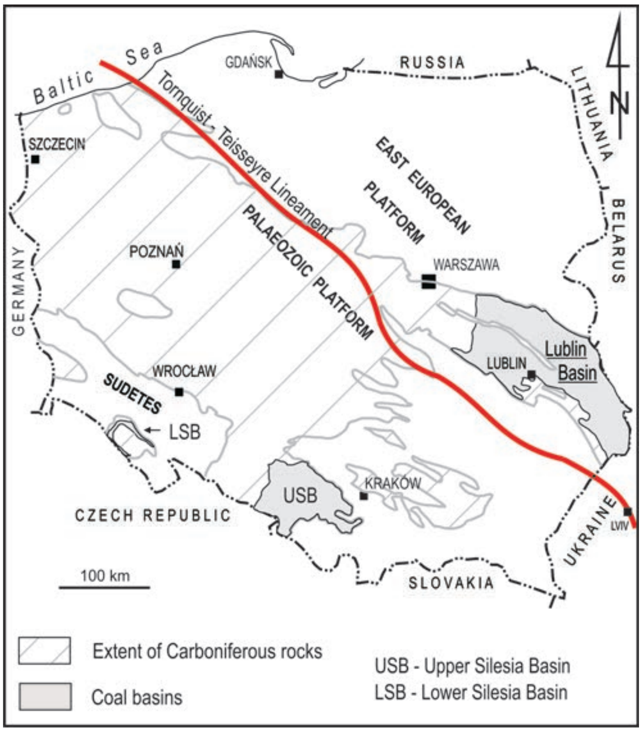


Fig. 1 Sketch map of the Carboniferous deposits in Poland.

tion. The skeletons of all of the specimens were altered by recrystallization and/or replacement. In some instances, these diagenetic alterations resulted in the total destruction of the septal microstructure, external walls and other skeletal elements. However, the fine structure of the skeleton was preserved well enough to be described and illustrated for several taxa. Computer drawings on highly enlarged pictures support the illustrations of the morphology, inadequately represented in the photographs. The protosepta and the alar septa are marked by black triangles in the pictures, whenever they are recognizable.

The material studied belongs to the Upper Silesia Branch of the State Geological Institute. It is temporarily deposited and housed in the Institute of Geology at the Adam Mickiewicz University, in Poznań. The first part of the specimen number indicates the collection number, while the second part signifies the sample number. In some cases, several new specimens were found in particular samples. In such cases, small letters were added to the sample number (e.g., 521_59a).

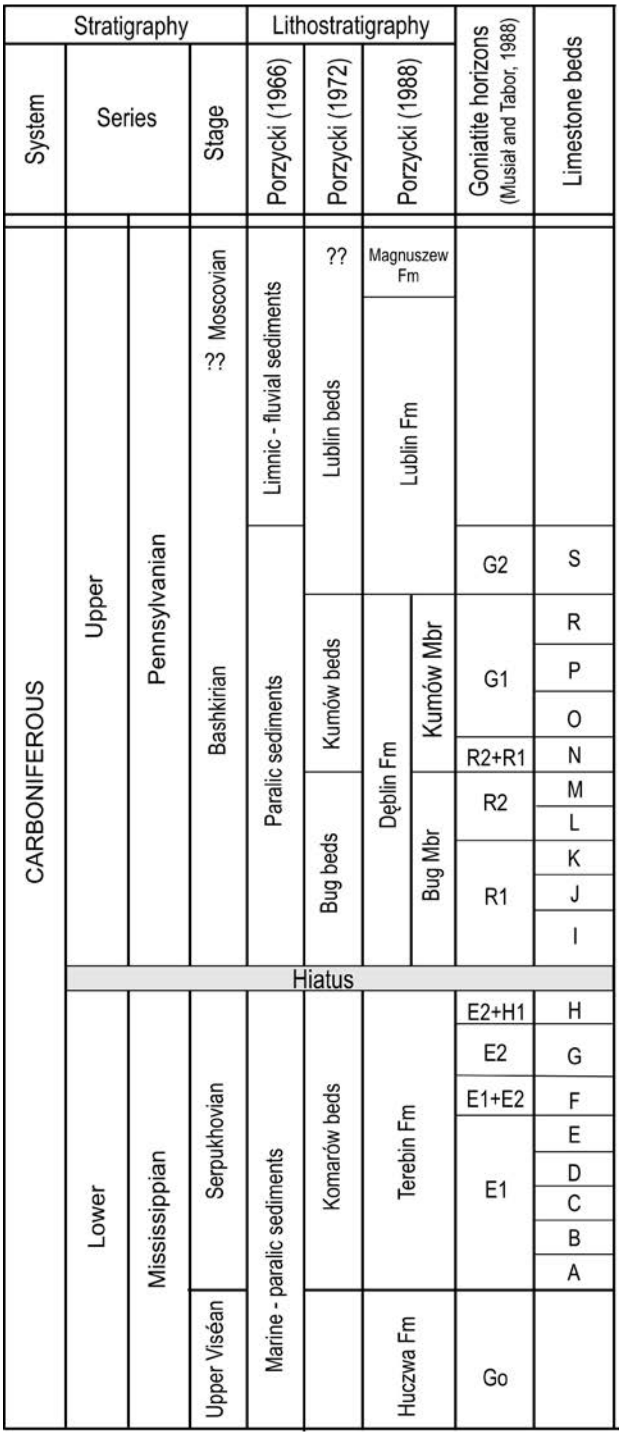


Fig. 2. Carboniferous stratigraphy of the Lublin Coal Basin.

GEOLOGICAL SETTING

(by Łucja Musiał and Albin Zdanowski)

The Lublin Basin is filled with sediments which represent the time interval between the late Viséan (Mississippian) and the Moscovian (Pennsylvanian; Fig. 2). These sediments belong to the Early Palaeozoic part of the sedimentary cover of the south-western slope of the Eastern European Platform (Fig. 1). Their thickness ranges from close to zero in the northern to over 2,000 metres in the south-western part of the basin, i.e., in the axial areas of the Puławy depression and the Stoczek-Dorohucza Syncline (Zdanowski, 1999, 2007a; Fig. 3). The Lublin Carboniferous deposits were formed in marine-paralic, paralic and limno-fluvial environments. As far as their lithology is concerned, they are: 1) limestone-claystone-mudstone series with sandstones and thin coal seams in places, 2) sandstone-mudstone-claystone series with limestones and coal seams in places, 3) mudstone-claystone series with coal seams and sandstone intercalations. These series compose five lithostratigraphic units of formational rank (Figs 2, 3),

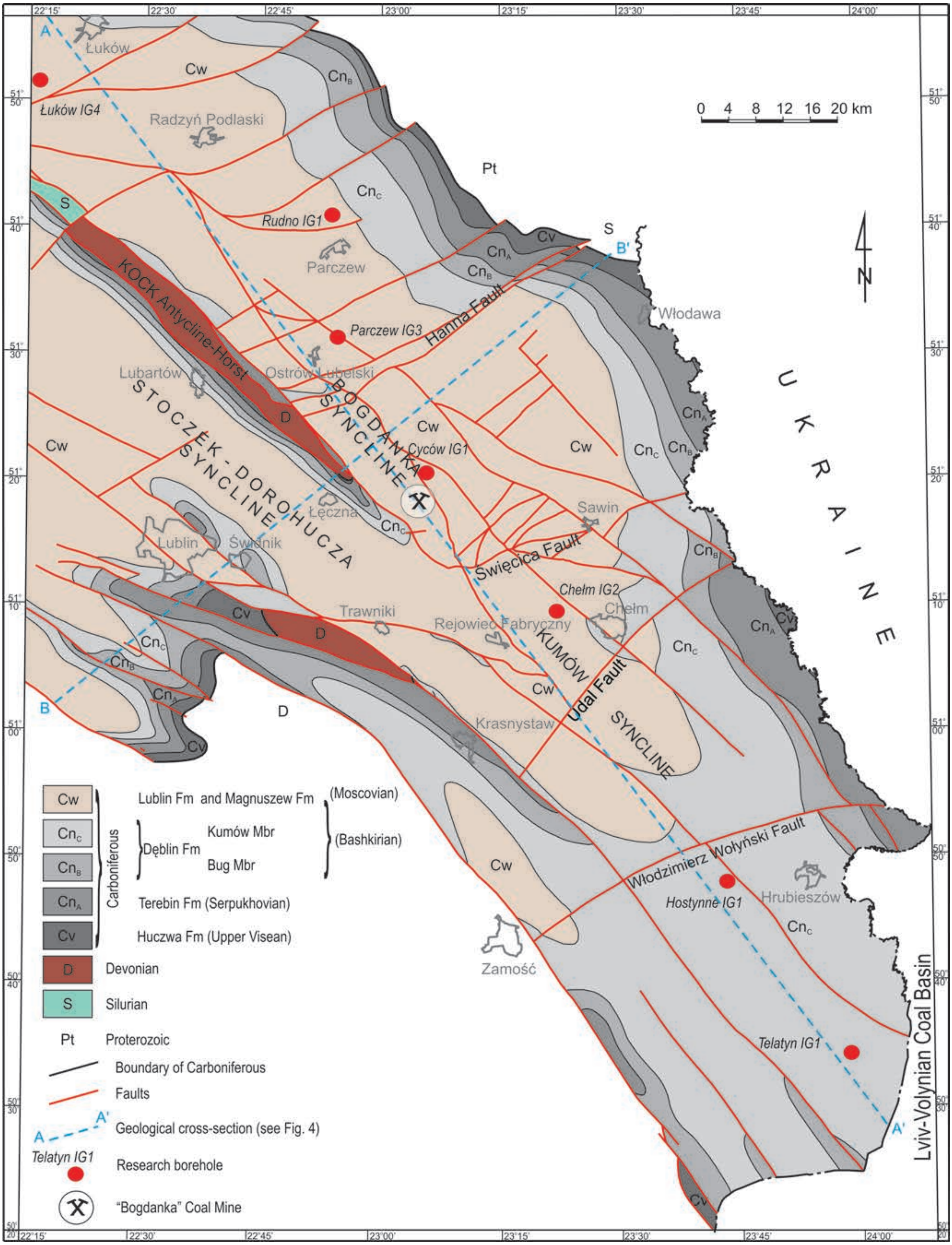


Fig. 3. Geological sketch map of the Lublin Coal Basin. Coral sampling sites marked by red points. Geology after Zdanowski (2007a).

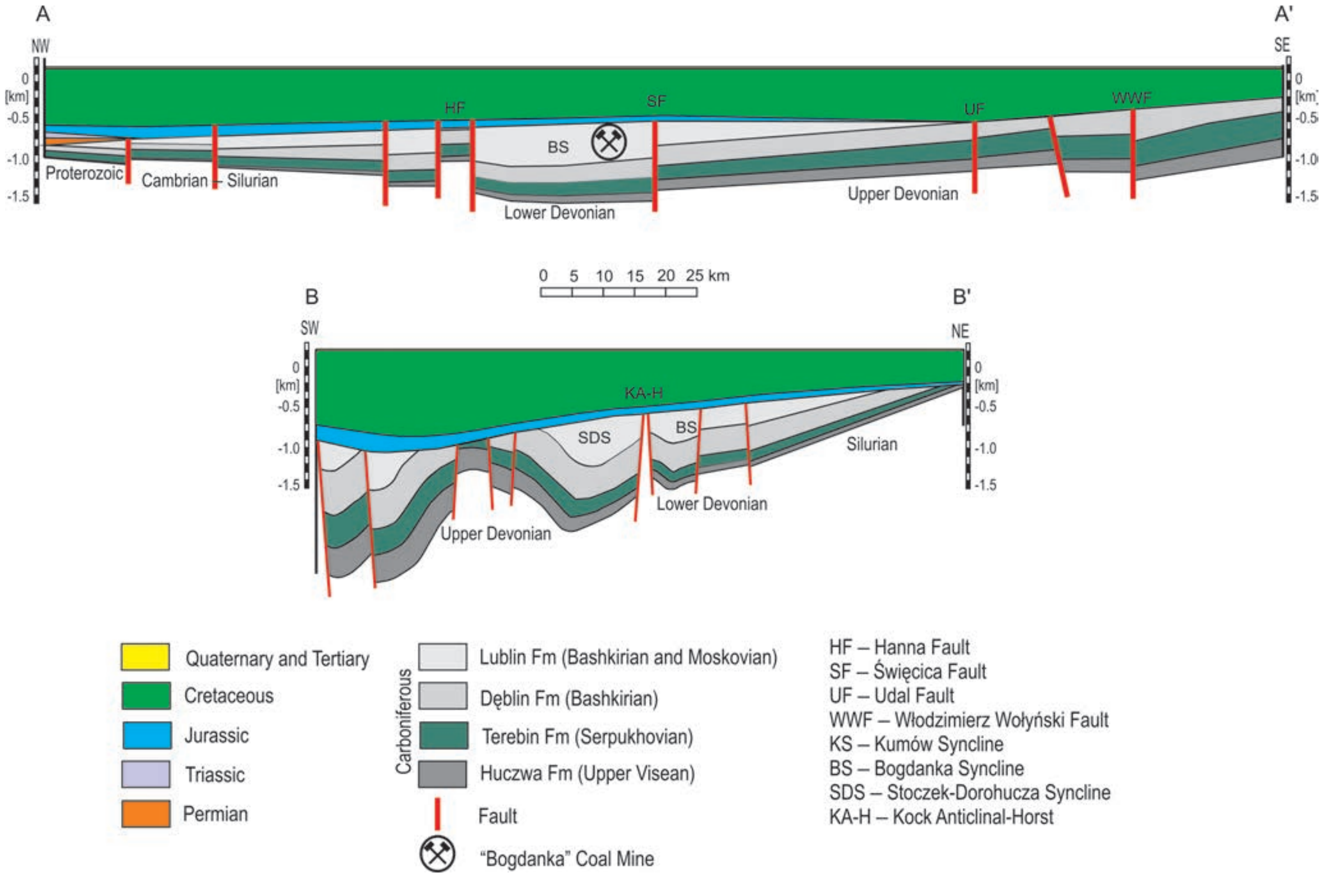


Fig. 4. Geological cross-sections through the Lublin Coal Basin. NW-SE: Łuków-Hrubieszów, NE-SW: Niedrzwica-Łęczna-Włodawa. See Figure 3 for the locations of cross sections.

each containing layers of humic coal that vary in thickness. From an economical point of view, the most interesting are the Dęblin Formation, with coal deposits extracted in several mines in the Lviv-Volynian Coal Basin, and the Lublin Formation, with coal deposits up to 4.0 m thick extracted in one mine "Bogdanka", located east of Lublin in the Bogdanka Syncline (Figs 3, 4).

The continuous Mississippian–Pennsylvanian succession is the most important part of the Lublin Basin stratigraphy. Palaeontological data reveal a hiatus in the goniatite H2 and in parts of the H1 and R1 biozones (Musial and Tabor, 1988; Fig. 2). Presumably, this hiatus is correlated with the post-Chesterian hiatus, described in Appalachian Mountains (Zdanowski, 2007b). The marine-paralic sediments below the hiatus are called the Terebin Formation. This unit consists of a succession of carbonates, claystones and mudstones with alternating sandstones and coal seams (on average 0.35 m thick), regularly occurring below the limestones. The majority of the sediments in this succession accumulated in a shallow sea and on coastal flood plains, as indicated by the fauna in the organo-detritic limestones and marly claystones, as well as by the plant remnants in the claystones and mudstones. The lithologies represented in these deposits indicate frequent changes in sedimentary conditions, from marine (limestones) to typically terrestrial (coals). As a result of such sedimentation, deposits with a characteristic cyclic structure were created, with a well-developed transgressive segment, which begins with limestone and gradually becomes regressive, ending upwards with carbonaceous sediment. Eight such sedimentary cycles are recorded in the Terebin Formation throughout the Lublin Basin area. The lowermost parts of these cycles are limestones with the alphabetical designations A, B, C, D, E, F, G and H. This series of sediments has a maximum thickness exceeding 450 m in the south-western part of the basin between Lublin and Zamość. The thickness decreases both to the north-east and east until the unit pinches out in the Łuków area. This reduction in thickness (Fig. 5) is the result of the gradual thinning and loss of the lower parts of the cyclothems, associated with limestones A, B and C, as well as erosion of parts of the profile between limestones F, G and H.

The macrofauna of the section of the profile discussed here documents the early Serpukhovian – *Eumorphoceras* E1 Biozone (Pendleian). However, index goniatitids, occur rarely, usually as fragments of shell impressions, which allowed the generic identification of *Anthracoceras*, *Sudeticeras*, and *Eumorphocras*. The following index goniatitids of the *Eumorphoceras* E1 Biozone were encountered in several profiles: *Emstites leion* (Bisat), *Eumorphoceras pseudobilingue* Bisat, *E.* cf. *pseudobilingue* Bisat, *Sudeticeras laevigatum* Ruprecht, *Cravenoceras* cf. *malhamense* Bisat (Korejwo, 1969; Musiał and Tabor, 1988, 2001; Musiał *et al.*, 2001).

The macrofauna of this interval consists mainly of brachiopod-bivalve taxa with smaller proportions of other animal taxa, including crinoids, bryozoans, gastropods, trilo-

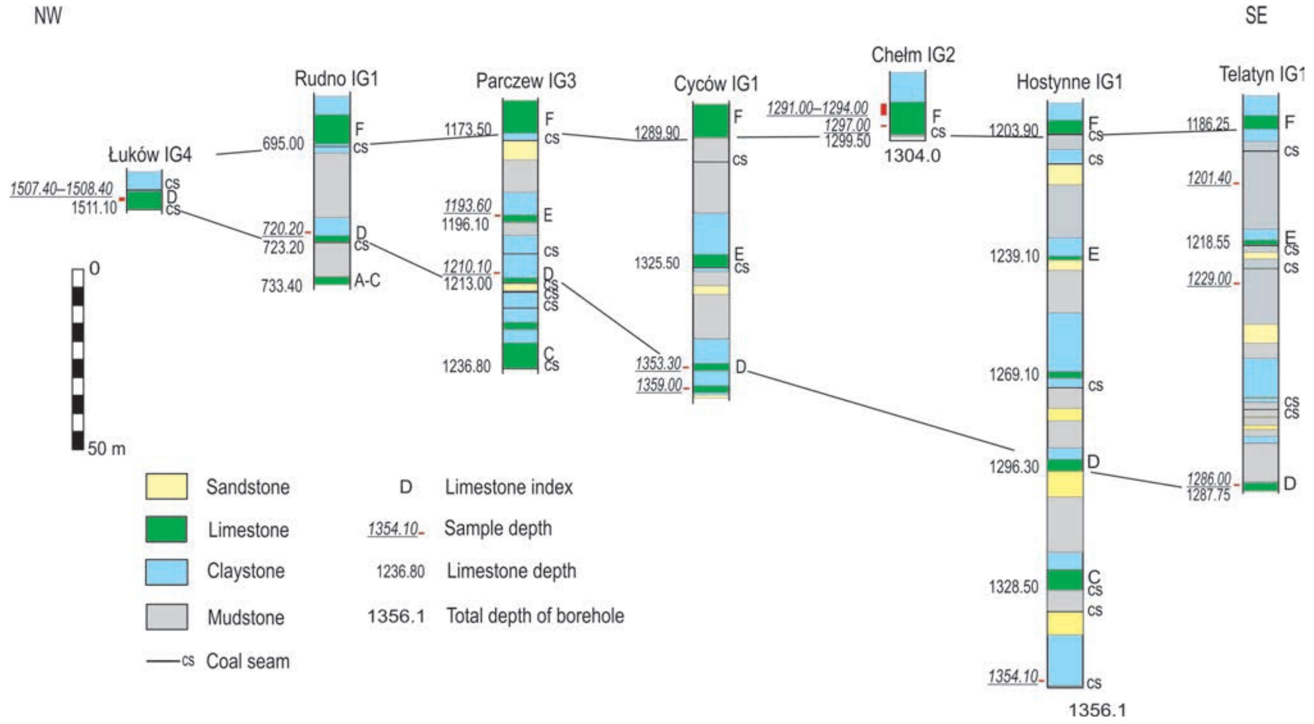


Fig. 5. Profiles of drill cores. Rugose corals yielding deposits marked by red quadrangles.

bites, cephalopods and rugose corals. These taxa are predominantly Serpukhovian, but there also is an array of species, common to the late Viséan, the range of which terminated within Limestone F. Some long-lived forms also occur in this group, including a few freshwater bivalves.

An unusually rich and taxonomically varied fauna exists in the organogenic limestones with alternating marls, in the marly claystones, and in the pelitic claystones. Generally, the fossil groups show little variation throughout the segment of the lower part of the Terebin Formation discussed here.

The particular cyclothems that make up the profile of the early Serpukhovian do not contain groups restricted to any of them. There is therefore no basis for describing and identifying the index limestones, with the exception of Limestone F. The latter is an important stratigraphical and correlative datum, easily recognizable throughout the entire Lublin Basin (Porzycki, 1988), and it limits the occurrence of the taxa common to both the Viséan and Serpukhovian. It also apparently marks the highest range of solitary rugose corals. This group of fossils does not appear again until Limestone S (late Bashkirian) of the Lublin Formation (Fig. 2), i.e. in the *Dunbarella* Biozone – bordering between Westphalian A and Westphalian B, correlated with level Katharina in Germany and Clay Cross in England (Musiał and Tabor, 1988) of the goniatite level A (Langsettian/Duckmantian).

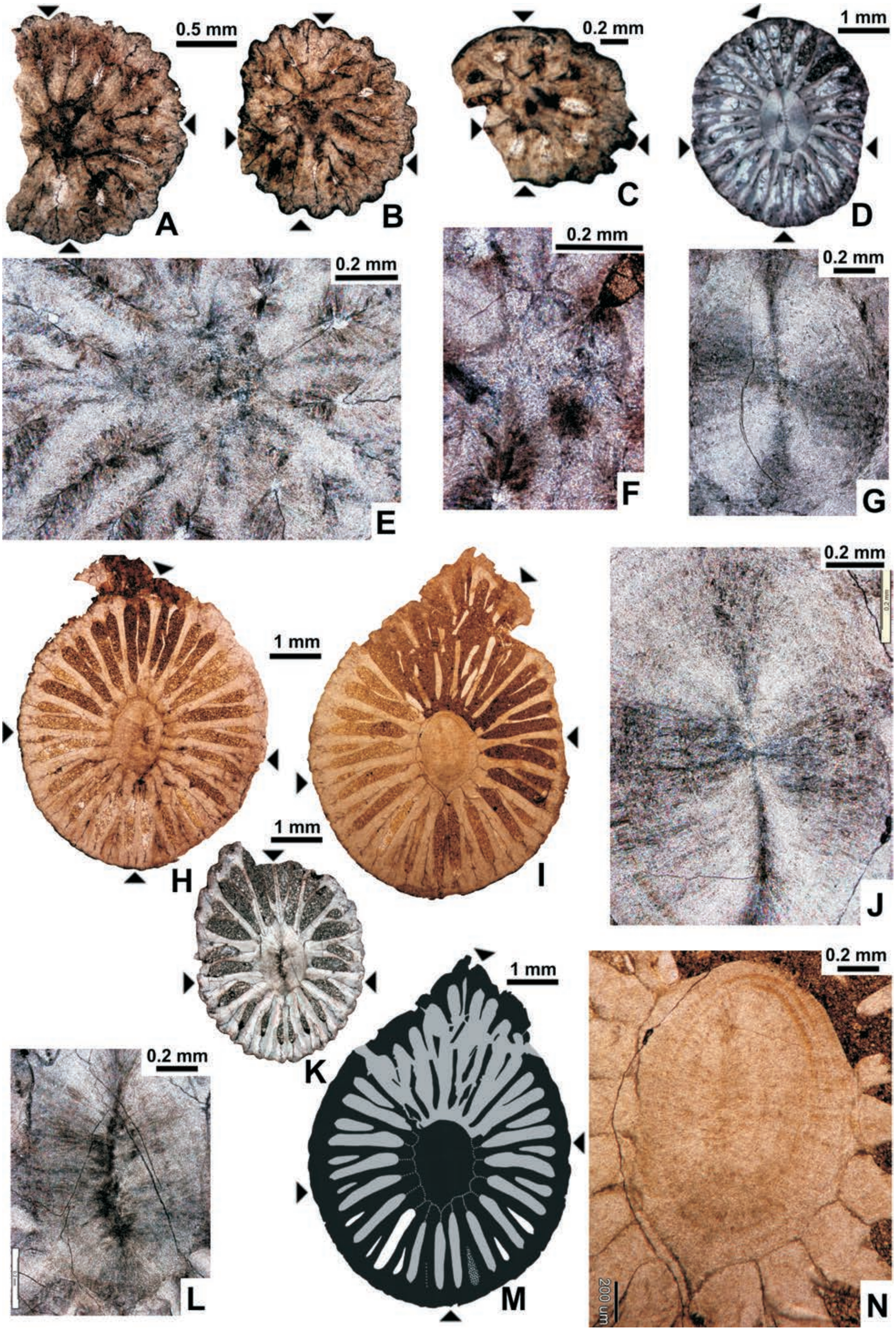
The basal limestone containing corals in the Chełm IG-2 well is recognized as Limestone F. Above it in the continuous sedimentary sequence, there are mainly clastic deposits of the upper part of the Terebin Formation with the correlation horizon *Posidonia corrugata* containing frequent *Posidonia* and goniatitids of the *Eumorphoceras* E2 Biozone (Arnsbergian).

The stratigraphic position of the rich rugose coral fauna from the Łuków IG-4 well presents some difficulty. The Viséan deposits dated by *Gigantoproductus* sp. were found at a depth of between 1509.9–1510.9 m; approximately two metres higher, the deposits do not contain any fauna. From 1506.1–1506.7 m, along with corals, a few poorly preserved gastropods occur as well as crinoid ossicles, fragments of brachiopod shells, and the long-lived species *Alitaria frechi* (Paeckelman). This 60-cm-thick bed rich in corals passes upwards into grey mudstone (1506.1–1505.2 m), which upwards gives way to 30 cm of *Stigmaria* palaeosol with the freshwater bivalve *Porubites*, not previously recorded in the Viséan deposits. In the light of the existing macrofauna, it seems probable that the sediments of the *Gigantoproductus* Zone mark the end of the Viséan succession, whereas the overlying deposits belong to the Serpukhovian. Unfortunately, the lack of index fossils makes a closer determination of the age impossible.

SYSTEMATIC PALAEONTOLOGY

Order STAURIIDA Verrill, 1865
Suborder CYATHAXONIINA Spasskiy, 1977
Family CYATHAXONIDAE Milne Edwards and Haime, 1850

Remarks: The genus *Cyathaxonia* Michelin, 1847 has been known for more than 150 years and is common in the Carboniferous strata of Europe, Asia northern Africa and to a lesser extent in North America. It also occurs in strata from late Famennian (Różkowska, 1969) up to late Artinskian (Kossovaya, 2007) time and has been the subject of many studies, the most important of which were summarized by Fedorowski and Vassilyuk (2011) in a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synonymy to that genus. The latter authors emended the generic diagnosis, offered a comprehensive discussion of the relationships of the genus and commented on both the relationship between *Cyathaxonia* and *Cyathocarinia* Soshkina, 1925 and the relationships of those two genera (or synonyms) to other Carboniferous taxa. However, a new interpretation of the type species of *Cyathocarinia* and its possibly independent taxonomic status was proposed by Kossovaya *et al*. (2012). Thus, only the earlier recognitions, interpretations, and suggestions by Fedorowski and Vassilyuk (2011) connected to *Cyathaxonia* are followed in this paper.

Faurot (1909, figs 4–8, 10–14, 15–17) was the first author to study the ontogeny of *C. cornu* Michelin, 1847. His idealized drawings illustrate the insertion of septa in a way that can be accepted. However, the comparison of Tetracoralla (= Rugosa) to Hexacoralla (= Scleractinia), but not the mode of insertion of the columella, was the aim of his paper. The latter topic was the subject of a special study by Fedorowski and Vassilyuk (2011) and was extensively discussed by Kossovaya *et al*. (2012), who excluded the taxonomic position of many taxa previously described within *Cyathaxonia* and/or *Cyathocarinia*. Neither this question nor the interpretations of the genus *Cyathaxonia* by various authors are discussed here. For these issues, the reader is referred to the papers cited above and to papers by de Groot (1963), Khoa (1977), Sando (1977), Rodríguez and Kullmann (1999), Weyer (2005).

Genus *Cyathaxonia* Michelin, 1847

Type species: *Cyathaxonia cornu* Michelin, 1847.

Cyathaxonia aff. *cornu* Michelin, 1847
Fig. 6

Material: Three corallites. Specimen 303_244 well preserved; five thin sections and one peel. Specimen 397_152a; one transverse thin section; only tip of corallite left. Specimen 379_152b; one transverse thin section; proximal part left.

Remarks: This species or morphotype is one of the most commonly described Carboniferous rugosans. Common in the Tournaisian and Viséan strata of Europe, it is considered by Rodríguez and Kullmann (1999) to extend up into the upper Moscovian (Westphalian D). Kossovaya *et al*. (2012, p. 361) did not mention *C. cornu* or *Cyathaxonia* sp. A of Rodríguez and Kullmann, 1999, when they removed other *Cyathaxonia* taxa of those authors to *Slovaniaxon* Kossovaya, Novak and Weyer, 2012. This may have been due to the occurrence of a true columella in those Moscovian specimens, documented in *Cyathaxonia* sp. A (Rodríguez and Kullmann, 1999, pl. 1, fig. 23), but not in the specimens included by those authors in *C. cornu*. Thus, whether this is a truly very long-lasting species or several closely comparable morphotypes will remain an unanswered question until new, objective criteria, allowing species recognition among *Cyathaxonia*, are established. All attempts made so far (see remarks for the family) are unsatisfactory. Thus, neither a detailed description nor a diagnosis is proposed for the specimens studied here. However, these specimens are considered at least closely related to *C. cornu*.

The following should be pointed out here: 1. Specimens illustrated (Fig. 6D, H, I, K, M) differ considerably in their n:d values (18:3.2 mm, 20:3.5 mm, 20:5.3 mm), whereas the main characters of their morphology, such as the oval shape of their columellae and the length of minor septa differentiated slightly within a given transverse section, and the counter-lateral minor septa dominating, closely resemble each other. 2. The formation of the columella, independently from the inner margins of septa (Fig. 6A–C, E, F), as demonstrated by Fedorowski and Vassilyuk (2011), is confirmed. 3. The inner morphology of the columella, commonly best demonstrated in crossed nicols (Fig. 6G, J), also can be seen in transmitted light in well-preserved specimens (Fig. 6N), whereas isogyre lines (= crystallization brush) may be absent from some sections (Fig. 6L), perhaps as a result of diagenetic alteration.

Occurrence: Specimens 397_152a, b, Parczew IG-3, drill core, depth 1210.1 m. Specimen 303_244, Cyców IG-1, drill core, depth 1353.3 m. Both from Limestone D, early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Suborder STEREOLASMATINA Hill, 1981
Family ANTIPHYLLIDAE Ilina, 1970
Subfamily ANTIPHYLLINAE Ilina, 1970

Genus *Rotiphyllum* Hudson, 1942

Type species: *Densiphyllum rushianum* Vaughan, 1908, by subsequent designation of Hudson (1942, p. 257).

For diagnosis, **synonymy** and **species** see Fedorowski (2009d, pp. 8, 9).

Remarks: This genus recently was discussed widely (Fedorowski 2009d, pp. 9–12). Only some notes on new occurrences of it (e.g., Rodríguez *et al*., 2012), lacking detailed descriptions or comprehensive discussion, has been published since then.

Rotiphyllum plumeum sp. nov.
Fig. 7

Holotype: Specimen 303_243 (Fig. 7A–N).

Type locality: Cyców IG-1, drill core, depth 1353.3 m, Limestone D.

Age: Early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Name derivation: Latin: *plumeus, a, um* – feather-like. After the arrangement of major septa in cardinal quadrants.

Material: Specimen 303_243 (holotype) almost complete with microstructure of most septa destroyed by diagenesis, but with less altered original microstructure preserved in some fragments of septa; specimen 303_250a (paratype) preserved as small fragment. Eight transverse thin sections and five peels available for study.

Diagnosis: *Rotiphyllum* with n:d value 17–18: 4.2–4.5 mm; major

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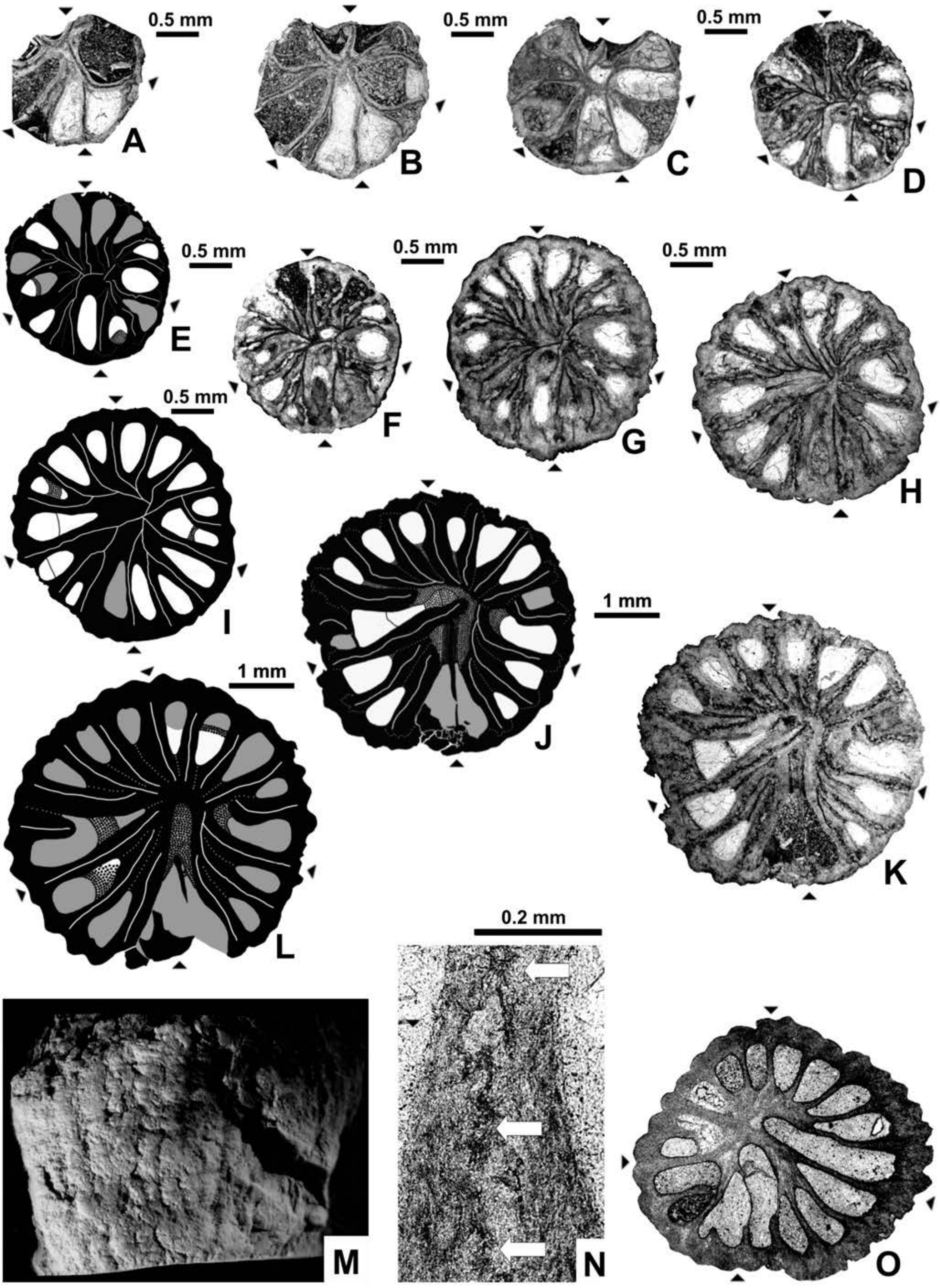
Fig. 6. *Cyathaxonia* aff. *cornu* Michelin, 1847. **A**–**C**, **E**, **F**, **H**–**J**, **M**, **N**. Specimen 303_247: A–C – late to early neanic growth stage; F – sclerenchyme at corallite axis forms basis for columella (enlarged from C); E – earliest growth stage of columella (enlarged from A) (all crossed nicols); H, I – mature growth stage; sections partly (H) and mostly (I) above calice floor; J – columella (enlarged from I; crossed nicols); M – above calice floor in almost all loculi (drawing from peel); N – columella (parallel nicols) for comparison with J (crossed nicols). **D**, **G.** Specimen 397_152A. Below calice floor in most loculi (D), enlarged columella (G) (both crossed nicols). **K**, **L.** Specimen 397_152B. Above calice floor in all loculi (K), enlarged columella (L). Note isogyre lines (polarization brush) well demonstrated in D, G, J and lacking from K, L.

Note. Transverse thin sections, except when stated otherwise. Cardinal septum at the bottom. Protosepta and alar septa marked by black triangles. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. Septal loculi sectioned above last tabula (calice floor) shadowed in drawings. For locality and stratigraphic position see Occurrence.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septa in cardinal quadrants pinnately arranged; alar pseudofossulae distinct.

Description of the holotype: External wall 0.3–0.5 mm thick, with septal furrows and growth striae (Fig. 7M), slightly corroded. Major septa in earliest preserved growth stage (fig. 7A–C) with n:d values 8:1.8×1.5 mm, 11:2.0 mm, and 12:2.1×1.8 (all incomplete), deformed by lateral attachment to substrate. Major septa during early ontogeny (Fig. 7A–G) irregularly arranged. Cardinal septum attached to middle part of long alar septum first (Fig. 7A–C) and younger metaseptum afterwards (Fig. 7H). It remains hardly distinguishable up to calice floor, where it approaches corallite axis (Fig. 7J, K), and intersects triangular cardinal fossula just above calice floor (Fig. 7L). Counter septum, slightly longer and/or thicker than adjacent major septa during part of early corallite growth (Fig. 7D–I), becomes indistinguishable where major septa form arch opposite left alar septum. That alar septum, strongly elongated in late neanic/early mature growth stage (Fig. 7H–K), imitates cardinal septum. Near calice floor (Fig. 7L), major septa become re-arranged again. Left alar septum remains long, but not dominating. Inner margins of major septa in counter quadrants, laterally contiguous, form arch opposite cardinal septum. Presence of minor septa manifested only in some loculi of calice by slight protrusions of inner margin of peripheral wall. Microstructure of septa mostly destroyed by recrystallization. Tiny bodies with radiate fibrils, forming irregular chain in middle part of septum, interpreted as remnants of trabeculae (Fig. 7N, arrows).

Variant: Corallite 303_250a (Fig. 7O) included in this species as paratype, represented by small mature fragment. Most septal loculi sectioned above calice floor, but inner margins of major septa remain connected either by their rhopaloid thickenings, or by sclerenchyme when their "middle dark lines" (i.e., primary septa) united. This and irregular arrangement of major septa, with one alar septum dominating, resemble arrangement of septa in early mature growth stage of holotype. Also, paratype displays n:d ratio (18:4.2 mm) similar to holotype and its minor septa absent from corallite lumen up to calice floor.

Remarks: This species differs from all known species of *Rotiphyllum* in its minute dimensions. It is almost half the size of *R. rushianum* (Vaughan, 1908), the type species for the genus with its n:d value 24:8.5 mm (Hudson, 1944), and possesses much better developed alar pseudofossulae. The latter character and the arrangement of septa in *R. plumeum* resemble those in *R. omaliusi* Milne Edwards and Haime, 1851, where a bias perhaps resulting from lateral attachment to the substrate is not considered. However, the much larger diameter and different n:d values of the topotypes of *R. omaliusi* (24–26:12–15 mm according to the illustrations by Carruthers, 1908) and other representatives of that species (e.g., Weyer, 1993), indicate a different taxonomic position of the species from the Lublin area.

Also, all *Rotiphyllum* species from the early Baskhirian of the Donets Basin are much larger and possess different n:d values (Fedorowski, 2009d, p. 11). Only *R. abnorme* Fedorowski, 2009d exhibits an arrangement of septa slightly similar to *R. plumeum*, but the very thick and almost smooth external wall (Fedorowski, 2009d, fig. 6A$_1$) and different n:d values, allow an easy distinction between these two species.

Occurrence: Cyców IG-1, drill core depth 1353.3 (holotype), depth 1359.0 (paratype). Limestone D, early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Genus *Axisvacuus* Fedorowski, 2009

Type species: *Axisvacuus verus* Fedorowski, 2009c, p. 285. By original designation.

For diagnosis, **synonymy**, **species** and **discussion** see Fedorowski (2009c, pp. 285–292). The separate taxonomic position of the genus *Axisvacuus* has not been questioned, and new species have not been described under that name until now.

Axisvacuus tenerus sp. nov.
Figs 8, 9

Holotype: Specimen 521_60a (Fig. 8A–I).

Type locality: Łuków IG-4, drill core, depth 1506.1–1506.7 m.

Age: Early Serpukhovian.

Name derivation: Latin: *tener, a, um* – not robust – after thin skeletal structures.

Material: Three specimens available. Holotype 521_60a embedded in rock, almost complete. Its peculiar diagenetic changes are described separately below. Paratype 397_133, almost complete, but slightly crushed near cardinal septum in earliest and fully mature growth stages. Paratype 437_44 with mature part strongly and immature slightly crushed (not illustrated). Microstructure of septa diagenetically altered in all corallites.12 transverse thin sections and 13 peels were available for study.

Diagnosis: *Axisvacuus* with maximum n:d value 18:4.5×5.5 mm; major septa long, with inner margins surrounding narrow axial area; sclerenchyme very narrow; minor septa absent from corallite lumen.

Description: External wall 0.4–0.6 mm thick with shallow septal furrows corresponding to both cycles of septa (Fig. 8D–F, 9J) as documented by peripheral outline and/or surface of well-preserved external wall fragments. Thickened, triangular margins of major septa dip into thickness of external wall (Fig. 8I). Differences in arrangement and length of major septa in holotype vary greatly. Their marked shortening (Fig. 8D) is due to diagenesis. Major septa in illustrated paratype permanently long (Fig. 9A–I).

In earliest growth stage available for study of holotype (Fig. 8A), with n:d value 11:1.9×2.2 mm, major septa slightly wavy, zaphrentoidally arranged. Cardinal septum imitates last metaseptum inserted in cardinal quadrants, but its inner margin meets inner margins of counter septum and left counter-lateral septum. Inner margin of right counter-lateral septum turned right to meet right alar septum. Within 0.3 mm of further corallite growth (Fig. 8B), cardinal septum shortened and number of septa reduced (n:d value 9:2.1×2.3 mm). Reduction in counter quadrants results from dissolution and recrystallization. Counter septum and alar septa meet at corallite axis. Early growth stage in paratype (Fig. 9A–D) with n:d values 10:2.1 mm and 12:2.6 mm (measured perpendicular to protosepta plane) more regular, with cardinal septum permanently meeting corallite axis and remaining major septa zaphrentoidally arranged.

Arrangement of major septa in next growth stage of holotype approximately 0.5 mm above previous one (Fig. 8C) with n:d value 12:2.6×3.1 mm resembling the former, except that most major septa meet in corallite axis. Short septal strips reappear in counter quadrants. Within next 0.5 mm corallite growth (Fig. 8D), all major septa become short, leaving wide axial area free. Cardinal septum slightly shortened, counter slightly elongated. Rem-

Fig. 7. *Rotiphyllum plumeum* sp. nov. **A–N.** Specimen 303_343; holotype: **A–I** – early to late neanic growth stage, **J–L** – mature growth stage, **M** – corallite surface, **N** – microstructure of septum; remnants of some trabeculae indicated by arrows. **O** – specimen 303_250a – mature growth stage (peel). E, I, J, and L drawings. See Note for Figure 6 for remaining explanations.

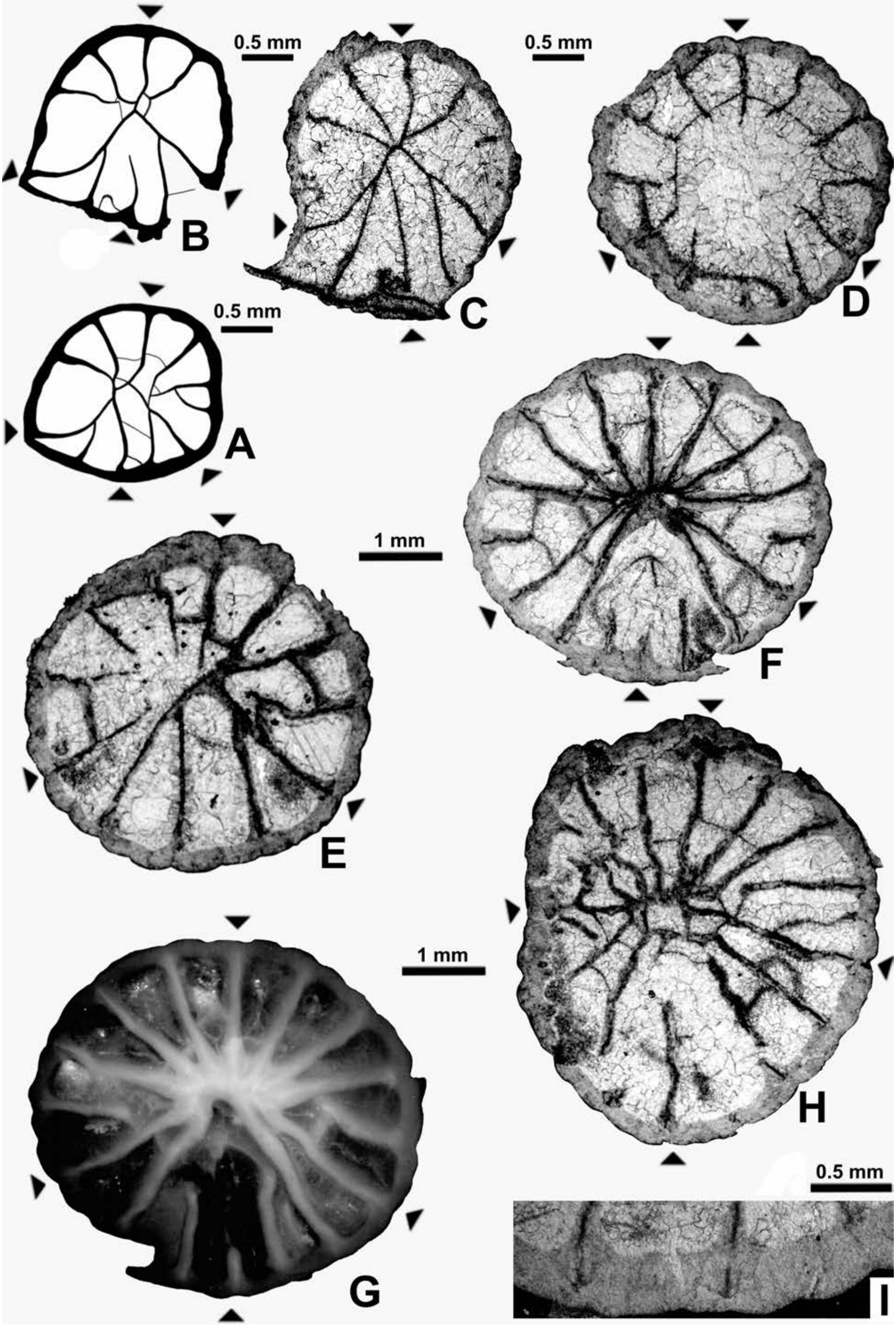
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Fig. 8. *Axisvacuus tenerus* sp. nov. Specimen 521_60a. Holotype. **A**–**E.** Early to late neanic growth stage (A, B – peels with drawings). **F.** Late neanic/early mature growth stage. **G.** Early mature growth stage (polished surface). **H.** Mature growth stage. **I.** External wall with peripheral margins embedded, but minor septa absent. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

nants of that arrangement remain for next 0.7 mm of corallite growth, with n:d value12:3.6×3.8 mm (Fig. 8E), but most major septa return to arrangement illustrated in Figure 8A–C. Growth stage in paratype (Fig. 9E), with n:d value 14:3.5 mm (measured as above), approximately corresponds to that in Figure 8E, F in holotype. However, paratype demonstrates rotiphylloid arrangement of major septa, and long cardinal septum meeting rhopaloid counter septum at corallite axis is more clearly shown.

In perhaps late neanic/early mature growth stage, with n:d value 16:4.4×4.8 mm, paratype more closely resembles more advanced growth stage of holotype (Fig. 8F). Most major septa approach or meet near corallite axis with slightly rhopaloid inner margins. Last

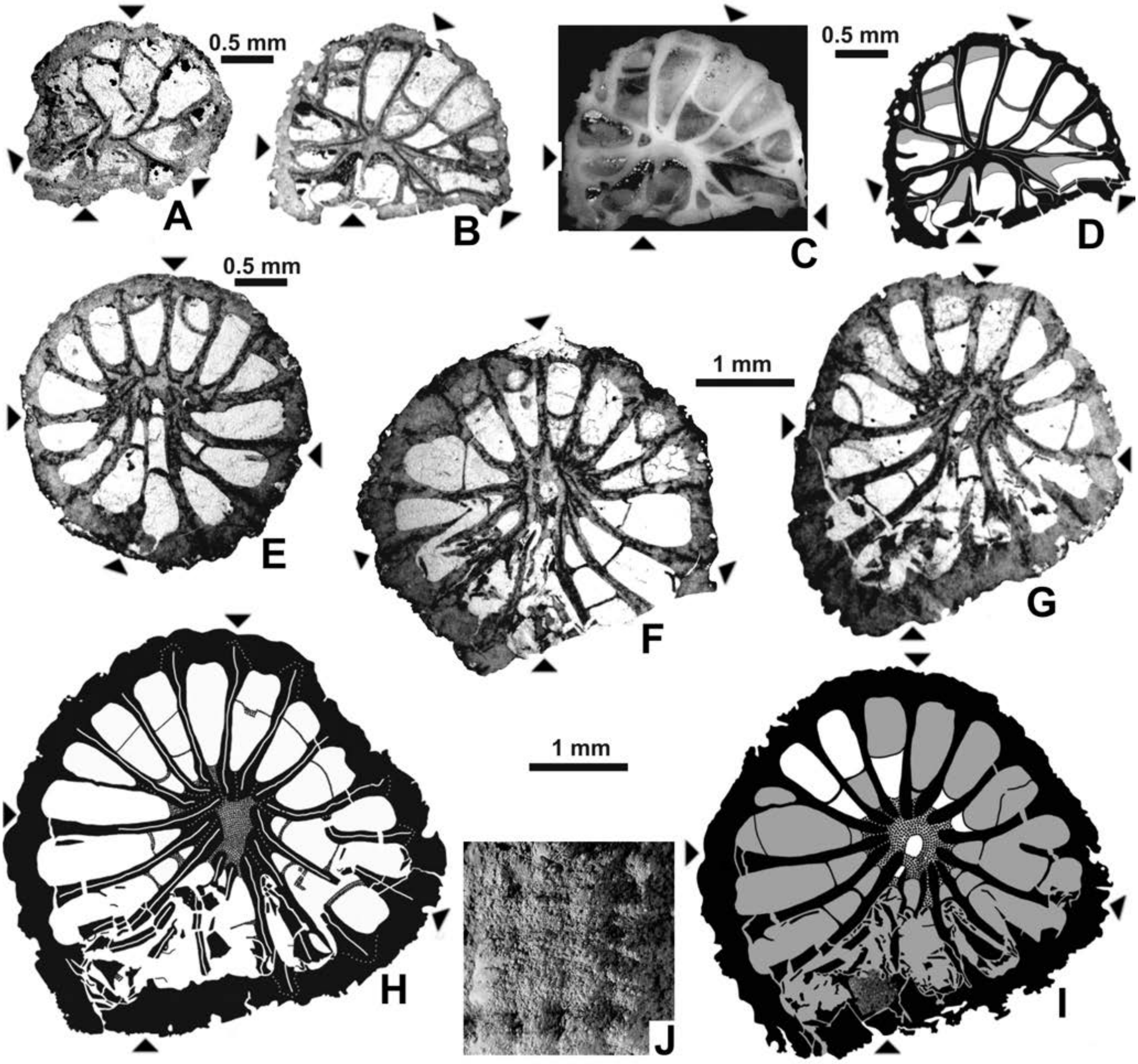


Fig. 9. *Axisvacuus tenerus* sp. nov. Specimen 397_133. Paratype. **A**–**D.** Neanic growth stage (C – polished surface, D – drawing). **E**–**I.** Early to late mature growth stage (H and I – peel with drawing). **J.** Fragment of corallite surface. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

inserted major septa underdeveloped. Cardinal septum diagenetically broken with inner segment attached to section of tabula documenting presence of tabular cardinal fossula. Septal cardinal fossula widely triangular, bordered by two long major septa approaching corallite axis with pair of underdeveloped major septa inside. Axial area in holotype originally free from major septa first demonstrated in polished surface (n:d value 16:3.9×4.1 mm) by arrangement of inner margins of major septa that terminated around narrow free axial area (Fig. 8G), and by tabula closing cardinal fossula near corallite axis. Thick inner margin of diagenetically broken cardinal septum attached to that tabula. At approximately 4 mm of paratype growth (Fig. 9F–H), n:d values 16:4.1 mm and 18:4.8 mm (measured as above) corresponds to that short holotype growth stage. Circumaxial structure in paratype resembles circulotheca of Fedorowski (2009b) when sectioned beneath tabula (Fig. 9F, G). Immediately above tabula (Fig. 9H) corallite axial area filled with sclerenchyme, again reduced from corallite axis in lower part of calice (Fig. 9I). Paratype's circumaxial area elevated well above calice floor, as documented by circulotheca-like structure.

Thin section of holotype (Fig. 8H), with n:d value 18: 4.5× 5.5 mm, made 1.2 mm above polished section, confirms formation of narrow axial area surrounded by inner margins of most major septa that become equally thin, but differentiated within all quadrants in accordance to their insertion. Broken inner margin of cardinal septum remains attached to tabula bordering free axial area from cardinal fossula side. Minor septa absent from corallite lumens of all specimens (e.g., Fig. 8I).

Diagenesis: Extreme changes in the arrangement of major septa in the holotype, described in detail above, can either be interpreted as being genetically or diagenetically caused. The first option is rejected as too being complex, when "Occam's razor" is accepted. Development of the zaphrentoid arrangement of septa, replaced by amplexoid and returning to zaphrentoid, obviously goes against that rule. Also, coarse-grained calcite present in septal loculi indicates: a) dissolution of parts of skeleton (Fig. 8B–E), b) inorganic crystallization at the expense of both organic calcite and inorganic infillings of some septal loculi first (Fig. 8B, C), or c) inorganic crystallization within the entire corallite axial area afterwards (Fig. 8D). Remnants of the original coral remain in the higher part of corallite (Fig. 8E, left). Compression was an additional factor that changed the morphology and shape of distal part of the holotype, destroying the uppermost part of that corallite (not illustrated), starting from Figure 8H.

Remarks: Despite diagenetic alterations in the early growth stage of specimen 521_60A, this specimen was selected as the holotype for two reasons: 1) It better exposes the inner area free from septa, whereas the morphology in that area of the paratype may be mixed with circulothecate corals, unrelated to *Axisvacuus*, 2) The cardinal fossula area in the paratype underwent advanced compression, making recognition of the true length of the cardinal septum difficult, whereas that septum, although diagenetically broken, is easily distinguishable in the specimen 521_60A. Regardless, both specimens are closely comparable in their n:d values and remaining diagnostic characteristics. Thicker and slightly rhopaloid major septa in the paratype are considered to have been environmentally caused.

The small diameter and number of septa of all specimens included in this species, superimposed on the arrangement and length of major septa and the total absence of minor septa as recognizable skeletal structures – only their furrows occur – form a set of characters allowing the distinction of *A. tenerus* from all other known species of *Axisvacuus*. (See synonymy and species content in Fedorowski, 2009c). Peculiar changes observed in its ontogeny are not considered important from a taxonomic view point.

A. tenerus is morphologically closest to *A. extendus* Fedorowski, 2009c, the stratigraphically oldest species of *Axisvacuus* in the Donets Basin (Limestone E1, lower Feninian, lowermost Kinderscoutian). It differs from that Ukrainian species in its smaller corallite diameter, less numerous major septa, lack of minor septa including the calice floor, and in different shape of cardinal fossula. Those two species bear closest similarity to *Rotiphyllum*.

Occurrence: Holotype: 521_60a, Łuków IG-4, drill core, depth 1506.1–1506.7 m, early Serpukhovian. Paratype: 397_133, Parczew IG-3, drill core, depth 1193.6 m. ?Paratype: 437_44, Rudno IG-1, drill core, depth 720.2 m. Both Limestone D, early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Family STEREOPHRENTIDAE Fomichev, 1953

Remarks: The emended diagnosis and the reasons for re-establishing the Family Stereophrentidae, synonymized by Hill (1981, p. F312) with the Family Hapsiphyllidae Grabau, 1928, was published by Fedorowski (2012, p. 113 and 113–119, respectively) and are accepted in the present paper without a need for emendation or supplements. Neither the generic content of the family nor possible subfamilies were proposed earlier and are not proposed here. *Zaphrentites*-like corals are cosmopolitan, known from Ordovician to Permian time, and are very common. Thus, their polyphyletic status seems likely, whereas poor actual knowledge of many of them prevents definitive reconstructions of individual lineages. Position and possible relationships of the genus *Zaphrentites* were discussed in the paper cited above and are not discussed again.

Genus *Zaphrentites* Hudson, 1941

Type species: '*Zaphrentis*' *parallela* Carruthers, 1910 by subsequent designation of Hudson (1941, p. 309).

Zaphrentites rotiphylloides sp. nov.
Fig. 10

Holotype: Specimen 397_198 (Fig. 10A–H; corallite A).

Type locality: Parczew IG-3 drill core, depth 1229.0 m, Limestone D.

Age: Early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Name derivation: Named after morphological similarity to *Rotiphyllum* Hudson, 1942.

Material: Five specimens. 397_198 (holotype), inner morphology well-preserved, proximal end and most of calice lacking; 476_199a, paratype, incomplete, obliquely cut when drilled. 467_296a (paratype), almost complete, inner morphology well-preserved, oblique section of mature growth stage resulted from a random cut of rock; 467_296b (paratype); 467_296c (paratype) small fragment of immature corallite. All paratypes deposited close to each other with calice of 467_296b hosting paratype 467_296a (Fig. 10H). Positions of those two corallites exclude either rejuvenation (compare many examples of rejuvenation in Fedorowski, 1987) or attachment of larvae and growth of polyps within calices of dead corallites (compare Berkowski, 2004, 2006). Two thin sections and seven peels available for study.

Diagnosis: *Zaphrentites* with n:d value 20:7.0–7.5 mm; major septa in cardinal quadrants pinnately arranged; in counter quadrants semi-radially arranged, terminate in elevated circum-axial sclerenchyme; cardinal fossula triangular; minor septa barely recognizable in thickness of external wall.

Description: Holotype external surface with moderately deep septal furrows (Fig. 10A). Lack of growth striae the result of slight abrasion during transport. External wall during early corallite growth purely sclerenchymal, in mature growth septothecal (Fig. 10E) with minor septa extending into corallite lumen as low protrusions. Calice floors elevated higher in counter than in cardinal quadrants, being highest in circumaxial area of those quadrants, as

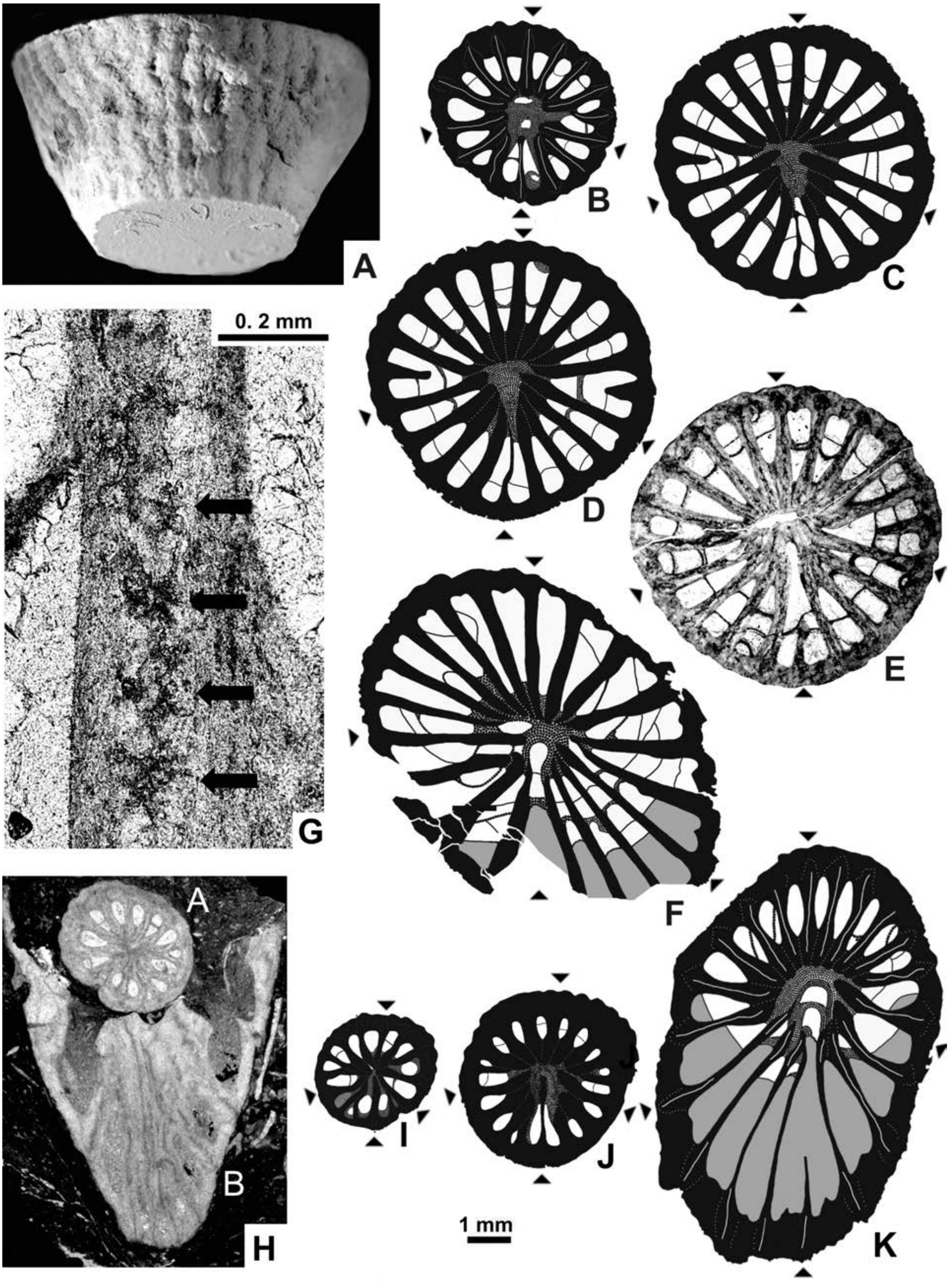
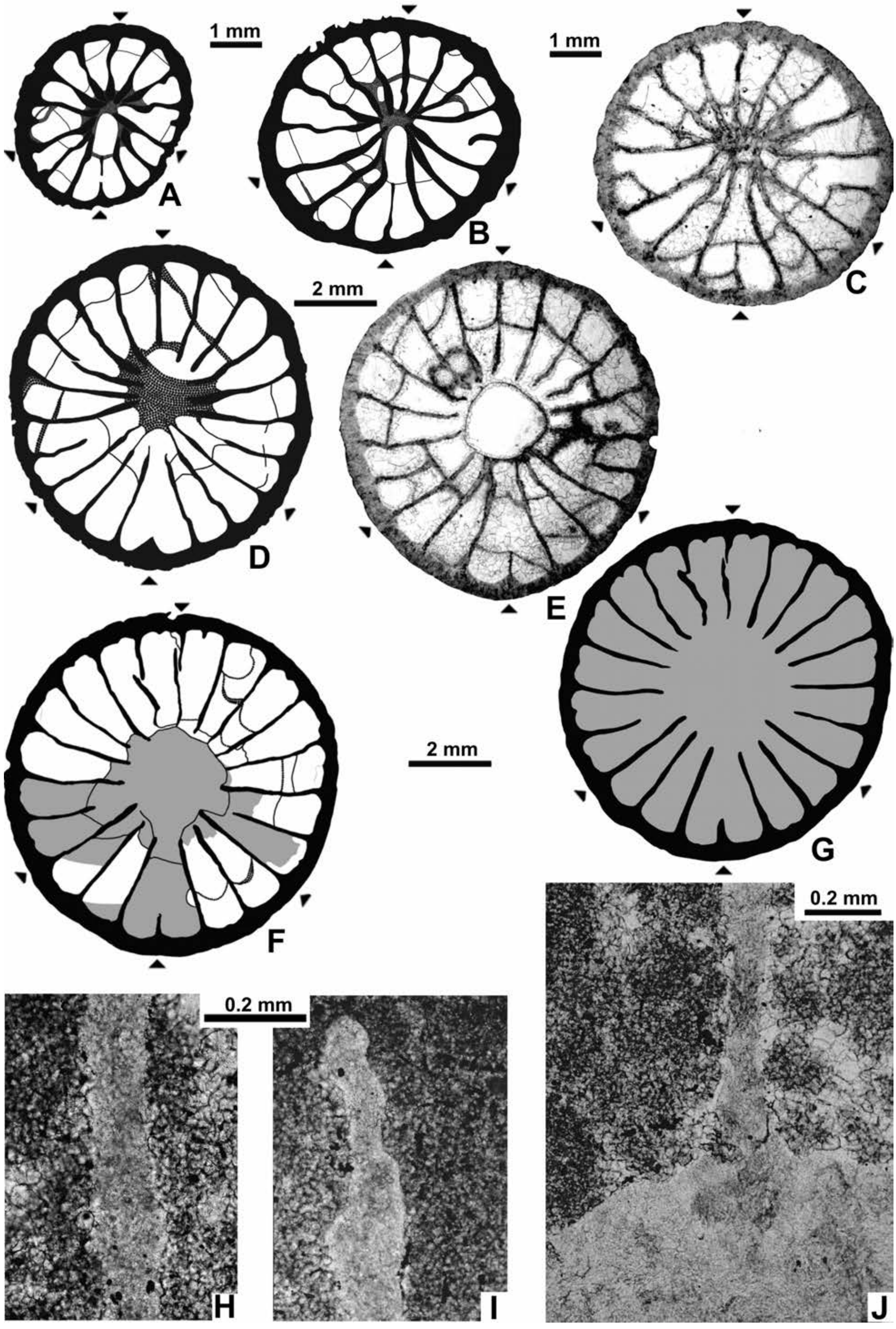


Fig. 10. *Zaphrentites rotiphylloides* sp. nov. **A–G.** Specimen 397_198. Holotype: A – corallite surface, B–D – late neanic to early mature growth stage, E, F – mature growth stage (B, C – thin sections with drawings, D, F – peels with drawings), G – microstructure of septum; trabeculae (arrows), perhaps enlarged by recrystallization. **H.** Thin section exposing transverse section of paratype 467_296a (corallite A) deposited in calice of paratype 467_296b (corallite B: oblique longitudinal thin section). **I–K.** Specimen 467_296a. Paratype: I, J – neanic growth stage, K – oblique section, mature growth stage (I–K – peels with drawings). Scale bar at the bottom corresponds to all figures except G. See Note at Figure 6 for remaining explanations.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demonstrated by sclerenchymal infillings (Fig. 10F, K). Arrangement and number of major septa similar in all specimens studied. In neanic growth stage cardinal septum reaches inner margin of cardinal fossula in holotype (Fig. 10B–D), but extends to corallite axis in paratype, being recognizable from surrounding sclerenchyme (Fig. 10I, J). Counter septum equal in length to counter-lateral septa. Alar septa longest of all major septa in cardinal quadrants, subsequent major septa shortened step by step towards cardinal septum (Fig. 10B–D, I, J). Major septa in counter quadrants of mature growth stage semi-radia- lly arranged, their slightly rhopaloid inner margins connected by circumaxial sclerenchyme. Cardinal fossula triangular during all growth stages available for study, except for earliest (Fig. 1H, corallite A). Alar pseudofossulae present only when last pair of major septa in counter quadrants underdeveloped. Microstructure of septa probably trabecular, but width of individual trabeculae uncertain. Dark areas in picture (Fig. 10G) may be trabeculae enlarged during recrystallization at expense of dissolved sclerenchymal sheets of septa.

Remarks: The mature and immature morphology of all corallites included in this species and the microstructure of their septa are strikingly similar. The arrangement of septa and shape of cardinal fossula closely resemble those characters in "*Zaphrentis*" *constricta* (Carruthers, 1910, pl. 27, fig 5A–D). N:d values of early mature and mature growth stages of Carruthers' specimen, 22:6.4 mm and 23:7.6 mm, differ from *Z. rotiphylloides* in a slightly larger number of septa at similar corallite diameters. The elongated cardinal septum, lasting up to maturity in *Z. rotiphylloides*, *vs* that septum becoming shortened in *Z. constricta* at the late neanic growth stage (Carruthers 1910, pl. 37, fig. 5c), constitutes the main difference between those two species. It contradicts a phylogenetic lineage within *Zaphrentites*, established by Carruthers (1910) and confirmed by Hudson (1941).

Occurrence: Parczew IG-3, drill core, depth 1229.0 m (holotype and two paratypes), Limestone C. Telatyn IG-1, drill core, depth 1286 m (paratype), Limestone D. Hostynne IG-1, drill core, depth 1201.4 m (paratype), Limestone F. All from early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Genus *Zaphrufimia* Fedorowski, 2012

Type species: *Zaphrentis disjuncta* Carruthers, 1910. By original designation of Fedorowski 2012, p. 119.

Diagnosis and **Remarks** see Fedorowski (2012, pp. 119–122)

Zaphrufimia anceps sp. nov.
Figs 11, 12

Holotype: Specimen 521_59a (Fig. 11A–J).

Type locality: Łuków IG-4 drill core, depth 1,506.1–1,506.7 m.

Age: Early Serpukhovian.

Name derivation: Latin: *anceps, cipitis* – uncertain, ambiguous – after generic characters weakly accentuated.

Material: Three specimens. Holotype 521_59a and paratype 521_ 59b preserved in most growth stages except for tips. Paratype 521_59c preserved as fragment of mature growth stage. All specimens worn and deposited next to each other. Internal morphology variously diagenetically altered. Wavy inner parts of major septa in paratype 521-59b and its earliest morphology, strange for Stereophrentidae, may have resulted from diagenetic processes and here not considered taxonomically important. However, a different taxonomic position for it cannot be excluded. Restricted material precludes the possibility of an indisputable conclusion. Eight thin sections and 23 peels available for study. Polished surfaces considered in addition to thin sections and peels.

Diagnosis: *Zaphrufimia* with n:d value 20:7.2 mm to 20:9.0 mm; major septa non-rhopaloid, weakly differentiated in length, less numerous in cardinal quadrants; cardinal septum shortened from neanic growth stage; counter septum only slightly shorter than counter-lateral septa; minor septa recognizable in external wall.

Description: External wall bears delicate growth striae and shallow septal furrows. In neanic growth stage 0.2–0.3 mm thick, mostly sclerenchymal with peripheral margins of major septa incorporated, but minor septa absent from wall thickness. Wall in mature growth stage 0.5 mm thick, in holotype mostly sclerenchymal, with peripheral margins of major septa incorporated and with minor septa hardly distinguishable (Fig. 11C, E). In paratypes, external wall in a form of septotheca, either slightly incomplete (Fig, 12G, J), or complete (Fig. 12 L). In neanic growth stage of holotype (Fig. 11A, B) n:d values 16:3.8×4.4 mm and 16:5.0×5.6 mm, three pinnately arranged major septa in each cardinal quadrant, and four semiradially arranged major septa in each counter quadrant. Cardinal septum shortened, in deep, key-hole cardinal fossula. Counter septum equal to counter-lateral septa. Axial sclerenchymal infilling weak. In earliest preserved growth stage of paratype 521_59b (Fig. 12A, B), with n:d values 13:3.5 mm and 14:3.5 mm, major septa short, thin, irregularly arranged, leaving wide, empty axial area. Protosepta hardly recognizable, possibly result of partial dissolution of skeleton. Within 0.3 mm of further corallite growth (n:d value 14:3.2×3.6 mm), arrangement of slightly thickened and wavy major septa become comparable to earliest growth stage of holotype studied, except for broken cardinal septum divided into peripheral part, attached to external wall, and innermost fragment, attached to axial sclerenchyme (Fig. 12C). Triangular cardinal fossula in this and slightly more advanced growth stage with n:d value 17:4.0 mm (Fig. 12D) perhaps result of diagenesis. Cardinal septum and last inserted major septum of left cardinal quadrant broken, with innermost fragments attached to axial sclerenchyma wider at this growth stage than below. In contrast to holotype, counter septum in paratype slightly shortened at this growth stage, considered late neanic/early mature. Length of protosepta forms main difference between those two specimens in neanic growth stage (Figs 11C *vs* 12D).

In mature growth stage of all three corallites, major septa remain thin (Figs 11D–G, 12E–G, K, L), almost radially arranged in holotype (Fig. 11D–G), shortened step by step in all quadrants of both paratypes (Fig. 12E–G, K, L). Length of protosepta in all specimens different. Cardinal septum very short in holotype and paratype 521_9b, but thin and only slightly shortened, in deep cardinal fossula in corallite 521_59c (Fig. 12K, L). Counter septum most clearly shortened in paratype 521_59b (Fig. 12G), very slightly shortened in remaining two corallites. Inner margins of major septa dependent on their position against tabulae as illustrated in holotype; slightly rhopaloid when sectioned at tabula surface, thin beneath and above its surface (Fig. 11D, E, respecti-

◄

Fig. 11. *Zaphrufimia anceps* sp. nov. Specimen 521_59a. Holotype. **A**–**C.** Neanic to late neanic growth stage (A, B peels with drawings). **D**–**F.** Mature growth stage (D – peel with drawing, F – thin section wih drawing). **G.** Lower part of calice (polished surface with drawing). **H**, **I.** Diagenetically altered major septa with external surface smooth (H) and nodular (I). **J.** Diagenetically altered major septum with shade of its incorporation in external wall. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

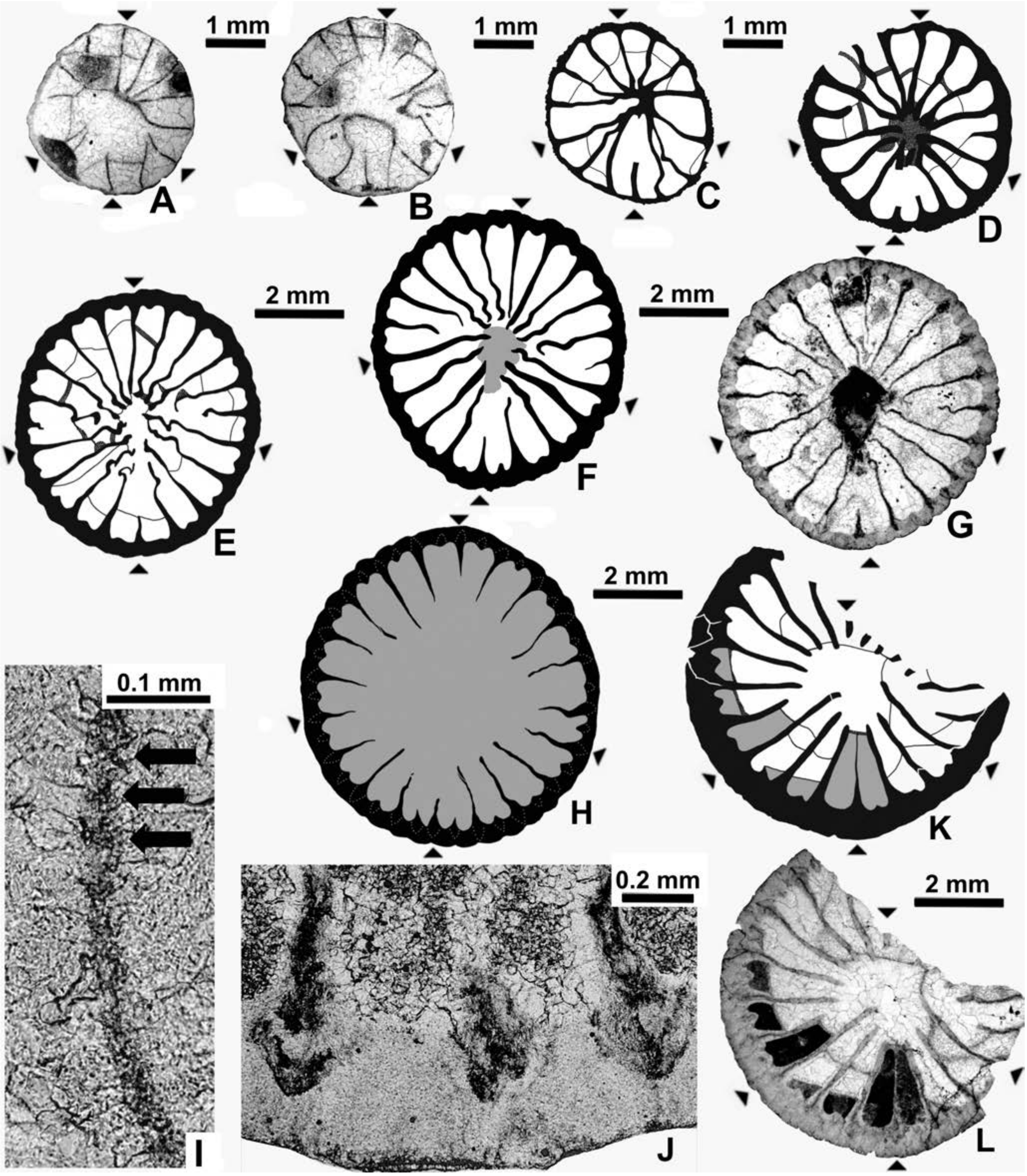


Fig. 12. *Zaphrufimia anceps* sp. nov. Paratypes. **A**–**J.** Specimen 521_59b: A, B – peculiar arrangement of major septa in early neanic growth stage; C, D – neanic growth stage (peels with drawings); E–G – mature growth stage (E, F peels with drawing). Curve of inner parts of septa diagenetically caused; H – middle part of calice (polished surface with drawing), I – primary septum (dark) with probable remnants of trabeculae preserved in upper part (arrows), J – external wall with major and minor septa incorporated. **K**, **L.** Specimen 521_59c mature growth stage of incomplete corallite (K peel with drawing). Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

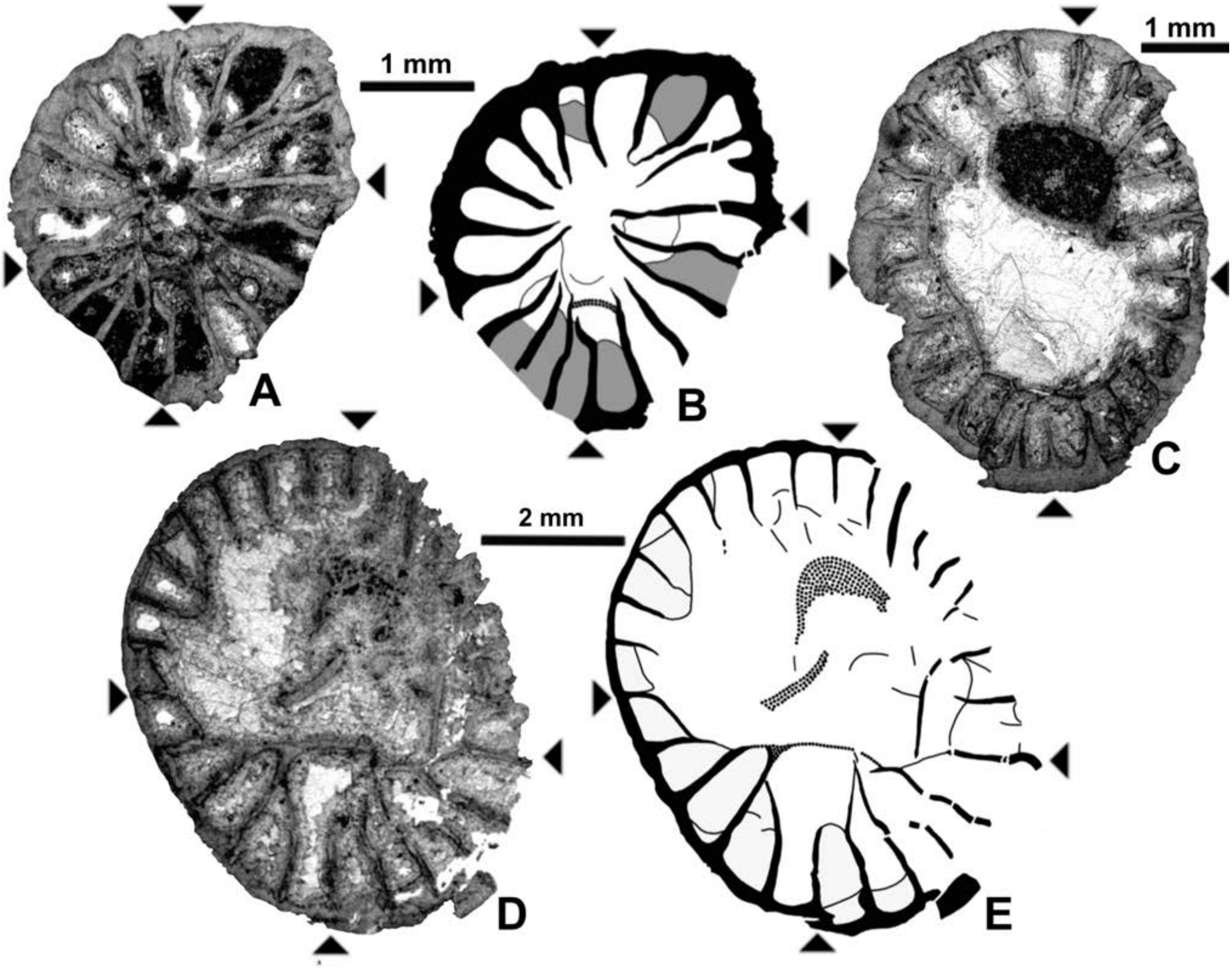


Fig. 13. *Zaphrufimia* sp. Specimen 476_199. **A**, **B.** Late neanic growth stage (B drawing from A). **C.** Early mature growth stage, strongly diagenetically deformed. **D**, **E.** Mature growth stage, diagenetically deformed (E thin section with drawing). Scale bars located between two adjacent pictures correspond to both; that upper right of the picture correspond only to it. See Note for Figure 6 for remaining explanations.

vely). Number of major septa in holotype and paratype 521_59c similar in quadrants: three in each cardinal quadrant and six in each counter quadrant. That difference smaller in paratype 521-59b: 4×2 major septa in cardinal quadrants and 5×2 major septa in counter quadrants, but total maximum number identical in all three specimens. Their maximum n:d values measured: 20:9.0 mm (holotype), 20:7.2 mm (paratype 521_59b), 20:8.2 mm (paratype 521_59c). Axial areas in holotype and paratype 521_59b filled with mud. i.e., sectioned above calice floors. Remaining parts of those corallites filled with calcite, i.e., sectioned beneath calice floor. Infillings described document tabulae sagging axially.

Remarks: The specimens described here vary in several small details, but these variations are not great enough to characterize different species, because their main diagnostic features closely resemble each other. They resemble the lectotype specimen of the nominative subspecies of *Z. disjuncta* in n:d values, in possessing a slightly shortened counter septum, thin major septa and underdeveloped minor septa. However, that lectotype specimen represents an extreme simplification. Other specimens included in that subspecies and the species as a whole (Fedorowski, 2012; Fedorowski and Machłajewska, 2014) comprise specimens with rhopaloid major septa more distinctly differentiated in length and the counter septum more distinctly shortened. An older stratigraphic occurrence of *Z. anceps* and its primitive characteristics may indicate that it is ancestral to *Z. disjuncta*.

Occurrence: All specimens as the holotype.

Zaphrufimia sp.
Fig. 13

Material: One incomplete, worn corallite 476_199, embedded in grainstone. Inner morphology strongly altered by dolomitization. Four thin sections (three illustrated) available for study.

Description: In ontogenetically earliest growth stage available for study (Fig. 13A, B), n:d value 19:3.1×3.7 mm, major septa slightly wavy, sharply ended, zaphrentoidally arranged, but with their inner margins free. Both protosepta slightly shortened, counter septum slightly more. Cardinal septum approaches inner margin of cardinal fossula, axially and peripherally slightly widened. In corallite sectioned approximately 1.7 mm above (Fig. 13C), n:d value 22:4.5×5.7 mm, all major septa almost equal in length, shortened to 1/3 corallite radius. Shortening of septa diagenetically caused as demonstrated by big dolomite crystals and mud infilling (Fig. 13C, whitish and dark respectively). Only cardinal septum shortened little more than remaining septa. Ontogenetically most advanced growth stage available for study (Fig. 13D, E), with n:d value 26:5.7×7.3, morphologically similar to previous one, but with cardinal and counter septa clearly shortened. Inner part of corallite partly filled with large dolomite crystals, but with broken tabulae also present. Both oval shape of corallite and broken skeletal fragments caused by compression.

Remarks: This corallite is described and illustrated, despite a poor state of preservation, because 1) the specimens collected from drill cores are from units totally lacking natural outcrops and thus are the only source of information, 2) the corallite possesses diagnostic generic features well developed, 3) representatives of *Zaphrufimia* are almost unknown from the literature, and 4) corals of this age and from this area have never been studied before.

Occurrence: Telatyn IG-1, drill core, depth 1286 m, Limestone D, early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Family *INCERTAE SEDIS*

Genus *Chelmia* gen. nov.

Type species: *Chelmia radiata* sp. nov. by original designation.

Name derivation: Named for the city of Chełm, where specimens belonging to this genus were collected.

Diagnosis: Solitary; major septa amplexoid, radially arranged, leave axial area empty; cardinal septum slightly shortened; counter septum temporarily elongated; dissepiments present in some septal loculi; microstructure very finely trabecular.

Remarks: The relationships of *Chelmia* are uncertain. Its resembles *Axisvacuus* Fedorowski, 2009c by the slightly elongated counter septum in maturity and the semi-radial arrangement of major septa that leaves the axial area free. The occurrence of dissepiments and extremely tiny trabeculae, approximately 0.005 mm in diameter, suggest a separate family status of that genus. Among solitary dissepimented rugose coral species, only *Caninia cornucopiae* Michelin, 1840, possessing the counter septum elongated in early maturity and regular dissepiments present in the advanced growth stage (Carruthers, 1908; Fedorowski, 2010), displays a morphology somewhat comparable to *Chelmia*.

The morphological peculiarity of specimens included in the type species of the genus, the exceptional occurrence of early Serpukhovian (Pendleian) Rugosa in this part of Europe, and their suspected value for the phylogeny of Pennsylvanian Rugosa of Eastern Europe legitimizes the introduction of this new genus, based on the incomplete and restricted material available.

Species content. Monotypic.

Chelmia radiata sp. nov.

Figs 14, 15

Holotype: Specimen 188_156b (Fig. 14A–I).

Type Locality: Chełm IG-2 drill core, depth 1294 m, Limestone F.

Age: Early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Name derivation: Latin: *radiatus* – radial. After radial arrangement of septa.

Diagnosis: *Chelmia* with n:d value 24 and 25:8.5 mm; minor septa well developed where dissepimentarium occurs, appear as short strips at peripheral wall where dissepimentarium absent.

Material: Four incomplete corallites occurring as disorganized clasts within grainstone. All specimens collected from two adjacent fragments in same drill core. All diagenetically altered to various degrees. Holotype (188_156b) and one paratype (188_156a) cut transversally. Two paratypes (188_156c, 188_156d) cut obliquely during drilling or preparation. Two transverse thin sections six peels and six polished surfaces available for study.

Description: In holotype, major septa thin, radially arranged. Axial area free from septa varies in width depending on position against axial parts of tabulae. Major septa vary in length in individual transverse thin sections or polished surfaces, almost equally long in some (Fig. 14A), slightly differentiated in other sections (Fig. 14B–E) with counter-lateral septa shorter than adjacent major septa. Newly inserted pair of septa in counter quadrants underdeveloped (Fig.14D). Length of cardinal septum depends on its position against tabulae: slightly shortened just beneath tabulae and equal to adjacent major septa above their surfaces. Length of counter septum also depends on its position against tabulae, being thin in most of that part of corallite growth studied; elongated and slightly rhopaloid when sectioned just above surface of tabula (Fig. 14D). Minor septa vary from bodies incorporated in thickness of external wall through short spines that extend out of external wall in loculi lacking dissepiments (Fig. 14I), to skeletal structures reaching up to 1/6 length of major septa in loculi with dissepimentarium well developed (Fig. 14F). That development inconsistent even within same transverse section (Fig. 14E). Impossible to make well oriented longitudinal section. In random oblique sections of paratypes (Figs 14J, 15D) tabulae and additional tabellae widely distributed, domed (Fig. 14J) or flat axially (Fig. 15D). Arrangement of tabulae in holotype probably domed, as suggested by rare, convex axial sections of tabulae in corallite periaxial parts and numerous sections of tabulae at its periphery (Fig. 14A–E). Microstructure strongly altered diagenetically in most septa. In inner parts of some septa where least altered (Fig. 14G, arrow) remnants of extremely tiny separate trabeculae (approximately 0.005 mm). Chain of larger irregular bodies of very differentiated size, 0.01–0.03 mm, distinguishable in other septa (Fig. 14H) interpreted as trabeculae enlarged during recrystallization at expense of sclerenchymal sheets of septa.

Temporary elongation of counter septum present in holotype and incomplete dissepimentarium observed in holotype and in one paratype (Fig. 15D) considered diagnostic for completely developed corallites. In contrast, strongly curved counter septum and major septa adjacent to it in one paratype (Fig. 15A–C), resulting from diagenetic alteration, lacks taxonomic value.

Remarks: As for the genus.

Occurrence: As for the holotype.

Suborder PLEROPHYLLINA Sokolov, 1960

Family POLYCOELIIDAE de Fromentel, 1861

Genus *Sochkineophyllum* Grabau, 1928

Type species: *Pleurophyllum artinse* Soshkina, 1925, by subsequent designation of Grabau, 1928, p. 75.

Remarks: Fedorowski and Bamber (2001) offered a comprehensive discussion on the genus *Sochkineophyllum* and/or specimens bearing that generic name without their fundamental diagnostic features being completely known. Comprehensive papers dealing with that genus have not been published since then, although Chwieduk (2013) described *S. tergidiseptatum* (Tidten, 1972) from new sites of the Wordian or Capitanian age in Spitsbergen. Poorly described and inadequately illustrated *Sochkineophyllum*? sp. of Denayer (2012) almost certainly does not belong to that genus.

The stratigraphic distribution of the *Sochkineophyllum*-like specimens ranges from the uppermost Famennian or lowermost Tournaisian in Poland (Fedorowski, 1973) to the Wordian or Capitanian in the Svalbard and Canadian Arctic Archipelagos (Tidten, 1972; Ezaki and Kawamura, 1992; Fedorowski and Bamber, 2001; Chwieduk, 2013). Such an enormously long occurrence (nearly 100 million years) seems unlikely for a genus. Also, several differences in such important features as presence *vs* absence of the calophylloid morphology in immature skeletons and the presence of

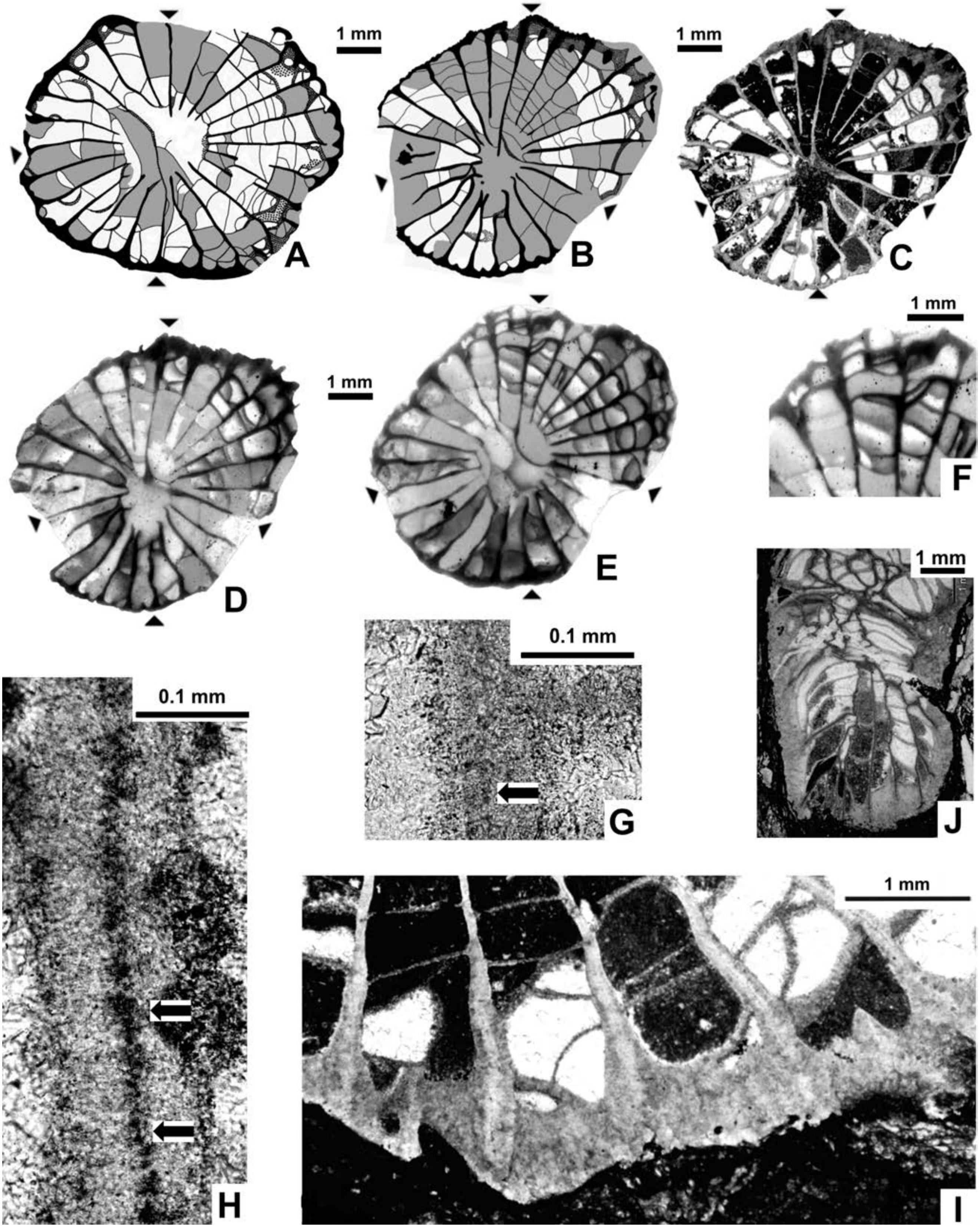


Fig. 14. *Chelmia radiata* gen. et sp. nov. Transverse sections except when stated otherwise. **A**–**I.** Specimen 188_156b; holotype: A–E – mature growth stage; F – enlarged from E to better demonstrate dissepimentarium (A – peel with drawing; B – drawing from C; D–F – polished surfaces); G, H – microstructure of septa; some trabeculae indicated by arrows, I – enlarged from top of photo C; external wall with peripheral margins of septa incorporated; appearance of first dissepiment. **J.** Specimen 188_156c. Paratype. Oblique section. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

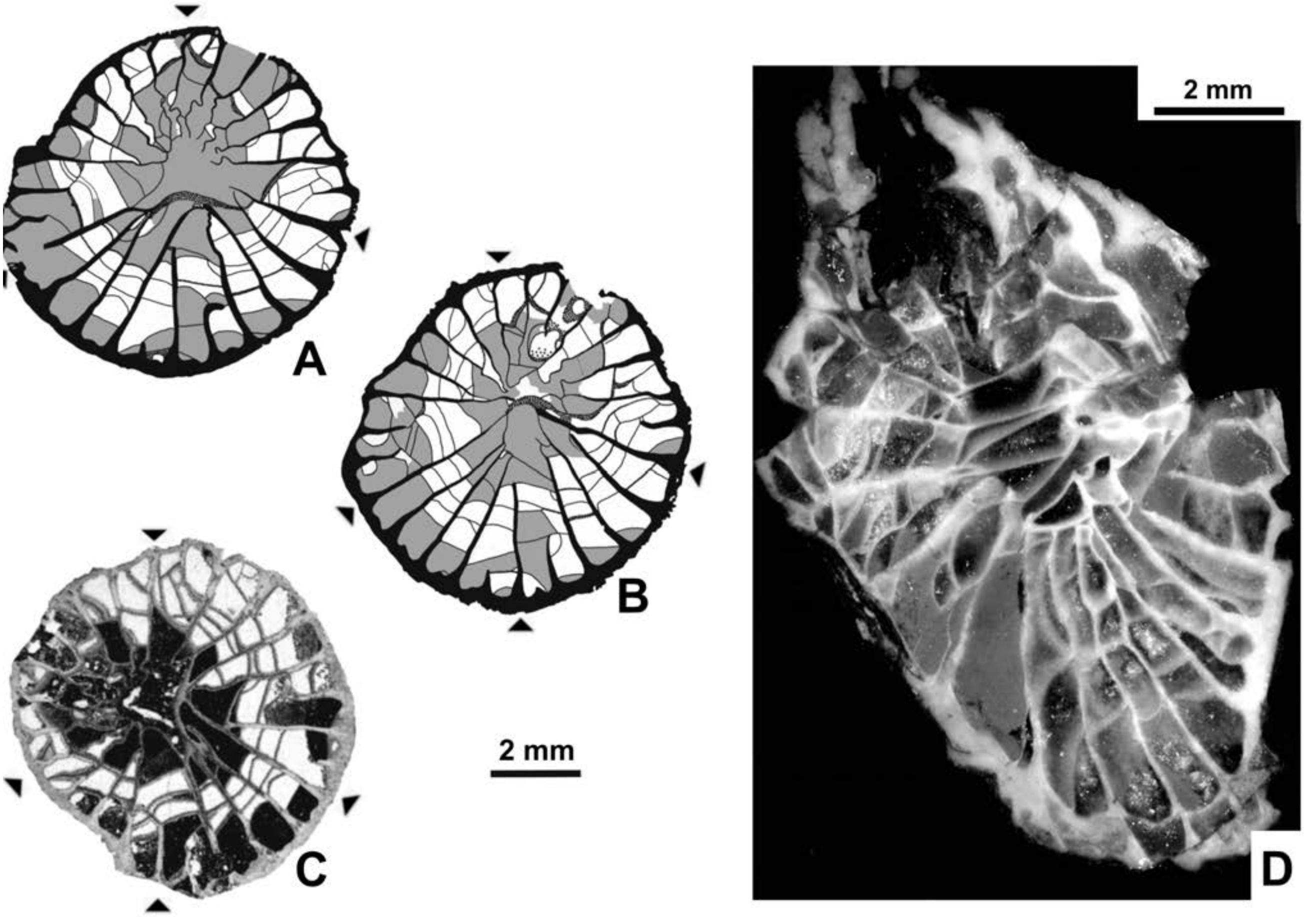


Fig. 15. *Chelmia radiata* gen. et sp. nov. **A–C.** Specimen 188_156a. Paratype. Transverse sections. Mature growth stage. Major septa in counter quadrants diagenetically deformed (A – polished surface; B – peel; A and B both with drawings); **C** – transverse thin section. **D.** Specimen 188_156d. Paratype. Oblique polished surface; dissepiments occur in some loculi. Scale bar in lower part corresponds to pictures A–C. See Note for Figure 6 for remaining explanations.

biformly reduced minor septa *vs* either absence of minor septa from the corallite lumen or their long length legitimize the short synonymy proposed by Fedorowski and Bamber (2001, p. 59). Lack of new and rigid data precludes a suggestion here of a credible synonymy. In addition, the microstructure of septa is unknown from the majority of the *Sochkineophyllum*-like species described so far.

?*Sochkineophyllum symmetricum* sp. nov.
Fig. 16

Holotype: 437_49 (Fig. 16A–J).
Type locality: Rudno IG-1, drill core, depth 724.4 m, Limestone D.
Age: Early Serpukhovian (Pendleian, *Eumorphocers* E1 Biozone).
Name derivation: Latin: *symmetricus* – after clearly bilateral symmetry of the mature growth stage.
Material: One specimen 24 mm long with earliest growth stage lacking and with 18 mm of advanced mature growth stage and crushed calice. Microstructure of septa diagenetically altered. Six thin sections and two peels available for study.
Diagnosis: Solitary, non-dissepimented corals with mature n:d values beneath calice floor 24:6.8×8.0 mm to 28:8.2; major septa bilaterally arranged, much thicker in cardinal quadrants; cardinal septum shortened in maturity; counter septum longest; counter-lateral septa comparatively short, inclined towards counter septum; minor septa beneath mature calice absent from corallite lumen.
Description: Irregular arrangement of major septa in ontogenetically earliest growth stage preserved (neanic) roughly resembles rotiphylloid arrangement by long protosepta with counter septum dominating strongly since that early growth stage (Fig. 16A–D). Irregular distribution of sclerenchymal thickenings of septa, comparatively short counter-lateral septa inclined towards counter septum, and lack of calophylloid differentiation in length of major septa, typical for *Sochkineophyllum*, the main characteristics of this early growth stage.
Most of mature characteristics achieved at n:d value 22:7.0×6.1 mm (Fig. 16E, F) and last for approximately 6 mm of corallite growth (Fig. 16G, H). At this growth stage, cardinal septal fossula short, closed, and triangular; counter septum strongly rhopaloid; and greatest length of middle major septa in counter quadrants of septa, most important characters in addition to those mentioned in diagnosis.

Beneath calice floor (Fig. 16I), thinned counter septum reaches key-hole cardinal fossula. Cardinal septum strongly shortened. Other characters remain similar to those in earlier growth stage. Minor septa absent from both corallite lumen and external wall. In crushed part of corallite near calice floor (not illustrated), major septa of cardinal quadrants equal in thickness to those of counter quadrants. Their length and arrangement are impossible to decipher.
Remarks: The specimen described here does not resemble any of the specimens described so far. From the type species *Pleurophyllum artiense* Soshkina, 1925 from the Permian (Cisuralian, Artinskian) deposits of the Urals, ?*S. symmetricum* differs in its bilateral

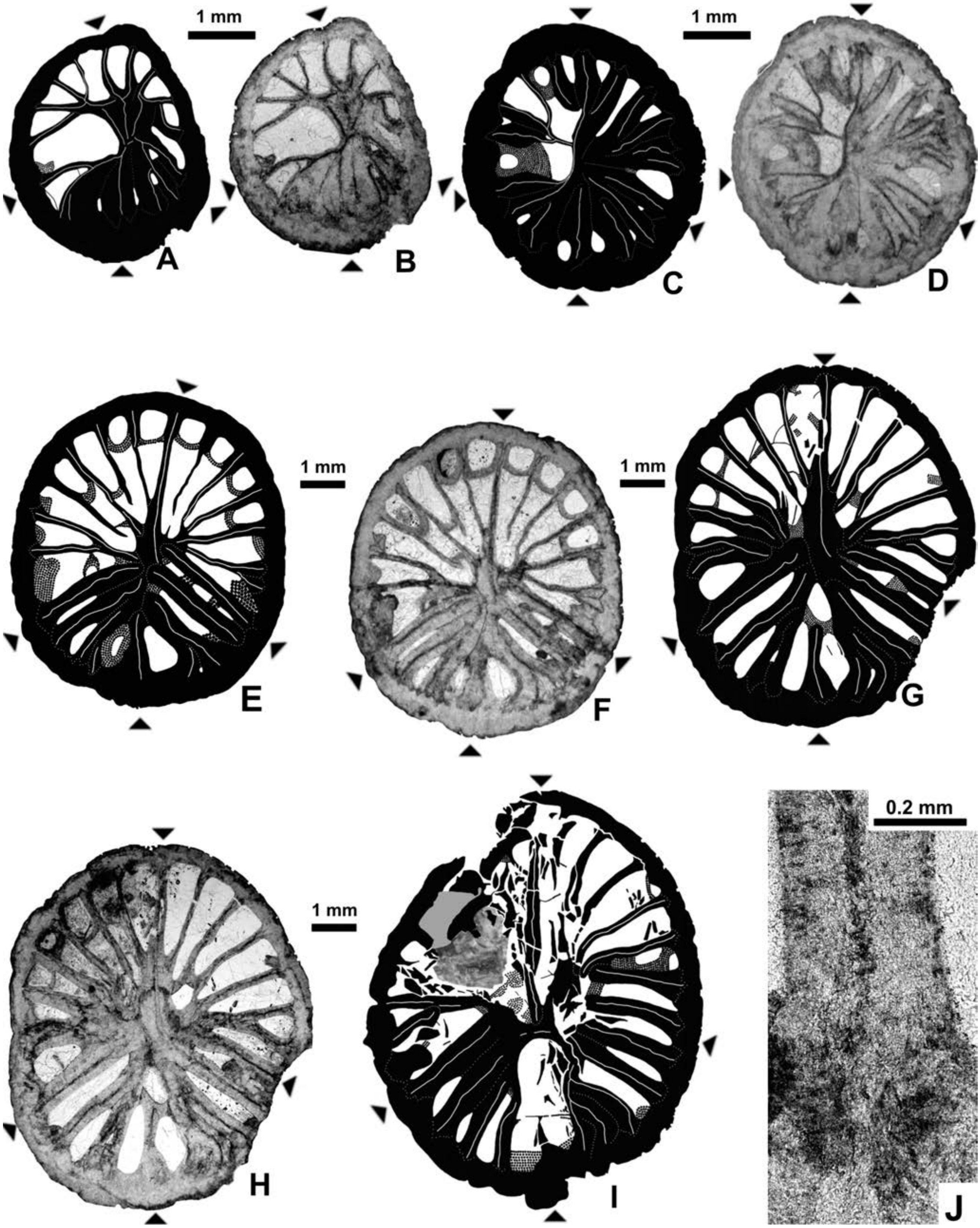


Fig. 16. ?*Sochkineophyllum symmetricum* sp. nov. Specimen 437_49. Holotype. **A**–**D.** Neanic growth stage, A and C drawings. **E**–**I.** Early to late mature growth stage: E, G, and I drawings. **J.** Microstructure of septum and its stylolitic contact with external wall. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

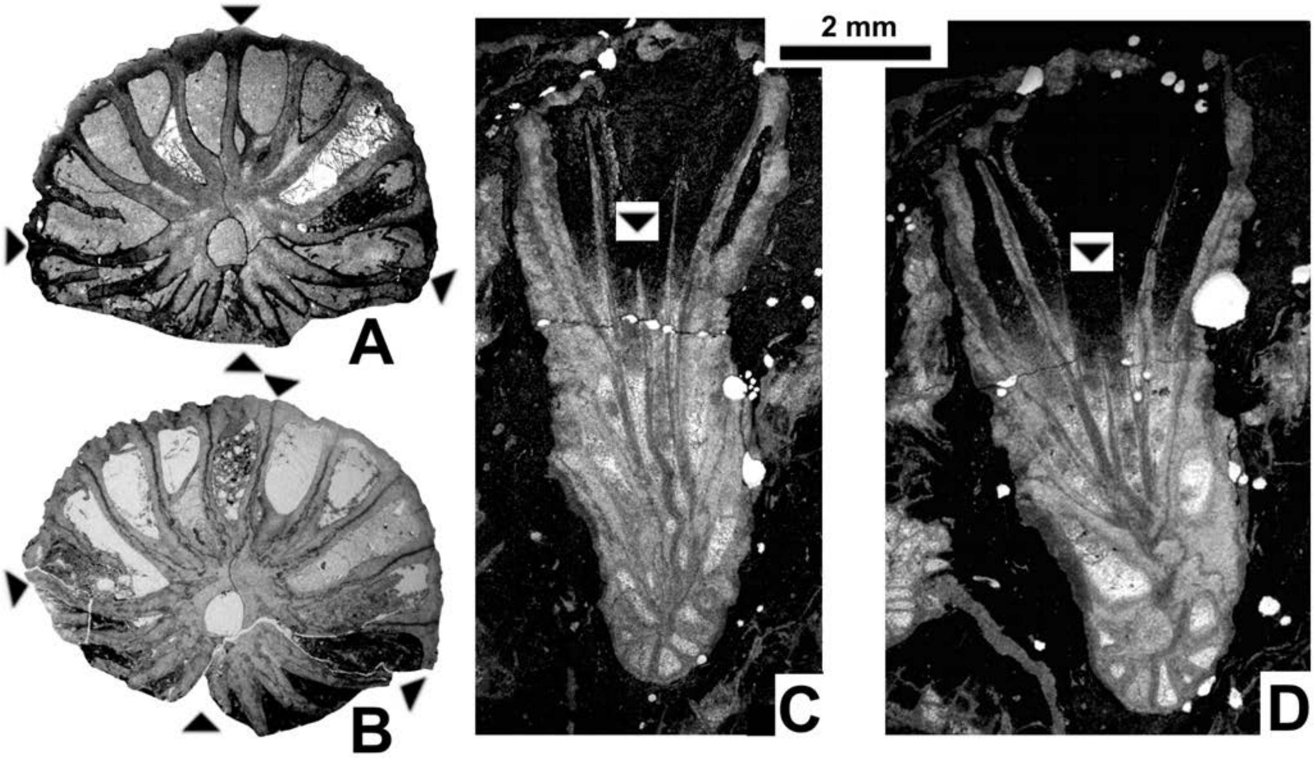


Fig. 17. *Ostravaia* aff. *silesiaca* Fedorowski, 2010. **A**, **B.** Specimen 467_352 – mature growth stage (A – peel). **C**, **D.** Oblique sections (peels): C – neanic growth stage in proximal part; D – early mature growth stage in proximal part; calice exposed by both peels. Scale bar between C and D corresponds to all pictures. See Note for Figure 6 for remaining explanations.

symmetry, distribution of stereoplasmic thickenings of major septa, and by the morphology of early growth stage which lacks calophylloid arrangements of septa. The latter character, a long time span between the occurrence in the Artinskian type species and the early Serpukhovian specimen described here, and dramatic changes in the global geography that took place during that very long period of time, make a true relationship of *S. artiense* and ?*S. symmetricum* unlikely. That doubt is indicated by the question mark. Both taxa are here considered as morphotypes, closely comparable in their mature growth stages, but not related. However, the very restricted nature of the material precludes introduction of a new generic name.

Occurrence: As for the holotype.

Suborder UNCERTAIN
Family OSTRAVAIAIDAE Fedorowski, 2010

Diagnosis: Non-dissepimented Rugosa with earliest growth stage rotiphylloid, followed by circulotheca. Microstructure of septa finely trabecular.

Remarks: The position of Ostravaiainae Fedorowski, 2010 within the Family Antiphyllidae Ilina, 1970 was originally considered tentative (Fedorowski, 2010, p. 167). Mature characters of *Birkenmajerites primus* sp. nov. makes that position even more doubtful. Members of the Family Antiphyllidae not only lack a circulotheca, but also possess an elongated counter septum. Characters of *B. primus*, and such species as "*Permia*" *caverna* Hudson, 1944 allow separation of the Ostravaiainae from the Antiphyllidae and its elevation to the family level with a new diagnosis proposed above. The diagnosis is laconic, because some other taxa of doubtful taxonomic position, such as *Silesamplus* Fedorowski, 2009a and the taxa mentioned in the discussion on that genus (Fedorowski, 2009a, pp. 310–314) may also belong to that family. Reduction in the length of both protosepta in the mature growth stage of *B. primus* and a biform reduction of its minor septa increase morphological variation within the family, indicating distinction at a subfamily level. Lack of details of the ontogeny and the microstructure of several potential members of the Ostravaiaidae preclude their reliable taxonomic recognition and detailed discussion.

Genus *Ostravaia* Fedorowski, 2010

Type species: *Ostravaia silesiaca* Fedorowski, 2010, p. 167 (by original designation).

Diagnosis and **remarks:** See Fedorowski, (2010, pp. 166,167).

Ostravaia aff. *silesiaca* Fedorowski, 2010
Fig. 17

Material: Two incomplete specimens. 467_352 – mature growth stage, slightly incomplete in cardinal quadrants. 521_59d – randomly cut corallite. In proximal end neanic and early mature growth stage exposed; in distal end calice sectioned in cardinal quadrants. One transverse thin section and three peels available for study.

Description: Mature specimen 467_352 (Fig. 17A, B) with n:d value 18:5.2 mm. Major septa rhopaloid, slightly differentiated in length, form complete circulotheca. Cardinal septum shortened. Counter septum and alar septa indistinguishable from adjacent major septa. Axial area within circulotheca 0.5 mm wide. Minor septa underdeveloped, but recognizable in 0.2- mm-thick external wall.

In specimen 521_59d, rotiphylloid arrangement of major septa recognizable in earliest growth stage exposed (Fig. 17C) and early appearance of a circumaxial structure, perhaps of an aulos type, in opposite surface exposed by cutting. Shortening of cardinal septum below calice (Fig. 17D, black triangle) and in calice visable in upper part of both sides of section (Fig. 17C, D, black triangle).

Remarks: The specimens described bear a combination of main characters of *Ostravaia silesiaca*, including the n:d values of the mature specimen and the aulos-like circumaxial structure of the obliquely cut corallite. Incompleteness of both specimens precludes their identification with confidence.

Occurrence: Hostynne IG-1, drill core, depth 1354.1 m, below Limestone C, early Serpukhovian, (Pendleian, *Eumorphoceras* E1 Biozone). Łuków IG-4, drill core, depth 1506.1–1506.7 m, early Serpukhovian.

Genus *Birkenmajerites* gen. nov.

Type species: *Birkenmajerites primus* sp. nov.

Name derivation: Named in honour of Professor Krzysztof Birkenmajer, the outstanding Polish geologist.

Diagnosis: Ostravaiaidae with both protosepta shortened in mature growth stage; tabularium biform; minor septa biformly reduced.

Discussion: The neanic growth stage of *Birkenmajerites* resembles that of *Ostravaia* Fedorowski, 2010 in possessing a well-developed circulotheca. The finely trabecular microstructure of septa in both genera is closely comparable. Those important features support a position of *Birkenmajerites* within the family Ostravaiaidae. The most important differences between those two genera, to date the only formally described representatives of that family, are shown in the mature growth stage of *B. primus* sp. nov., in which the major septa are long and irregular in length, both protosepta are shortened, and the minor septa biformly are reduced. Some British species of "*Permia*" of Hudson 1944, which need revision, may be ancestral for both *Ostravaia* and *Birkenmajerites*.

Birkenmajerites primus sp. nov.
Figs 18, 19

Holotype: Specimen 397_155 (Figs 18, 19).

Type locality: Parczew IG-3 drill core, depth 1210.3 m, Limestone D.

Age: Early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone).

Name derivation: Latin: *primus*, a, um – first. After being first species of that new genus described.

Material: Holotype only. Specimen well preserved in early and late neanic growth stage. Skeletal elements diagenetically damaged by recrystallization and compression, resulting in stylolitic contacts of major and minor septa in septotheca; major septa crushed in mature growth stage, but arrangement recognizable. Trabeculae preserved in inner segments of some major septa. Seven thin sections and six peels available for study.

Diagnosis: *Birkenmajerites* with n:d value 25:9.0 mm near calice floor; neanic circulotheca replaced successively by short-lasting stereocolumn and narrow free axial area; major septa long, irregularly variable in length.

Description: Corallite almost conical, very slightly curved in cardinal/counter septal plane with cardinal septum at concave side. In earliest growth stage preserved (Fig. 18A) n:d value 18:4.5 mm, circulotheca complete. In more advanced neanic growth stage (Figs 18B, 19C) n:d value 19:5.2×5.7 mm, circulotheca incomplete, but stereoplasmatic ring continuous (see Fedorowski, 2009b for terminology). Cardinal septal fossula present, but true tabular cardinal fossula not marked by sections of tabulae, possibly absent. Inner margins of major septa in circulotheca slightly and irregularly variable in length; protosepta neither shorter nor longer than remaining major septa. Attachment of biformly reduced minor septa to adjacent major septa not always follow rules typical for Rugosa; i.e., their position at cardinal septum side of major septa not always recognizable, possibly result of compression, documented by stylolitic contact of septa (Fig. 19B) up to calice.

In late neanic/early mature growth stage (Figs 18C, 19D), n:d value 20:6.1×6.7 mm, septa remain rhopaloid and slightly differentiated in length; circumaxial sclerenchyme extends to corallite axis. Short-lasting occurrence of that structure and its weakness may suggest section immediately above tabula surface, somewhat confirmed by next section, considered early mature as showing both protosepta shortened (Figs 18D, 19E) with n:d value 21:7.2×8.0 mm. Sclerenchyme remains between inner margins of major septa, irregularly differentiated in length; almost lacking from corallite axis. Alar septa neither dominate nor obviously shortened by comparison to other major septa. Last inserted major septum in that growth stage underdeveloped in right quadrant, but long in left quadrant. Both those major septa remain shortened during mature growth stage, including calice floor (Fig. 18E–G; loculi cut above last tabula shadowed). Major septa, except shortened protosepta, remain long and differentiated in length during corallite mature growth stage. Length of cardinal septum in calice strongly reduced (Fig. 18G).

Remnants of trabeculae seen only in some primary septa in one transverse section (Fig. 19A). In best preserved primary septum trabeculae approximately 0.025 mm wide, forming chain of irregular dots. Individual calcite fibrils unrecognizable. Primary septum passes into sclerenchymal cover without any recognizable border perhaps destroyed by recrystallization, as were sclerenchymal sheets, individual growth layers of which disappeared. Preservation of trabeculae perhaps possible thanks to enrichment with iron ions.

Discussion: Lack of other species to compare.

Occurrence: As for the holotype.

Suborder AULOPHYLLINA Hill, 1981
Family AULOPHYLLIDAE Dybowski, 1873
Subfamily AULOPHYLLINAE Dybowski, 1873

Genus *Nervophyllum* Vassilyuk, 1959

Type species: *Nervophyllum bescheviensis* Vassilyuk, 1959 (by original designation).

Emended diagnosis: Aulophyllinae with long median lamella, connected to cardinal septum at least in neanic to early mature growth stage, may disappear in late maturity; extra septal lamellae from few to numerous; axial column continuous; tabularium normal or incompletely biform.

Discussion: Representatives of *Nervophyllum* were recognized previously only from the Donets Basin, Ukraine (Vassilyuk, 1959, 1960) and from the Góry Świętokrzyskie (Holy Cross) Mountains in Poland (Fedorowski, 1971). Genus *Berkhia* Gorsky, 1951 from the "Barents Series" of the Novaya Zemlja may be either a genus, closely related to *Nervophyllum*, or an older synonym of that genus, or a younger synonym of *Aulophyllum* Milne Edwards and Haime, 1850, as has been already suggested by Fedorowski (1971). Unfortunately, the Novaya Zemlja taxon which was based on a very incomplete study and description has not been revised since its introduction. Thus, its taxonomic status is uncertain.

Neither the very long generic diagnosis proposed by Vassilyuk (1960, pp. 151–152), that included a discussion, nor the diagnosis proposed by Fedorowski (1971, p. 114) correspond to recent standards and thus must be emended. Also, the present author changed his opinion on the relationship of *Nervophyllum* at a subfamily level. *Nervophyllum primitivum* Fedorowski, 1971 may well point to the genus *Dibunophyllum* as an ancestor, as suggested earlier, but extra septal lamellae present in its axial column (both terms in-

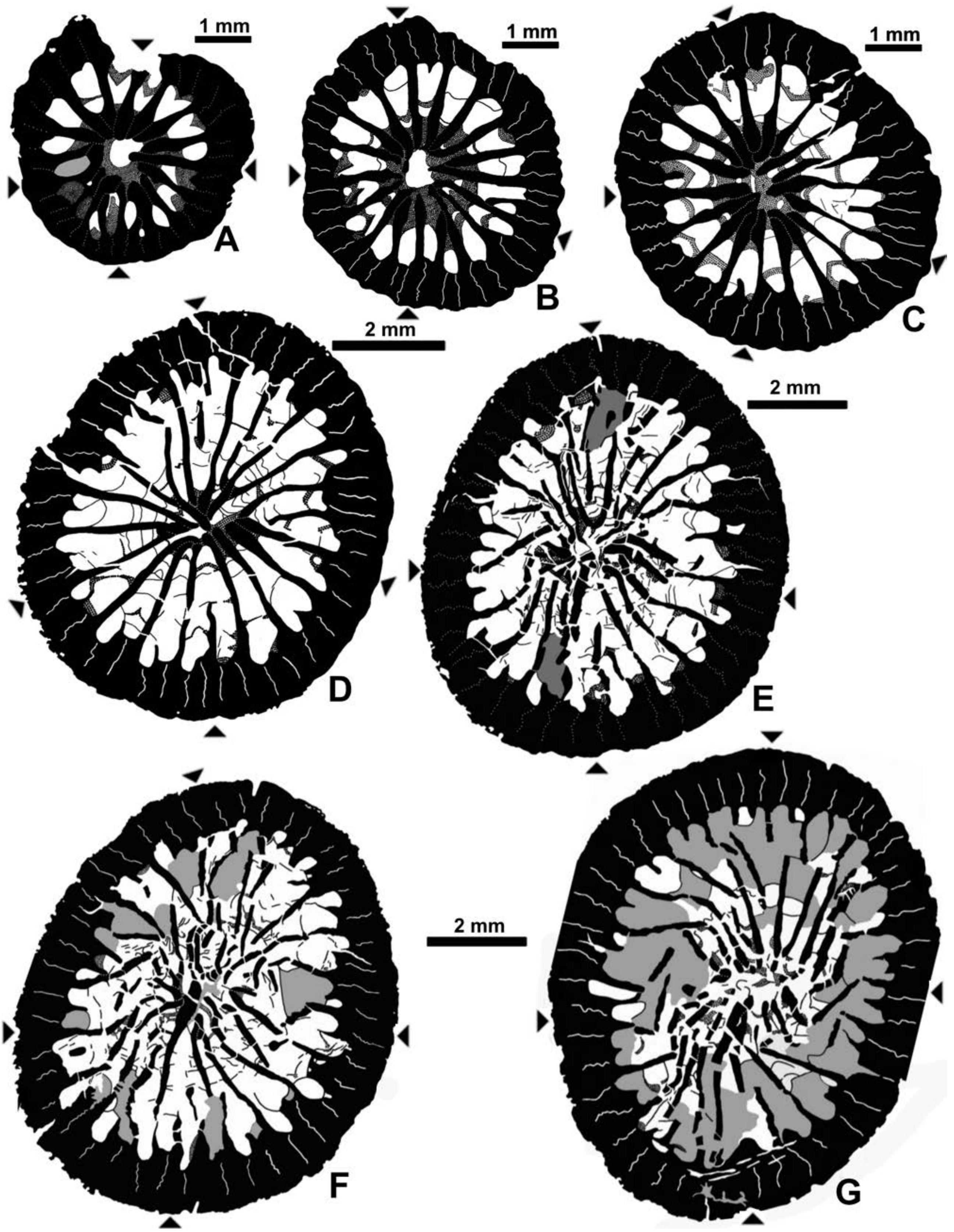


Fig. 18. *Birkenmajerites primus* gen et sp. nov. Specimen 377_155, holotype. **A**, **B.** Neanic growth stage. **C.** Late neanic/early mature growth stage. **D**–**G.** Early to late mature growth stage. All thin sections with drawings. Scale bars located upper right of the picture correspond only to it. Scale bar between F and G corresponds to both. See Note for Figure 6 for remaining explanations.

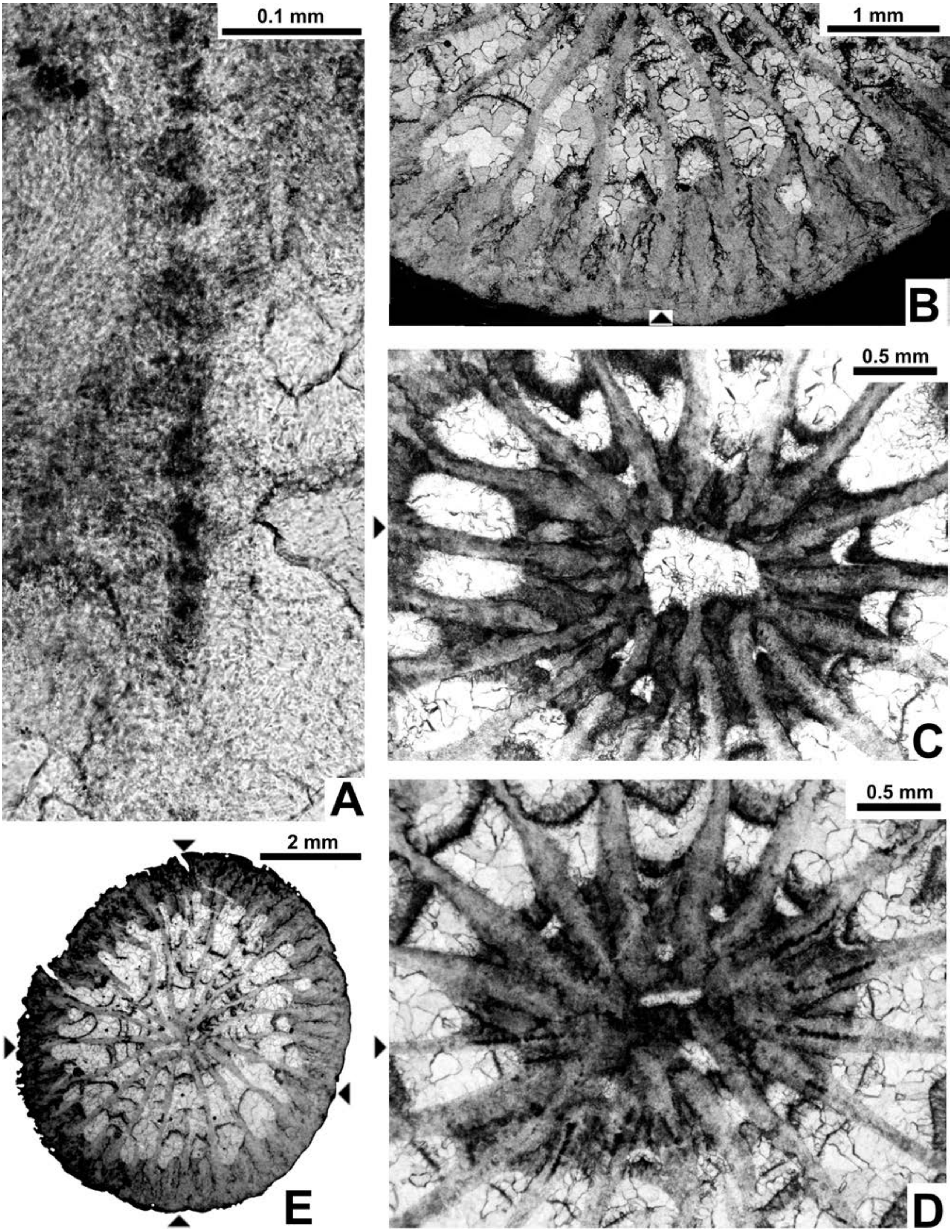


Fig. 19. *Birkenmajerites primus* gen. et sp. nov. Specimen 377_155, holotype. **A.** Chain of trabeculae preserved in part of primary major septum. **B.** Septotheca; stylolitic contact of major and minor septa; cardinal septum marked by triangle in white quadrangle. **C**, **D.** Circulotheca (C) and its replacement by temporary axial column (D); cardinal septum marked by triangle. **E.** Early mature growth stage; protosepta shortened. Magnification indicated by individual scale bars. See Note for Figure 6 for remaining explanations.

troduced by Fedorowski *et al*., 2007) are typical for the Subfamily Aulophyllinae. None of the genera undoubtedly belonging to the Subfamily Dibunophyllinae Wang, 1950 possess extra septal lamellae, whereas all representatives of the Subfamily Aulophyllinae described so far, possess that character more or less well developed. Thus, the author now considers the presence or absence of extra septal lamellae as the main character, allowing a distinction between those two subfamilies. Consequently, *N. primitivum* and remaining species of *Nervophyllum* should be transferred to the latter subfamily, although derivation of *Nervophyllum* from *Dibunophyllum*, suggested previously (Fedorowski, 1971), is not questioned. The appearance of *Dibunophyllum* earlier than any member of the subfamily Aulophyllinae identified so far and the supposition that a descendant is commonly more advanced than its ancestor support that suggestion.

Nervophyllum lukoviensis sp. nov.
Fig. 20

Holotype: Specimen 521_59e (Fig. 20B–F).
Type locality: Łuków IG-4 drill core, depth 1506.1–1506.7 m.
Age: Early Serpukhovian.
Name derivation: *lukoviensis* – after the type area near town of Łuków.
Material: Two short fragments of corallites. Holotype 521_59e (mature growth stage with calice) and paratype 521_60b (immature growth stage) internally well preserved. Earliest growth stages missing. Microstructure of septa destroyed. One transverse thin section and four peels available for study.
Diagnosis: *Nervophyllum* with n:d value below calice floor 35: 14×12 mm; inner margins of some major septa incorporated in axial structure; minor septa penetrate outer tabularium; cardinal septum connected to thin extension of median lamella; extra septal lamellae only in maturity; dissepimentarium 1/4 corallite radius wide; dissepiments mostly regular.
Description: In mature growth stage (Fig. 20B–D), reaching 17.5 mm in diameter next to shallow calice margin reduced to 14×12 mm at distance of 9 mm lower (Fig. 20E, F), external corallite wall approximately 0.1 mm thick. Septa in dissepimentarium thin, straight when dissepimentarium regular, wavy when complex dissepimentarium developed locally. Major septa radially arranged, slightly and equally thickened in tabularium, amplexoidally elongated along tabulae surfaces to join their lamellae in axial structure; mostly free from septal lamellae below tabulae. Thin cardinal septum connected directly to thin extension of slightly thickened, monoseptal median lamella free from counter septum. Alar septa recognizable only when last pair of major septa in counter quadrants shortened. Minor septa intersect slightly thickened inner wall, reach up to 1/2 length of major septa. Axial structure occupies almost 1/2 corallite diameter, consists of median lamella, numerous sections of axial tabellae and septal lamellae of different lengths. Some normal septal lamellae extending from inner margins of major septa to median lamella, some others short. Extra septal lamellae mostly short, not numerous, recognizable mainly next to median lamella. Dissepimentarium approximately 1/4 corallite diameter. Dissepiments mostly regular, in some parts of corallite irregular and lateral.

Morphology of immature corallite (Fig. 20A) simple, when compared to mature one. Differences most apparent in axial structure, occupying slightly more than 1/2 corallite radius, and containing only a few septal lamellae with extra septal lamellae not yet developed.

Longitudinal section (Fig. 20E, F) documents presence of continuous axial column in last 8.8 mm corallite growth, including calice. Median lamella continuous, but differentiated in thickness. Septal lamellae differentiated in number both in course of corallite growth and left *vs* right of median lamella. Axial tabellae densely packed, elongated when septal lamellae absent, or short, when spanning septal lamellae. Tabulae outside axial column incomplete, 5–6 in approximately 3 mm corallite growth. Some peripheral tabellae sloping down. These may suggest occurrence of biform tabularium in individual septal loculi, not documented firmly. Most dissepiments small, bubble-like, arranged in steep rows. Those next to tabularium commonly elongated with inner walls thickened by sclerenchyme.
Remarks: The genus *Nervophyllum* remains unknown outside Poland and the Donets Basin in the Ukraine. The diagnostic characters of *N. lukoviensis* distinguish it clearly from all four species of that genus described so far. It is smaller from all of them and has different n:d value. Width of its axial column exceeds greatly both width of the axial column in the type species and in the Polish species, whereas it is simpler from most of them, except *N. primitivum* Fedorowski, 1971. The latter species differs from *N. lukoviensis* in features mentioned above and in possessing the minor septa short, the major septa clearly thickened in the tabularium and in the tabulae densely packed in its tabularium.
Occurrence: As for the holotype.

Subfamily DIBUNOPHYLLINAE Wang, 1950

Genus *Dibunophyllum* Thomson and Nicholson, 1876

Type species: *Dibunophyllum muirheadi* Thomson and Nicholson, 1876 by subsequent designation of Gregory (1917, p. 232). A younger synonym of *Clisiophyllum bipartitum* McCoy, 1849 and *Clisiophyllum turbinatum* McCoy, 1851 (see Hill, 1938–1941, p. 65).
Emended diagnosis: Solitary Dibunophyllinae with long, thin median lamella pointing towards and/or connected with cardinal septum; axial column continuous, composed of axial tabellae and regular septal lamellae; extra septal lamellae absent.
Remarks: Hill (1981, p. F361) in the Treatise repeated her earlier diagnosis (Hill 1938–1941, p. 65) that included several quantitative characters, such as: "Minor septa are degenerate" and "the width of the dissepimentarium is about two-thirds the length of the major septa, which is two thirds the radius of the corallum;". Such quantitative characters cannot be used for generic diagnosis, whereas such features as "variable axial structure is typically one third as wide as the corallum" are proper for the Scottish *Dibunophyllum bipartitum* revised by her, but not for several species described elsewhere. Many of those latter species should be transferred to new genera, if that original diagnosis is followed literally. Thus, the authors accepting Hill's (1938–1941, 1981) diagnosis, including the present author (Fedorowski, 1971, p. 55) and Rodriguez *et al*. (2013b) ignored those quantitative parts of the diagnosis. Such an approach makes emendation of the diagnosis necessary.

The diagnosis proposed here, on the other hand, is too general in not pointing to the thickness of the median lamella and the width of the axial structure – two characters traditionally accepted as distinguishing *Arachnolasma* Grabau, 1922 from *Dibunophyllum*. However, both those characters are very variable in *Arachnolasma* as documented already by Yu (1933, pl. 1, figs 6–10, pl. 2, figs 1–7), who illustrated specimens collected from the type area of *Arachnolasma*. Subsequent studies of specimens included either in *Dibunophyllum* or in *Arachnolasma*, conducted in various regions of the World (e.g., Vassilyuk, 1960; Dobrolyubova, 1970; Fedorowski, 1971; Semenoff-Tian-Chansky, 1974; Khoa, 1977; Wu and Zhao, 1989; Rodriguez *et al*., 2001; Fan *et al*., 2003; Gómez-Herguedas and Rodriguez, 2005) show a continuous range of characters within and between species included in both genera with the boundary between them not sharp and with the generic designation of individual species depending sometimes on the subjective preferences of authors, rather than on objective criteria. Lack of preci-

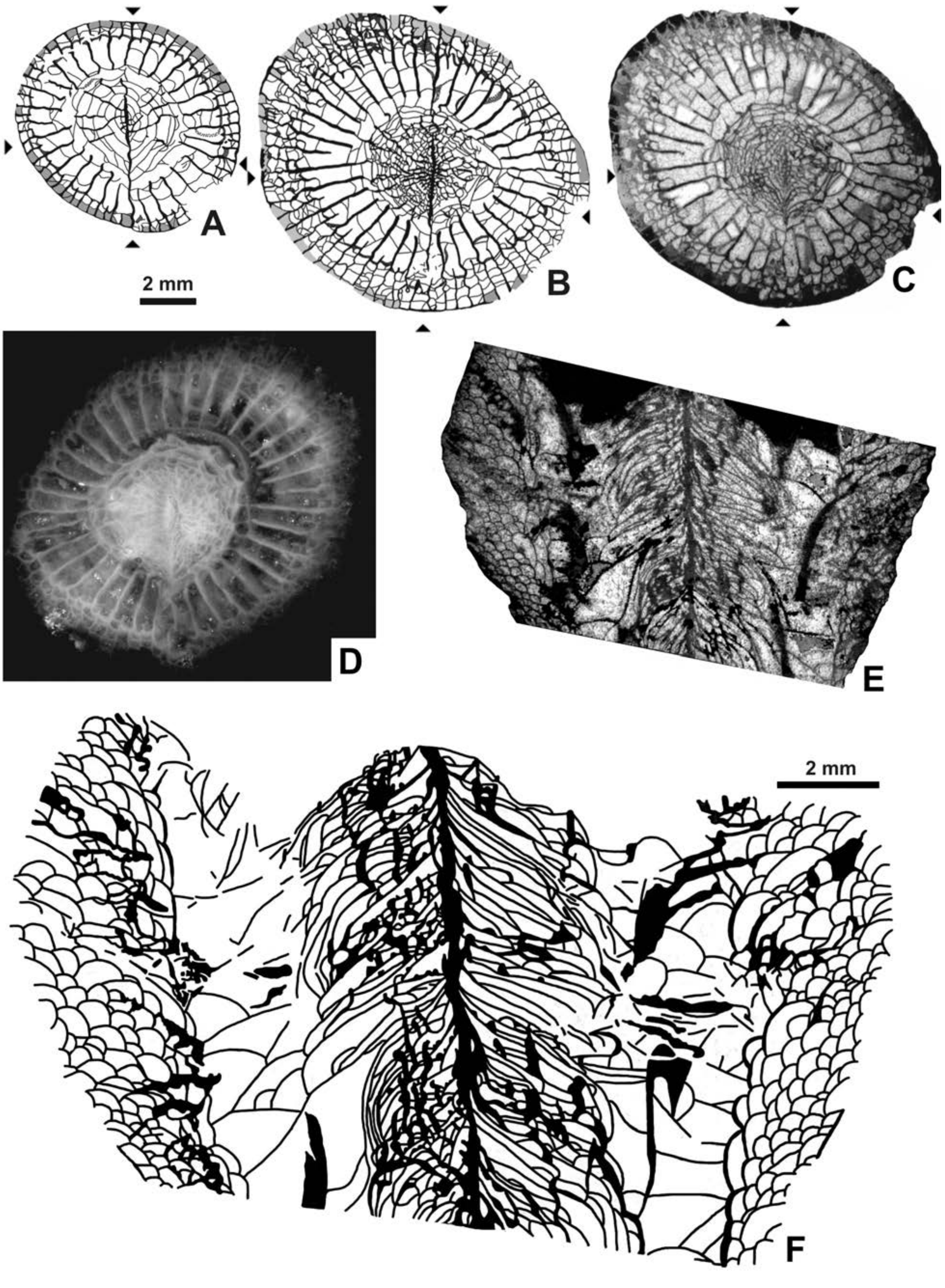
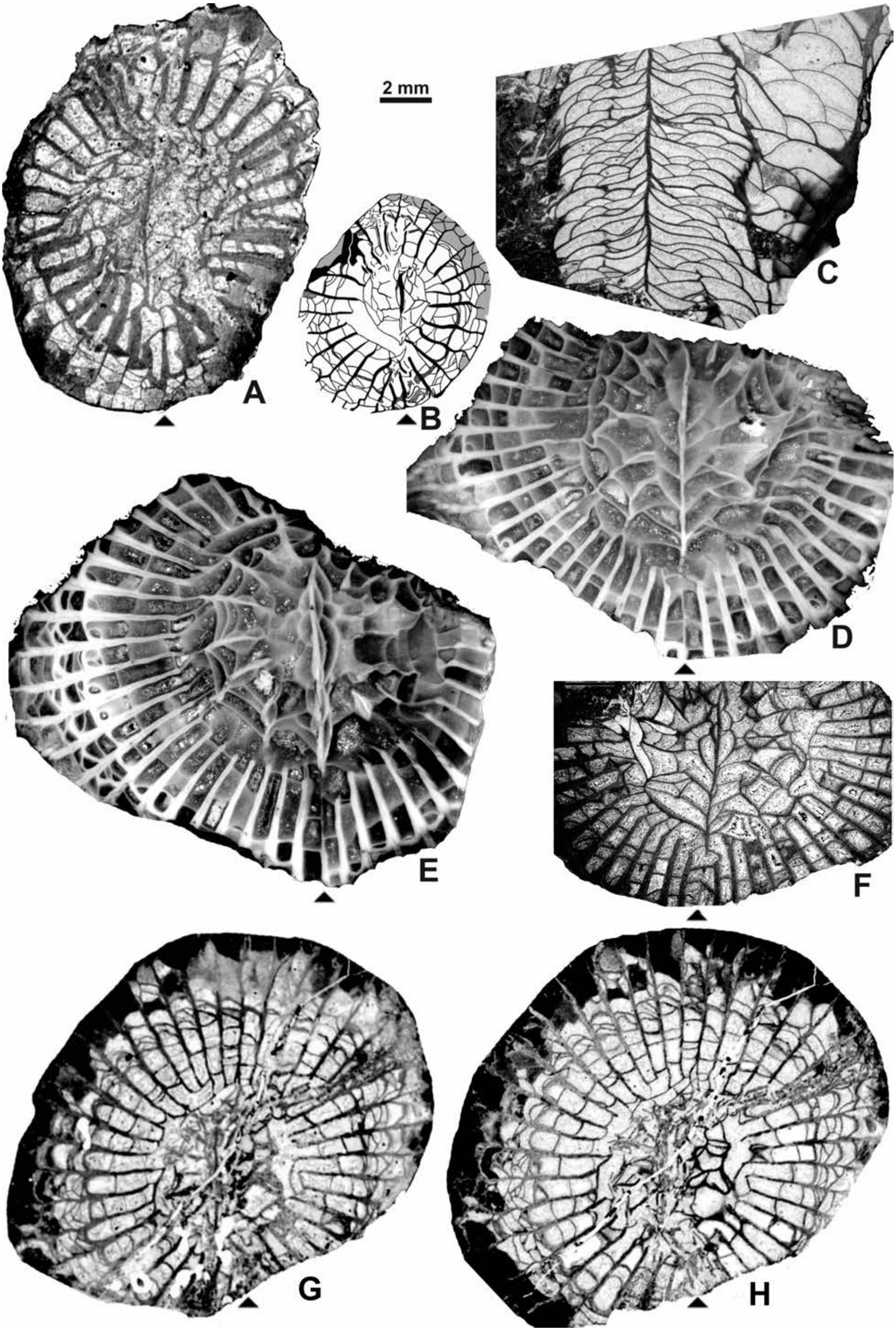


Fig. 20. Nervophyllum lukoviensis sp. nov. Transverse sections except when stated otherwise. **A.** Specimen 521_60b. Paratype, early mature growth stage (peel). **B**–**F.** Specimen 521_59e. Holotype, mature growth stage (B – peel with drawing); D – polished surface above C; E, F– longitudinal sections of the most advanced corallite growth, calice included. Mirror images (E – peel, F – peel with drawing; enlarged to better document details). Scale bar between A and D corresponds to all images and drawings except F. See Note for Figure 6 for remaining explanations.


2 mm
A
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H

sion in diagnostic characters allows placement of species in either *Arachnolasma* or *Dibunophyllum*. *Dibunophyllum subpercrassum* Vassilyuk, 1964 transferred by Fedorowski (1971, p. 96) to *Arachnolasma* may serve as an example of a morphologically intermixture of species. Since quantitative characters, such as thick *vs* thin median lamella, or wide *vs* narrow axial structure, are subjective, they cannot be accepted as diagnostic for the distinction between those two genera. Thus, other diagnostic criteria must be found, if *Arachnolasma* and *Dibunophyllum* are to be treated as truly different genera. The occurrence of a continuous axial column in the longitudinal sections, always present in the type species of *Dibunophyllum vs* the absence or incompleteness of such a column, accompanied by very narrow axial structure in transverse section, may serve as such qualitative criteria for distinguishing between those two genera. *Arachnolasma kamyshnense* Dobrolyubova, 1966 (in Dobrolyubova *et al*., 1966) may serve as an example of *Arachnolasma*, if the criteria mentioned are accepted.

In Poland, the genus *Dibunophyllum* is abundant in the late Viséan strata of the Sudetes, the Góry Świętokrzyskie Mountains and the Lublin Basin where it is represented by numerous species known from both Western and Eastern Europe (Fedorowski, 1968, 1971; Khoa, 1977), documenting an easy, long-distance faunal exchange at that time. The late Viséan was also the time when that genus became very widespread. It was most abundant in Europe, Asia, and North Africa, but it also occurs in Nova Scotia and Ellesmere Island of North America. However, the Nova Scotia fauna belongs to the Western European Coral Province, as established already by Fedorowski (1981) on the basis of Bell's (1929) and Lewis' (1935) taxonomical studies, supplemented more recently by Poty (2002), whereas the Ellesmere Island occurrence belongs to the Lazarus fauna (Fedorowski *et al*., 2012). Viséan records of *Dibunophyllum* from other parts of North America (e.g., Newell, 1935; Cocke, 1970; Cocke and Haynes, 1973) refer to a morphotype they called *Dibunophyllum*, but this morphotype does not belong to that genus *ss* (Fedorowski, 1981; Fedorowski *et al*., 2012). It is unknown from Australia and South America. Species described by Pinto (1977) under the name *Dibunophylloides* from the Desmoinesian strata of Brasil belongs to the same group of taxa as the North American "dibunophylla".

Until now, *Dibunophyllum* was unknown from the Serpukhovian strata of Poland, but it continued to occur through that age in several other areas. Its best documented Serpukhovian occurrences are those of southern Scotland (Hill, 1938–1941), the Donets Basin (Vassilyuk, 1960), and northern Africa (Semenoff-Tian-Chansky, 1974; Rodriguez *et al*., 2013a). Its well documented Bashkirian occurrences are: the Donets Basin (Vassilyuk, 1960), North Africa (Semenoff-Tian-Chansky, 1974; Rodriguez *et al*., 2013b; Cózar *et al*., 2014), Western Guizhou Province of south China (Wu and Zhao, 1989), and NW part of the Ellesmere Island, Canadian Arctic Archipelago of North America, (Fedorowski *et al*., 2012).

The abundance of *Dibunophyllum* species and their frequent descriptions by many authors (see the list above and papers cited in those articles) made that genus one of the best-known Carboniferous rugose coral genera. The comprehensive revision by Hill (1938–1941) of all Scottish "genera" and "species" introduced by earlier British authors (see her paper for the references), has supplied a basis for a proper understanding of both the characters important for species identification and the intraspecific variability within the genus.

Dibunophyllum bipartitum (McCoy, 1849)
Figs 21, 22

Lectotype: Specimen SM.A1971, in the Hopkins Collection from Derbyshire. Chosen by Hill (1938–1941, p. 67, pl. 1, figs 15–17).

Material: Three incomplete specimens: 188_145 fragmented and corroded with most of dissepimentarium missing, but morphology of remaining skeleton well preserved; 521_57a slightly compressed, with axial structure and cardinal septum area partly crushed; outer dissepimentarium corroded; 521_58a preserved as 45 mm long fragment, including immature and mature growth stages, slightly compressed, dissepimentarium of mature skeleton mostly corroded. Two thin sections, 14 peels and seven polished surfaces available for study. In addition the incomplete, but reasonably well-preserved specimens 521_58b, 188_150, 188_152, 188_156a and several fragments are questionably included in *D. bipartitum* (see Remarks). Three thin sections, ten peels, and 12 polished surfaces available for study from these specimens.

Description: Early growth stage (Fig. 21B) typical for most specimens undoubtedly belonging to this species. Thickened median lamella in corallite 521_58a, although present in slightly crushed axial structure (Fig. 21 G, H) considered typical. Axial column only apparently wider than 1/3 corallite diameter. Longitudinal section (Fig. 21C) illustrates lacks right dissepimentarium and left dissepimentarium and lateral tabularium. Other characters, such as major septa dilated in tabularium, minor septa short, cardinal fossula parallel-walled and herringbone dissepiments, closely resemble type material. Smaller corallite diameters and number of septa form main difference. Largest n:d values are: 521_57a – 40:19.5×14.5 mm; 521_58a – 36:18.5×13.0 mm and 36: 9.0×8.2 mm. Specimen 188_145 with 42 major septa lacks most of its dissepimentarium. True width of corallites reduced by compaction and/or corrosion.

Several specimens (Fig. 22A–I) display some morphological characters comparable to typically built *D. bipartitum*, but differ from them in some other features. Those similarities and differences discussed in Remarks.

Remarks: *Dibunophyllum bipartitum* belongs to a commonly described and well known species. Its wide intraspecific variability, established by Hill (1938–1941) on the basis of Scottish specimens, was made even wider by subsequent authors (e.g., Vassilyuk, 1964; Wu, 1964; Wu and Zhao, 1989: Dobrolyubova, 1970; Fedorowski, 1971; Semenoff-Tian-Chansky, 1974; Poty, 1981, 2002; Poty and Hannay, 1994; Liao and Rodriguez, 1999; Rodríguez *et al*., 2001, 2013a). The existing data, although numerous, are mostly incomplete in such characters as the early ontogeny and the microstructure of the septa. The microstructure of the septum illustrated by Rodriguez *et al*. (2013, fig. 6l) demonstrates diagenetic alterations of the septum rather than its original microstructure. Besides, only the well-preserved microstructure of the septa in the type Scottish material can be a true reference of that character when studied. Thus, it is impossible to judge whether a wide intraspecific morphological variability and an almost worldwide geographical distribution of the species are real, i.e., are specimens named *D. bipartitum* in distant occurrences closely re-

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Fig. 21. *Dibunophyllum bipartitum* (McCoy, 1849). Transverse sections except when stated. **A, B.** Specimen 521_58a: A – mature growth stage; B – early mature growth stage (peel with drawing). **C–F.** Specimen 188_145: C – longitudinal section; D–F – mature growth stage (D, E – polished surfaces). **G, H.** Specimen 521_57a – mature growth stage. Only cardinal septa marked by black triangles. Scale bar at the top corresponds to all images and drawings. See Note for Figure 6 for remaining explanations.

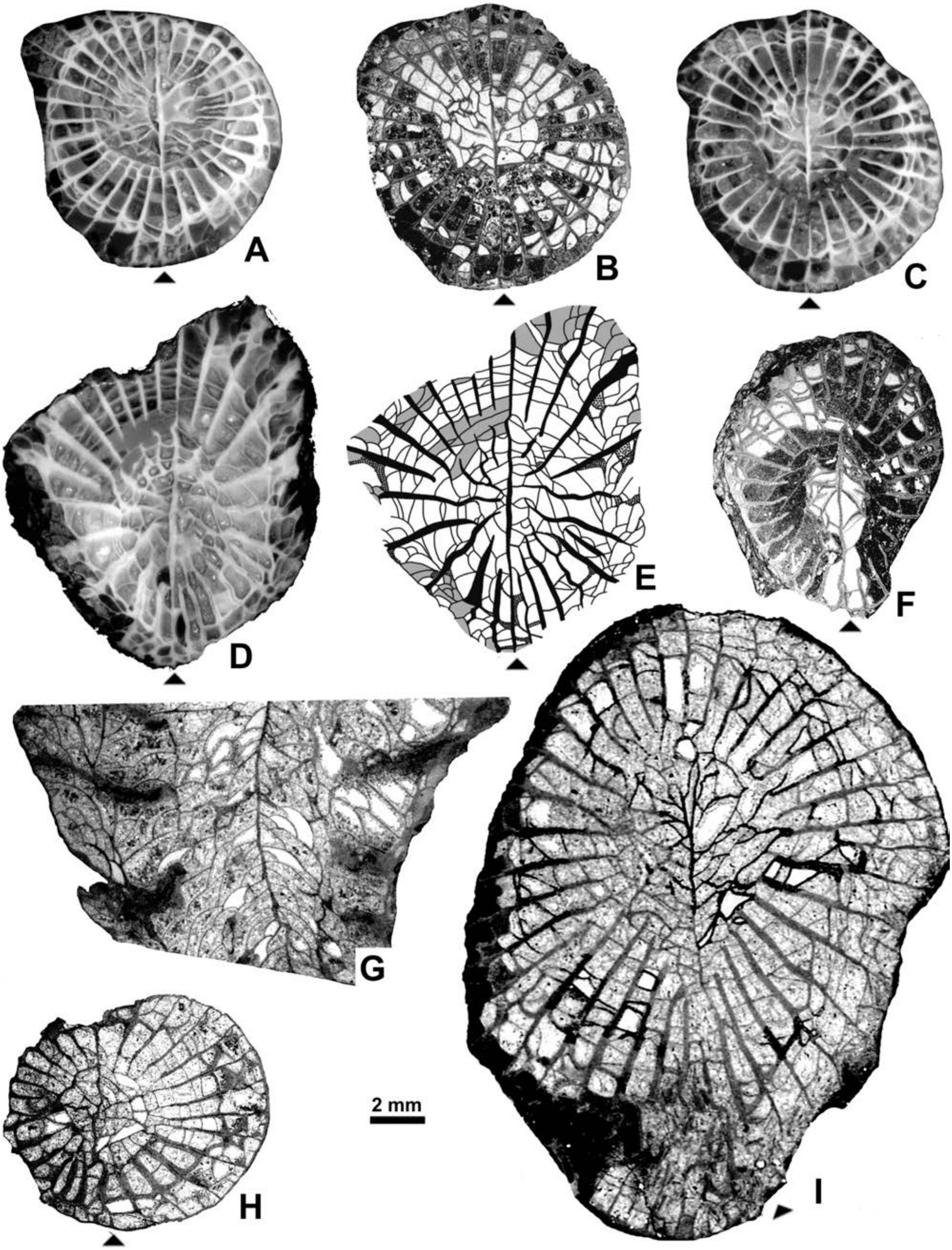


Fig. 22. *Dibunophyllum* ?*bipartitum* (McCoy, 1849). Transverse sections except when stated otherwise. **A**–**C.** Specimen 188_152. Mature growth stage (A, C – polished surfaces). **D**, **E.** Specimen 188_150. Mature growth stage (D – polished surface, E – peel with drawing). **F.** Specimen 188_156a. Mature growth stage. **G**–**I.** Specimen 521-548b: G – longitudinal section; H – early mature growth stage; I – mature growth stage (all peels). Only cardinal septa marked by black triangles. Scale bar at the bottom corresponds to all images and drawings. See Note for Figure 6 for remaining explanations.

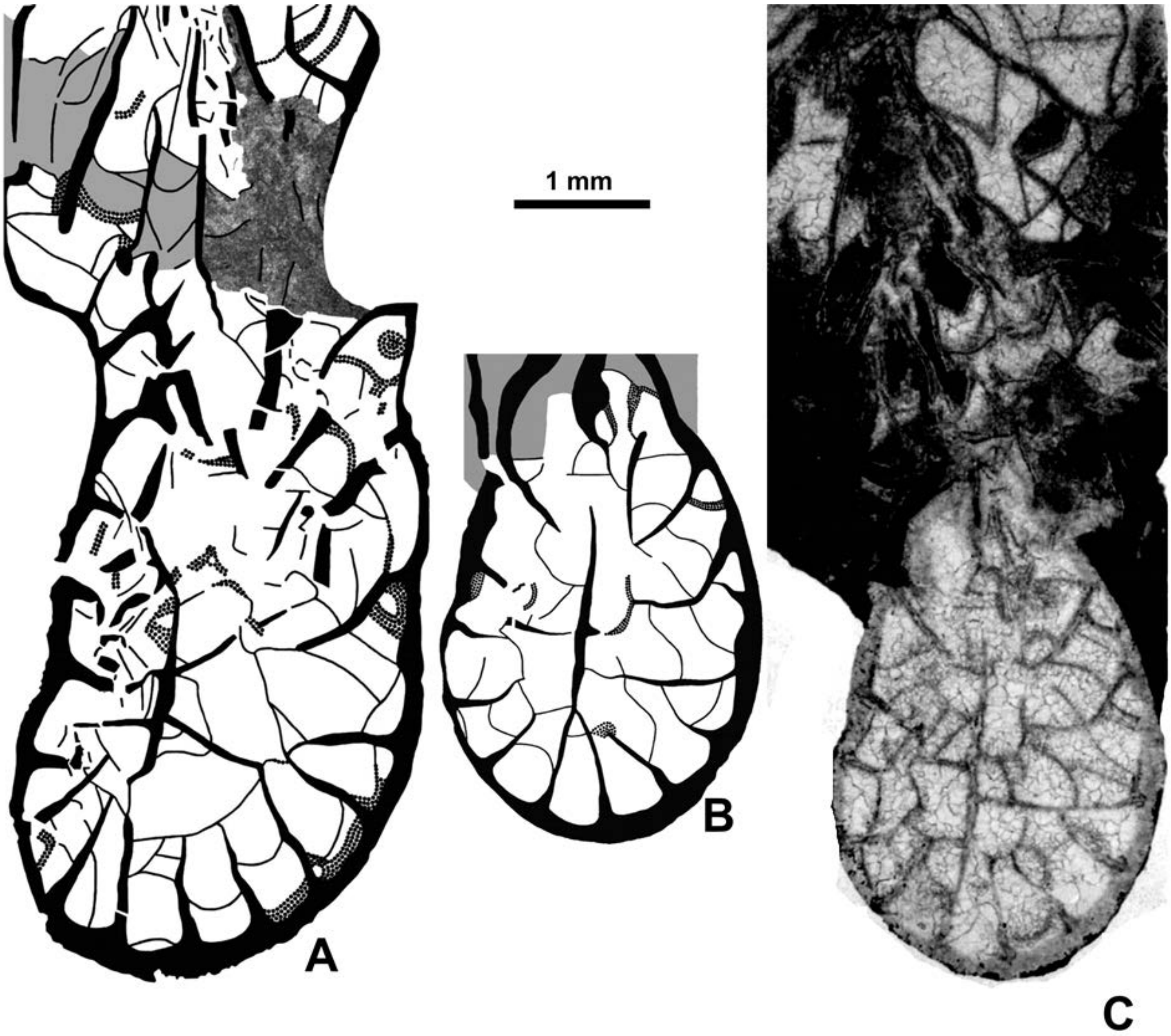


Fig. 23. ?*Cordibia* sp. **A**–**C.** Specimen 521_58c. Transverse sections of offsetting corallite with dibunophylloid axial structure present (A, B – peels with drawings). Scale bar near the top corresponds to all images and drawings.

lated genetically, or they are similar morphotypes? The doubts of the present author have resulted in the omission of a synonymy.

The corallites studied here are divided into two groups: those closely resembling the type material (Fig. 21A–H) and those morphologically distant from it in some characters (Fig. 22A–I). Corallites of the first group differ from each other, but each of them can be compared to particular variants of species, including those from Scotland (Thomson and Nicholson, 1876; Hill, 1938–1941). The very long, thin median lamella is connected to the cardinal septum in two of them (Fig. 21A, D, E), but this character rarely appears in the Scottish types and in specimens of *D. bipartitum* described from other regions. N:d values of the present specimens are much smaller than those in the Scottish (Hill, 1938–1941), Chinese (Wu, 1964; Wu and Zhao, 1989), Polish (Fedorowski, 1971) North African (Semenoff-Tian-Chansky, 1974; Rodríguez *et al*., 2013a) representatives of that species. This reduction in size may have resulted from an environmental stress.

The second group of specimens (Fig. 22A–I) is here questionably included *D. bipartitum*. Corals included in this group differ from both the first group mentioned above and the Scottish specimens in smaller corallite diameters and different n:d values. Their axial structures are much narrower (1/4 corallite diameter or less), composed of thin, long median lamella, commonly connected to both protosepta. Also, a few inner margins of septa rather than septal lamellae are incorporated in their axial structures. The true septal lamellae, i.e., isolated from the corresponding major septa are rare. The narrow axial structure makes these corallites slightly similar to *D. percrassum* Gorsky, 1951. They differ from the latter species in the much smaller size and different n:d value, in the major septa much less dilated, and in possessing the median lamella thin, commonly united with both protosepta. Differences mentioned may appear adequate for the introduction of a new species when more material is collected.

Occurrence: Chełm IG-2 drill core, depth 1291.0 and 1297.0 m, Limestone F, early Serpukhovian (Pendleian, *Eumorphoceras* E1 Biozone); Łuków IG-4. Depth 1506.1–1506.7 m, early Serpukhovian.

Genus *Cordibia* Fedorowski and Ogar, 2013

Type species: *Cordibia pumila* Fedorowski and Ogar, 2013.
Diagnosis: See Fedorowski and Ogar 2013, p. 302.

Discussion: See Fedorowski and Ogar 2013, p. 302–303.

?*Cordibia* sp.
Figs 23, 24

Material: Three incomplete corallites, all worn. Two of them, deposited next to each other, may represent one species: Specimen 521_60c – mature corallite, slightly corroded at periphery, narrowed abruptly by rejuvenation, and specimen 521_60d – compressed offsetting corallite. Specimen 521_58c offsetting corallite, represents perhaps different species; parent corallite crushed, offset preserved reasonably well in part of its growth. Two transverse thin sections, six peels and four polished surfaces available for study.

Description: In ontogenetically earliest growth stage of corallite 521_58c available for study (Fig. 23B, C), n:d value 14:2.7 mm (smaller diameter), two major septa common to parent and offset corallite. Long, slightly thickened median lamella united with one major septum, probably cardinal. Some remaining major septa join it with their thin inner margins, other free-ended. Minor septa and dissepiments not developed at this growth stage. Morphology in more advanced growth stage of same corallite (Fig. 23A) similar, except axial structure composed of thickened median lamella, four septal lamellae, two at each side, and sections of axial tabellae, suggesting occurrence of dibunophylloid axial column.

Corallite 521_60c underwent considerable environmental stress, resulting in significant reduction of size (Fig. 24A *vs* 24B, C) and change of growth direction (Fig. 24D, E). Its n:d values: 34:11.0×13.0 mm, 34:8.5×10.5 mm and 34:10.3×11.5 mm. Major septa radially arranged, slightly dilated in inner dissepimentarium and outer tabularium; most of them 3/4 corallite radius long; inner margins of some elongated; most terminated at sections of axial tabellae or tabulae instead of approaching median lamella, reached by only one or two. Cardinal septum slightly shorter than adjacent major septa. Position of counter septum uncertain. Corallite symmetry and permanent elongation of one septum in counter quadrants suggests it as counter septum (Fig. 24A–C, triangle with question mark). However, asymmetrically situated major septum connected to slightly thickened median lamella during entire growth observed, may be counter septum. Median lamella intersects corallite axis, pointing to cardinal septum, almost meeting it prior to corallite narrowing (Fig. 24A). Minor septa very short, visible only when external wall preserved. Width of dissepimentarium below and above level of corallite narrowing differs. Prior to narrowing, comparable to shallow rejuvenation, it reaches slightly more than 1/3 corallite radius when completely preserved, reduced to 1/4 above that event. Most dissepiments herringbone and irregular. Rare lonsdaleoid dissepiments at periphery (Fig. 24A, C lower). In longitudinal section (Fig. 24D, E) dissepiments elongated, vertically arranged at tabularium boundary, almost horizontal at periphery. Tabulae incomplete, inclined at low angle towards median lamella; inner tabellae form narrow, interrupted and indistinct axial column.

Microstructure of septa and mode of offsetting unknown. Offset formed in middle part of compressed corallite (Fig. 24F) may suggest axial offsetting.

Remarks: Specimens discussed are conditionally included in the genus *Cordibia*. They may belong to different species, but are described and illustrated in order to document the taxonomic variability of the rugose coral fauna studied. The laterally offsetting corallite 521_58c may belong to *Corwenia* Smith and Ryder, 1926, whereas the other two corallites and several strongly compressed specimens, may represent a new genus, if the offsetting is axial and leads to the appearance of true colonies. Detailed comparison of those specimens to other genera and species is omitted because of their incompleteness.

Occurrence: Łuków IG-4, depth 1506.1–1506.7 m, early Serpukhovian.

Suborder LITHOSTROTIONINA Spasskiy and Kachanov, 1971
Family LITHOSTROTIONIDAE d'Orbigny, 1852
Subfamily LITHOSTROTIONINAE d'Orbigny, 1852

Genus *Siphonodendron* McCoy, 1849

Type species: *Lithodendron pauciradialis* McCoy, 1844, with lectotype chosen by Hill 1938–1941, p. 169.

Siphonodendron strzelcense Khoa, 1977
Fig. 25

*1977 *Lithostrotion* (*Siphonodendron*) *rossicum strzelcense* sp. nov. – Khoa, p. 328, pls 2:4; 3:1–3; text-figs 11–13.

Material: Several fragments of branches broken from colonies and deposited together with worn specimens of various other taxa. Most compressed. All slightly recrystallized. Five better preserved fragments studied. Longest (26 mm) branch broken apart close to parent corallite as indicated by flattening and thickening at one side (Fig. 25A). Offsetting corallite in one specimen (Fig. 25I). 28 peels and one transverse thin section available for study.

Description: Branches cylindrical. Measured n:d values 15:3.2 mm, 17:3.4 mm; 17:4.0 mm; 18:3.1 mm; 18:3.6 mm in short fragments measured, and 17:3.2mm, 18:3.4 mm and 19:3.2 mm in transverse sections of the longest branch studied, document variety in that character. Also, inner morphology varies both between branches and during growth of individual branch (Fig. 25A–F). Short major septa and short, slightly thickened median lamella (a pseudocolumella) common to all branches studied. Single row of rectangular dissepiments with inner parts thickened to form inner wall, and minor septa penetrating tabularium most common features. However, minor septa may undergo temporary reduction in some or most loculi, dissepimentarium may be slightly more complex in those loculi as observed in a course growth of longest branch studied (Fig. 25B, C). Tabulae mostly complete, domed, only slightly elevated next to pseudocolumella, 2–3 in 1 mm of corallite growth. Pseudocolumella thin. Its presence in all transverse sections and polished surfaces studied suggests its continuity.

Remarks: Khoa (1977) introduced this taxon as a subspecies of *Siphonodendron rossicum* Stuckenberg, 1904. Specimens described here, restricted to isolated branches, do not allow an analysis of that decision. Also, his suggestion of very wide intra-subspecific variability is not discussed for the same reason. The present author refers here to his holotype (Khoa, 1977, fig. 11), strikingly similar in morphology to corallites described in this paper. Stratigraphic position of the holotype a few metres above the Viséan-Namurian boundary and the position of some paratypes in Tyszowce and Ulhówek even higher (Khoa, 1977, fig. 2), apparently support the supposition of the early Pendleian age of the corals collected from the Łuków IG-4 borehole expressed here.

Occurrence: Strzelce IG-1, depth 561 m. Łuków IG-4, depth 1506.1–1506.7 m, early Serpukhovian.

?*Siphonodendron* sp.
Fig. 26

Material: Three fragments of corallites, perhaps colony branches Nos. 521_59f, 521_60e-1 and 521_60e-2; none offsetting; all worn and deposited next to specimens of different genera. One transverse thin section, two longitudinal thin sections (one oblique) and six peels available for study.

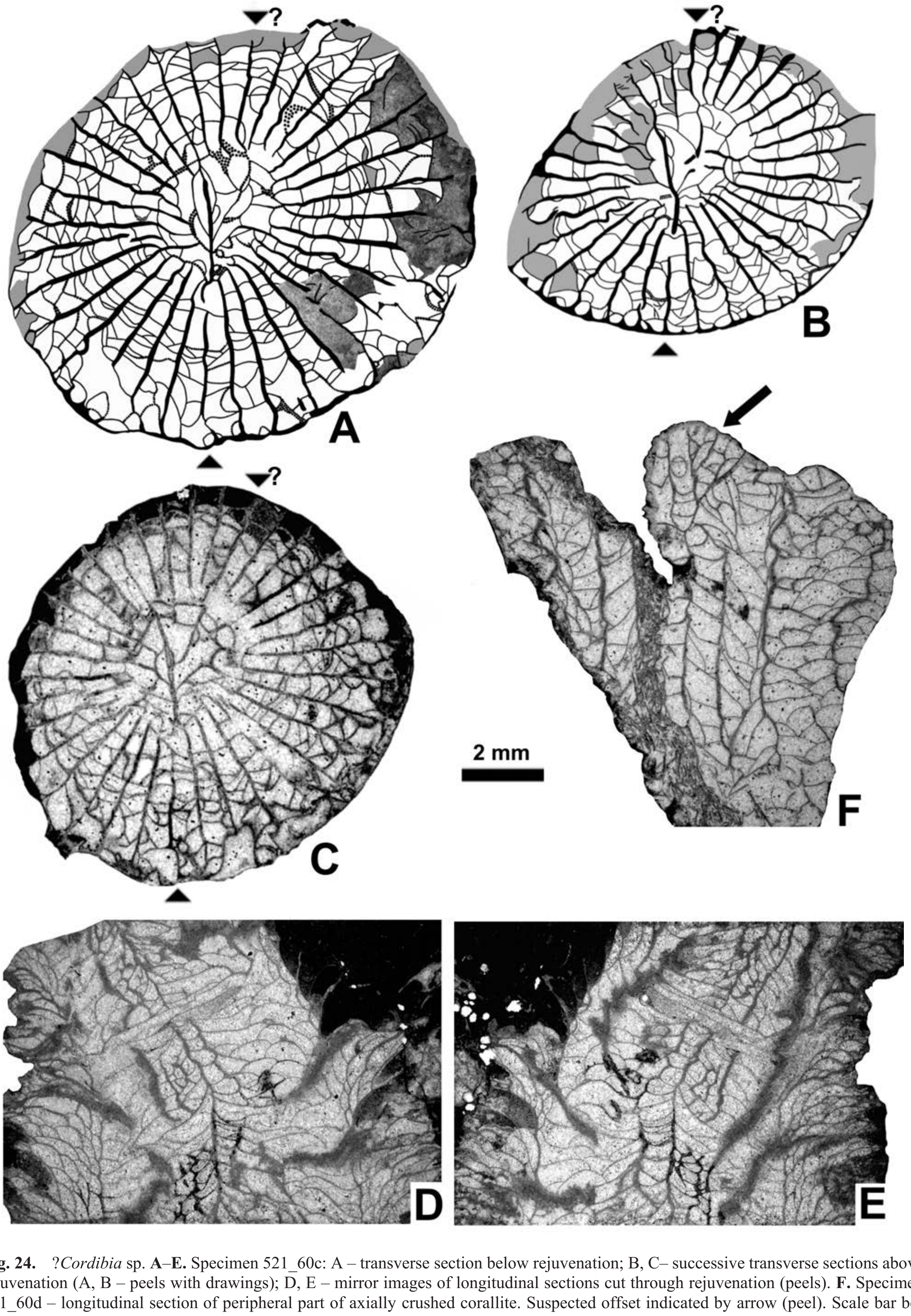


Fig. 24. ?*Cordibia* sp. **A–E.** Specimen 521_60c: A – transverse section below rejuvenation; B, C– successive transverse sections above rejuvenation (A, B – peels with drawings); D, E – mirror images of longitudinal sections cut through rejuvenation (peels). **F.** Specimen 521_60d – longitudinal section of peripheral part of axially crushed corallite. Suspected offset indicated by arrow (peel). Scale bar between C and F corresponds to all images and drawings. See Note for Figure 6 for remaining explanations.

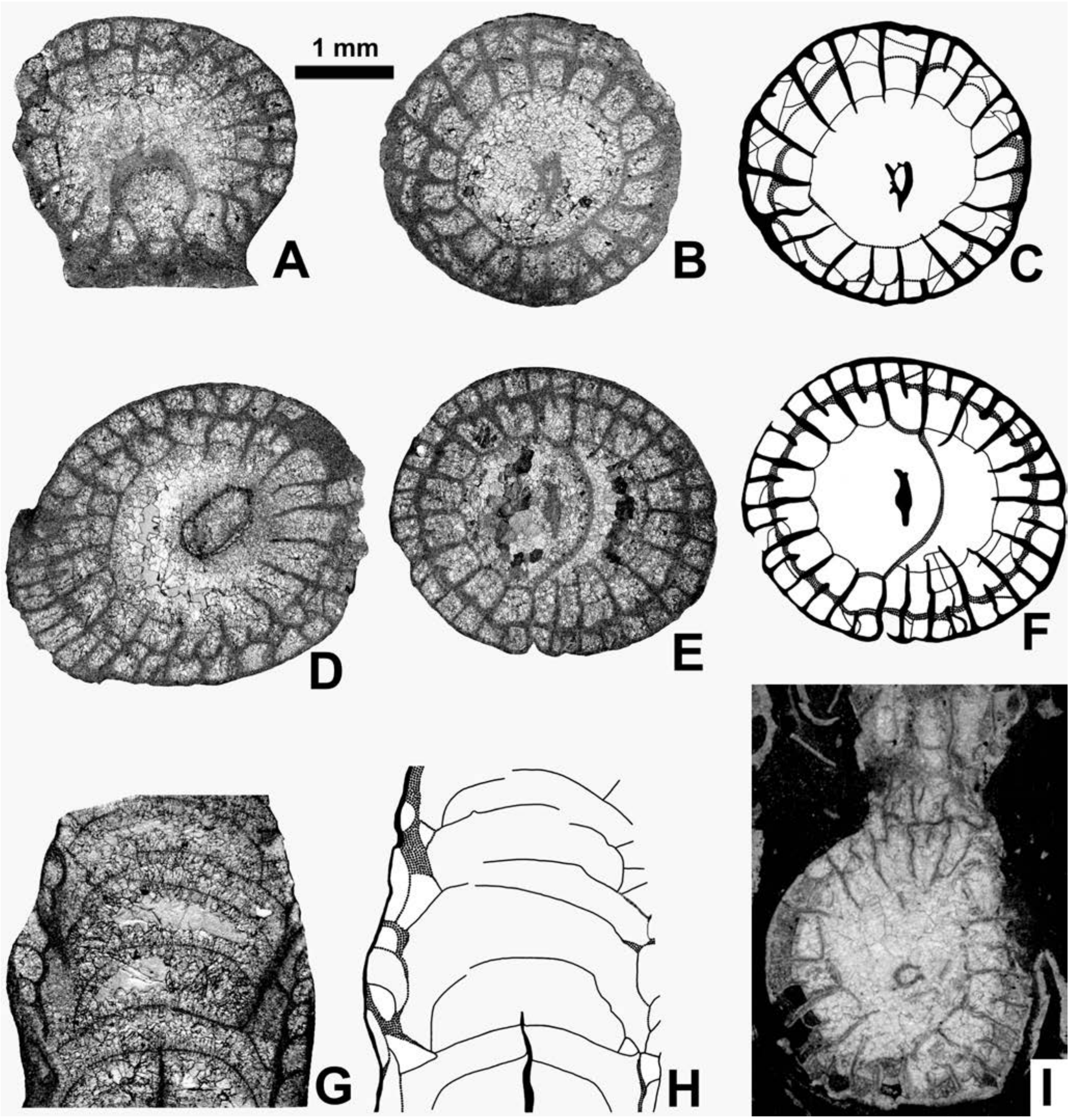


Fig. 25. *Siphonodendron strzelcense* Khoa, 1977. **A**–**H.** Specimen 521_60e: A–F – successive transverse polished surfaces with peels taken along 20 mm of corallite growth; C, F – computer drawings of B and E, respectively; G, H – slightly oblique longitudinal polished surfaces with peels; **H** more centric (drawing). **I.** Specimen 521_60f – transverse thin section of offsetting corallite. Scale bar between A and B corresponds to all images and drawings. Position of cardinal septum uncertain; not marked.

Description: External wall approximately 0.2 mm thick. Largest corallite n:d value 25:4.9x5.5 mm. Major septa thin, amplexoid, 1/2–2/3 corallite radius long. Minor septa vary in length from small spines at inner margin of external wall to reaching inner boundary of dissepimentarium. Pseudocolumella elongated towards cardinal septum, incorporates 2–4 short septal lamellae. Dissepimentarium of 2–4 rows of regular and herringbone dissepiments, occupies 1/4–1/5 corallite radius. Tabulae mostly incomplete. Inner tabellae elevated towards pseudocolumella, commonly rest on each other to form slightly incomplete columnotheca of Fedorowski (2009b). Peripheral tabellae slightly elevated towards columnotheca.

Remarks: Specimens described here resemble the peculiar corals described by Dobrolyubova (1958) as *Lithostrotion scoticum* Hill from the late Viséan (Mikhailovskiy Horizon) deposits of the Russian Platform, and by Khoa (1977) as his new species *Lithostrotion* (*Siphonodendron*) *dobrolyubovae* from the late Viséan of the Lublin area (Korczmin IG-1, Krasnystaw IG-1, Terebin IG-1). Specimens obtained from all those sites offset axially. They resemble *Diphyphyllum* in identical offsetting and in developing a

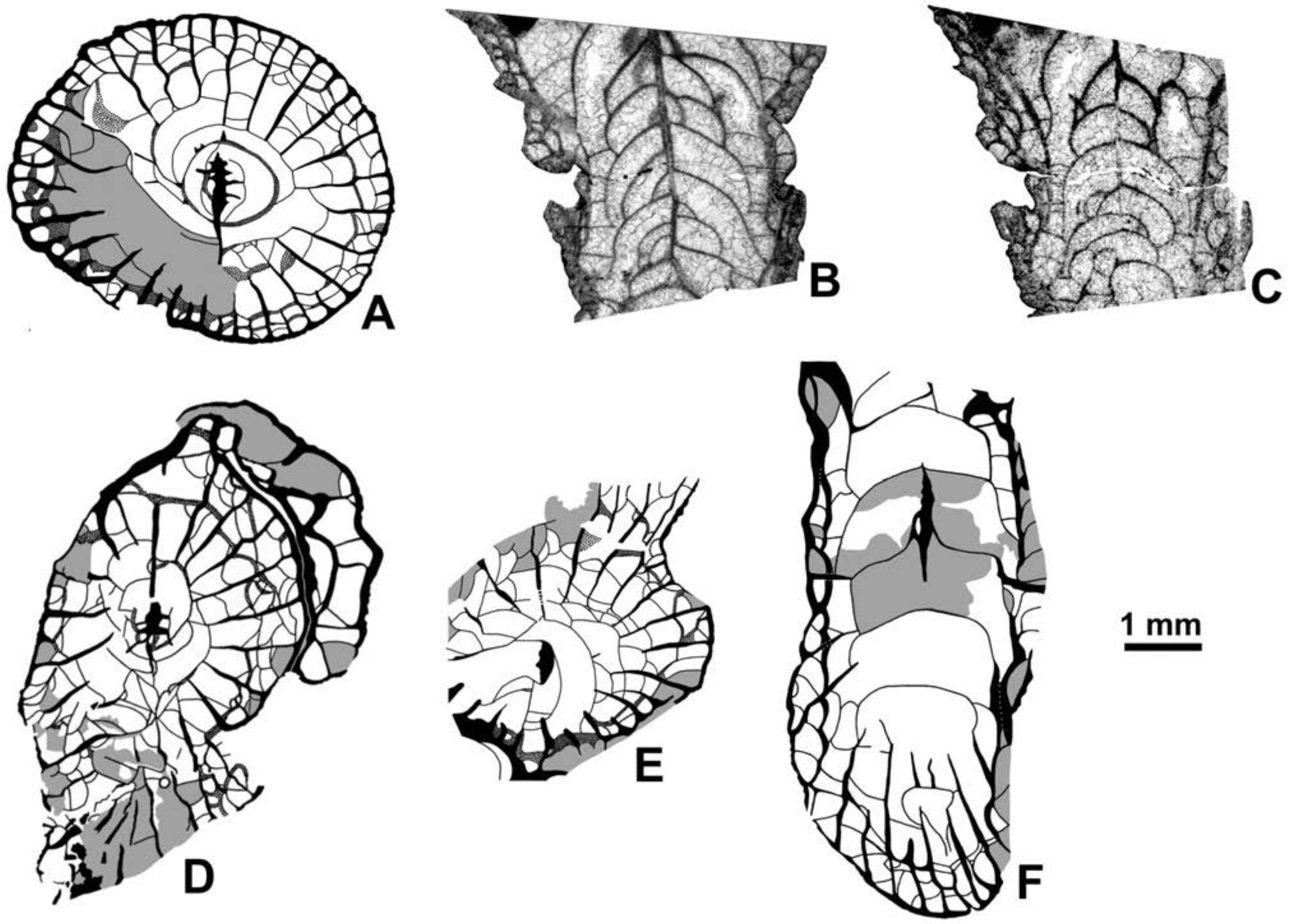


Fig. 26. *Siphonodendron* sp. **A**–**C.** Specimen 521_59f: A – transverse section (peel with drawing); B – centric longitudinal thin section; C – eccentric longitudinal thin section. **D**, **E.** Specimen 521_60e-1: D – transverse thin section with drawing; structure in upper right may be remnant of rejuvenation; E – growth stage preceding D (peel with drawing). **F.** Specimen 521_60e-2 – oblique longitudinal section (peel with drawing). Scale bar corresponds to all images and drawings. Position of cardinal septum uncertain; not marked.

columnotheca. Their identification as *Siphonodendron* was based on the occurrence of a pseudocolumella, whereas exclusively lateral offsetting of all typical siphonodendrons *vs* axial offsetting of both species mentioned above, was ignored by both Dobrolyubova (1958) and Khoa (1977). Those two species and perhaps the specimens described herein, resemble *Occulogermen* gen. nov. in the mode of offsetting, but differ from that genus in the different derivation and morphology of their median lamella (pseudocolumella?), and the different morphology of the tabularium. These corals occupy an intermediate position between *Siphonodendron* and *Nemistium* Smith, 1928 and perhaps should be separated into a new genus. Lack of well-preserved offsetting corallites in the material studied in this paper precludes closer comparison.

Occurrence: Łuków IG-4, depth 1506.1–1506.7 m, early Serpukhovian.

Subfamily DIPHYPHYLLINAE Dybowski, 1873 emended

Emended diagnosis: Dissepimented colonial corals; offsetting axial; columnotheca complete or discontinuous; septal flanges, lonsdaleoid dissepiments and axial structure in form of irregular septal lamellae or inconsistent median lamella may occur; cardinal septum shortened in some.

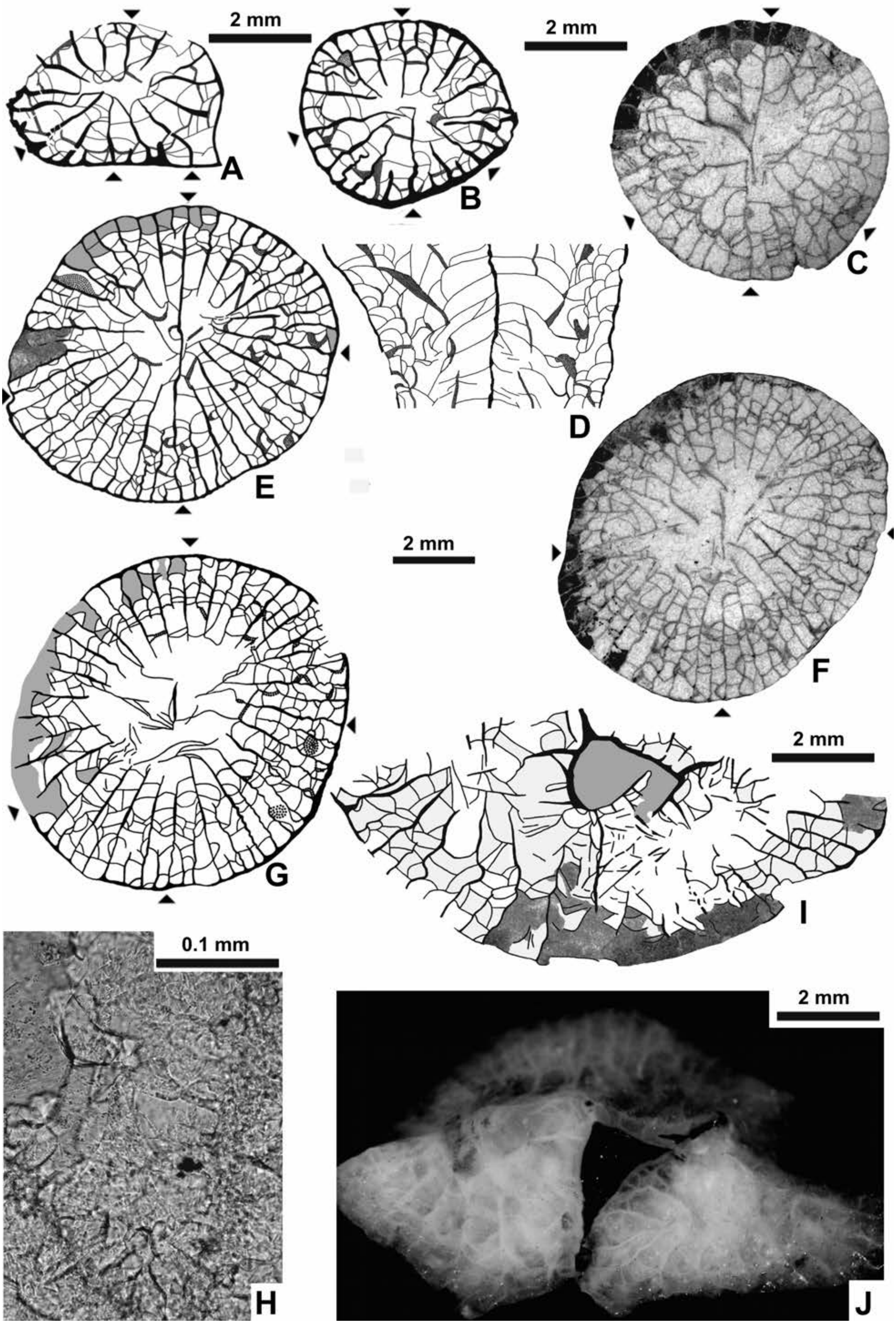
Genera included: *Diphyphyllum* Lonsdale, 1845; *Nemistium* Smith, 1928; *Tizraia* Said and Rodríguez, 2007; *Tizraia*? of Fedorowski *et al*., 2012, *Occulogermen* gen. nov.

Remarks: According to Hill (1981), the Subfamily Diphyphyllinae comprises five genera. This number was expanded afterwards by Said and Rodríguez (2007), who introduced the new genus *Tizraia*. Three of the genera described earlier, i.e., *Diphyphyllum*, *Nemistium*, and *Tizraia,* and ?*Tizraia* of Fedorowski *et al*., 2012 of an uncertain generic status, display axial offsetting, as does *Occulogermen*. Two other genera, *Tschussovskenia* Dobrolyubova, 1936 and *Opiphyllum* Kozyreva, 1973, offset laterally. The differences in the offsetting mentioned already have been discussed by Fedorowski *et al*. (2007), who suggested a possible differentiation at the subfamily level between taxa offsetting axially *vs* those offsetting laterally. In this paper, only axially offsetting taxa are considered members of the Subfamily Diphyphyllinae. The remaining ones are excluded from it, without introduction of a new subfamily name for them. The emended diagnosis for the Subfamily Diphyphyllinae as understood in this paper, is proposed.

Genus *Occulogermen* gen. nov.

Type species: *Occulogermen luciae* gen. and sp. nov.

Name derivation: Latin: *occulo, cului, cultum* – to hidden, and *germen, inis* – bud, offset – after offsetting rare and difficult to establish.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Diagnosis: Rarely offsetting, weakly fasciculate Diphyphyllinae; simple median lamella may occur; axial column underdeveloped.

Species assigned: Monotypic.

Remarks: *Occulogermen* is easily distinguishable from all earlier introduced genera, here included in the Subfamily Diphyphyllinae, by its incomplete axial column and major septa differentiated in length. Additionally, it differs from *Diphyphyllum* in the potential to form a simple median lamella, from *Nemistium* by possessing simple, inconsistent median lamella instead of an axial structure composed of disorderly arranged septal lamellae, and from *Tizraia* s.s. and ?*Tizraia* of Fedorowski *et al*. (2012) by lacking septal flanges. Weakly colonial rather than protocolonial growth form (see Fedorowski and Ogar, 2013 for definition) is confirmed by the holotype of the type species, studied from early growth stage up to axially offsetting mature growth stage (Fig. 27A–J).

Occulogermen luciae sp. nov.
Figs 27, 28

Holotype: Specimen 521_59h (Fig. 27A–J).

Type locality: Łuków IG-4. drill core, depth 1506.1–1506.7 m.

Age: Early Serpukhovian.

Name derivation: Named in honour of Dr. Łucja Musiał, outstanding Polish stratigrapher, with thanks for offering corals for this study.

Material: 20 fragments of corallites, eight of which illustrated. Most specimens crushed to various extents. Those possibly belonging to this species, but very damaged, not counted. Peripheral parts of most dissolved and filled in with mud (grey in drawings). Apparently discontinuous interseptal ridges (Fig. 28A), resulting from diagenetic alterations. Two corallites for certain and two others possibly have produced axial offsets.

Diagnosis: *Occulogermen* with n:d value 23:7.0×8.0 mm to 28: 8.5×9.5 mm; major septa inconsistent in length; most minor septa enter tabularium.

Description of the holotype: Flattening and thickening of skeletal structures at cardinal septum corallite side in earliest growth stage studied suggest its position immediately above junction with parent corallite at n:d value 14:3.0×4.5 mm (Fig. 27A). Major septa thinned axially, differentiated in length, leaving narrow axial area free. Cardinal septum one of longest. Minor septa and 1–2 rows of dissepiments present. Lonsdaleoid dissepiments at lower right corner interpreted as remnants of parent/offset common area. Those dissepiments disappear within 0.3 mm corallite growth (Fig. 27B), n:d value 16:3.8×4.4 mm. Skeletal structures remain thicker in cardinal septum corallite side. Cardinal septum elongated to corallite axis, counter septum slightly longer than counter-lateral septa. Next growth stage illustrated (Fig. 27C), approximately 1.2 mm above, n:d value 20:5.2×5.6 mm, both protosepta elongated, counter extends beyond inner margin of cardinal septum. Most minor septa reach or cross tabularium/dissepimentarium boundary. Peripheral dissepiments large, inner flat, herringbone and pseudo-herringbone.

Growth stage 4.2 mm higher (Fig. 27E), arbitrary considered early mature, n:d value 27: 7.5×8.5 mm. Major irregular septa slightly differentiated in length, leaving comparatively narrow, irregular axial free area. Both protosepta connected to median lamella. Curvatures at their joining points suggest derivation of median lamella from axial septum. Median lamella occurs permanently in longitudinal section (Fig. 27D) made between Figures 27C and 27E and remains up to end of corallite growth studied (Fig. 27F, G). In fully mature growth stage, n:d value 27: 8.0×9.6 mm, cardinal septum slightly shortened. Counter septum indistinguishable from remaining major septa of counter quadrants. Most minor septa enter tabularium. Dissepimentarium 1/4 to more than 1/3 corallite radius in some parts of corallite. Dissepiments in longitudinal section globose, larger at periphery (Fig. 27D). Tabulae mostly incomplete. Some axial tabellae rest on underlying one to form incomplete columnotheca. Peripheral tabellae vary in arrangement, mostly elevated, but some directed downwards, suggesting incomplete biform tabularium.

Compressed uppermost part of corallite (Fig. 27I, J) documents axial offsetting. In earliest growth stage studied four offsets recognizable; two reasonably well preserved, other two as small remnants. All four offsets surround remnants of parent's calice filled with inorganic matrix (Fig. 27I). Axial area in right of two better preserved offsets free from septa (Fig. 27I, lower right). In left offset (Fig. 27I, lower left) skeletal body, interpreted as median lamella, occurs in corallite axis between inner margins of two longest septa. Five thin slats attached to that skeletal body both sides perhaps septal lamellae. Distal part of holotype broken obliquely: partly beneath partly within offsetting area (Fig. 27J).

Microstructure of septa completely destroyed (Fig. 27H). Large calcite crystals either surrounded by smaller ones (Fig. 27H, right) or adjacent to other large crystals with easily traced borders is all left within septa after recrystallization. Thus, microstructure of *Occulogermen* remains unknown.

Intraspecific variability: All paratypes are smaller than the holotype and all either lack median lamella (pseudocolumella) in parts preserved (Fig. 28D–F), or its occurrence remains uncertain due to compression and slight damage (Fig. 28C, G). An occurrence of a well-developed median lamella connected to the cardinal septum (Fig. 28J) may be present. However, that corallite is much smaller than remaining ones (n:d value 25:6.0×4.5 mm) and possesses major septa approaching corallite axis. That corallite and a fragmentary corallite preserved only in its early growth stage (Fig. 28H) may belong to a different species.

All of the remaining corallites are accepted as paratypes (Fig. 28A–G). They resemble the holotype in the length and arrangement of their major septa, the slight shortening of the cardinal septum, a counter septum indistinguishable from other major septa in counter quadrants, and the minor septa crossing the dissepimentaria. They therefore do not need separate descriptions. Three characters, i.e., n:d values, common absence or interruption of median lamella (pseudocolumella), and narrower free axial areas in all paratypes differ from those in the holotype. However, the width of the corallite free axial area changes during the holotype growth (Fig. 27E–G) and n:d values of the paratypes are: 521_58h – 26: 7.7×9.4 mm, 521_58d – 24:7.0×8.5 mm, 521_58e – 23:7.0×8.0

Fig. 27. *Occulogermen luciae* gen. et sp. nov. Specimen 521_59h. Holotype. Transverse sections except when stated. **A**, **B.** Earliest growth stage studied, perhaps just above junction with parent corallite (peels with drawings). **C**, **E–G.** Early mature and mature growth stage. **D.** Longitudinal section between C and E (D, E, G – peels with drawings). **H.** Microstructure of major septum completely destroyed by diagenesis. **I.** Remnants of four axial offsets around remnant of parent's calice (peel with drawing). **J.** Broken part of parent's corallite (upper) and polished surfaces of two offsets, less advanced growth stage of which illustrated in I. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. Scale bar in the middle corresponds to figures D–G. See Note for Figure 6 for remaining explanations.

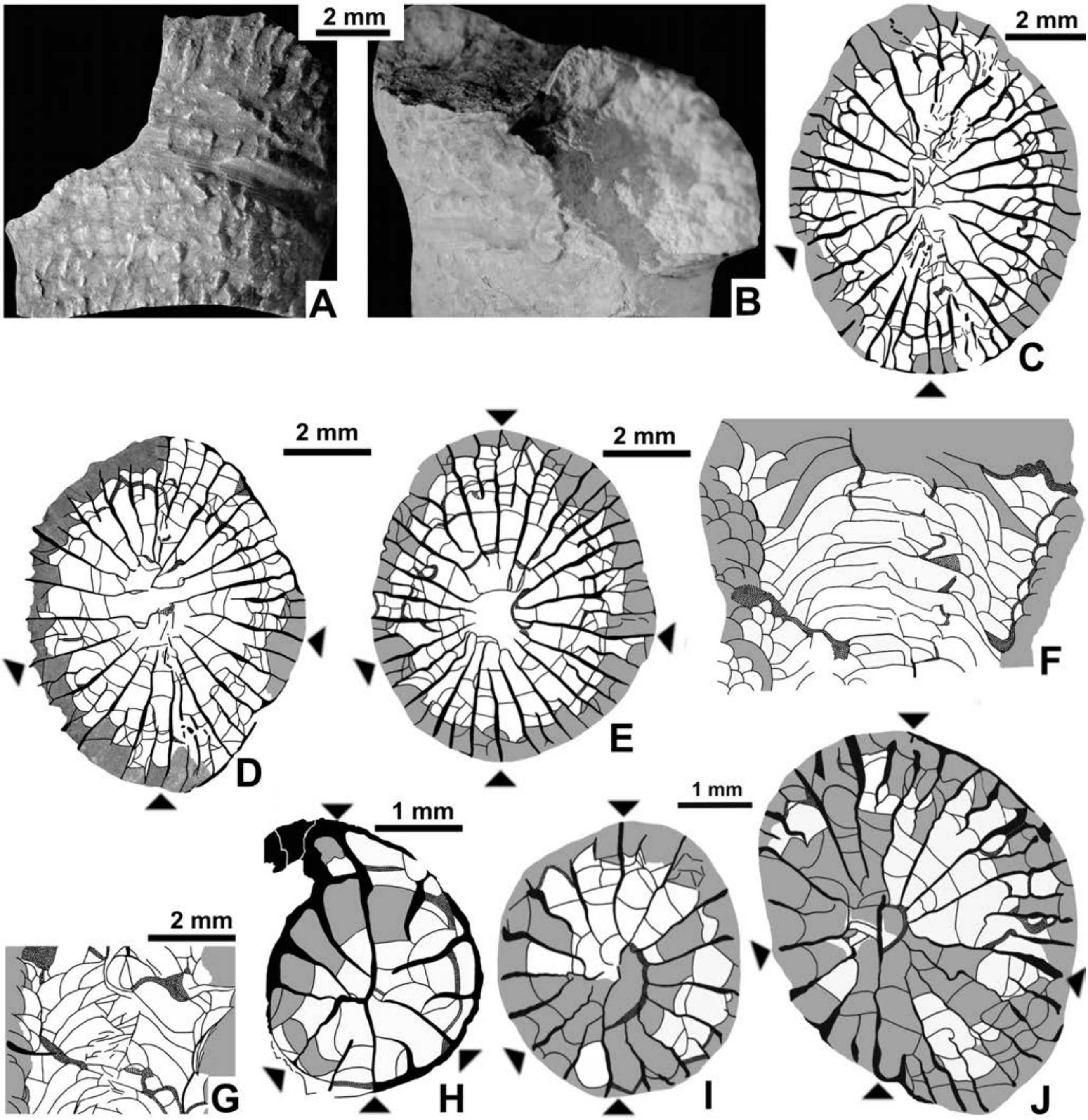


Fig. 28. Occulogermen luciae gen et sp. nov. Paratypes. **A**–**C**. Specimen 521_58d: A – corallite surface; breaks in interseptal ridges secondary; B – axially produced offsets; C – transverse section below offsetting part of corallite, mature growth stage, slightly compressed (peel with drawing). **D.** Specimen 521_59g – transverse section, mature growth stage. **E**, **F.** Specimen 521_58e: E – transverse section, mature growth stage; F – longitudinal section; pseudocolumella absent. **G.** Specimen 521_59i – oblique longitudinal section. **H.** Specimen 521_58f – transverse section, very early growth stage. **I**, **J.** Specimen 521_59j – transverse sections of early-mature and mature growth stage. Specimens figured in H–J may represent different species. C–J drawings. Scale bars located between two adjacent pictures correspond to both; those at or above the picture correspond only to it. See Note for Figure 6 for remaining explanations.

mm, 521_59g – 24:7.0×8.5 mm (all compressed). Thus, all those differences are considered to be intraspecific. Tabularium in corallites studied in detail (Fig. 28F, G) differs both from the holotype and from each other. Tabulae are incomplete in both of those specimens, but are weakly divided into peripheral and axial parts. Some (Fig. 28F) tabulae resemble mesa-shaped. Columnotheca not developed, but axial tabellae longer than short peripheral tabellae. Some axial tabellae anastomose with peripheral tabellae, some rest on underlying axial tabellae – a position typical for columnotheca – and some rest on underlying axial tabellae at one corallite side, but extend to dissepimentarium at its opposite side. Downward slope of some peripheral tabellae suggests a weakly developed biform tabularium, like that in the holotype (Fig. 28F, G). Axial offsetting observed in one paratype (Fig. 28B) closely resembles that in the holotype.

Occurrence: As for the holotype.

TAPHONOMY

The primary construction of rugose coral skeletons should be taken into account prior to any interpretation of their taphonomy. Individual skeletal elements of any rugose coral form a three-dimensional net, delicate in its early stage of formation and often strengthened afterwards. This organic strengthening may lead to the complete infilling of all empty spaces between particular skeletal elements, which makes the skeleton as solid or almost as solid as the immature skeletons of many solitary corals (e.g., Fig. 6A–C). More commonly, the organic coating is restricted to several layers of sclerenchymal sheets on particular skeletal elements (e.g., Fig. 9A–H). At that time, all the spaces between the skeletal elements are filled with sea water. Such a skeleton, light with respect to its volume, can be transported by comparatively weak currents, which otherwise are able to transport only much smaller, but compact clasts, such as crinoid ossicles, fragments of brachiopod and bivalve shells and corals with skeletons of thick sclerenchymal cover. The differences in the construction of the coral skeleton, i.e., the relation between their weight and volume, result in the selective transport of corals. Their sites of deposition are therefore impoverished by comparison with their life areas.

The infilling of intra-skeletal spaces in rugose corals is also important as an indicator of *post mortem* processes. Complete rugose coral skeletons are most commonly filled with inorganic calcite, precipitated step-by-step from the sea water originally occupying those spaces (see above). However, the infilling with calcite may take place either prior to or after transportation. Only skeletons partly or completely lacking these calcite infillings are comparatively light. Fillings, other than the ones precipitated from sea water, appear only if the skeleton was open to the surrounding environment. This infilling by sediment may occur either *in situ* or after transportation. The recognition of this difference is important for the stratigraphy in stuations, where index microfossils occur in the invading sediment.

The considerations that follow are restricted mainly to the interrelation between the rugose corals described in this paper and their surrounding deposits in selected boreholes. Both the lithology and the faunal content of particular drill cores differ to various extents. However, one can distinguish between the two main types of depositional environment and their fossil content in limestone bands D and F (see Geological Setting). These two types are analyzed below to supplement the comprehensive microfacies analysis of the late Mississippian and early Pennsylvanian deposits in the Lublin Basin by Skompski (1996) and the sequence stratigraphy by Waksmundzka (2010), who suggested environmental models dependant on sea-level fluctuations (Waksmundzka, 2010, text-fig. 9).

Chełm IG-2 and Telatyn IG-1 material

The second of the two types of infilling mentioned above is best demonstrated by limestone band F (Figs 5, 29, 30) in the Chełm IG-2 drill core (depth 1291.0–1297.0 m). The deposit is rich in the detritus of various organisms: brachiopods, bivalves, crinoid ossicles, bryozoan colonies, and algae. Small Foraminifera are distributed in a rather disorderly manner within the sediment (Fig. 29D). However, several occur in the fabric infilling in some loculi within the rugose coral skeletons (Fig. 29C) and are components of the sediment filling the umbos of brachiopods (Fig. 30D). Most of the detrital components of the sediment are irregularly distributed. Some are oriented in accordance with directions of the transporting media and/or shape of the larger bioclasts they surround. The sediment that surrounds such clasts, coral skeletons in this case, differs in lithology from the underlying deposits (Fig. 29A). In addition to bioclasts, rare grainstone clasts, coated with algae, occur (Fig. 30A, arrows 1 and 2 respectively). Rugose corals are not numerous, but rarely may be grouped close to each other (Fig. 29A). Their external walls are either almost complete (Fig. 29A, corallite ‘a’, Fig. 29 B) or absent from small to large parts of corallites (Fig. 29A, corallite ‘b’), or destroyed completely (Fig. 30A–C). Irrespective of the extent of the destruction, the peripheral margins of the major septa protruded into the surrounding sediment when the external wall disappeared.

The following types of interrelation between the rugose coral skeletons and the surrounding and/or infilling deposits were observed: 1) Skeletons are slightly damaged, but not overgrown by other organisms and not coated with sediment that is different from the surrounding deposits. Some intra-skeletal loculi are filled with sediment that is different from the surrounding deposits (Fig. 29A, corallites ‘a’, ‘b’). Mechanically broken parts of those corallites (arrows) are filled with the sediment, in which they were deposited (Fig. 29A, corallite ‘b’). 2) The skeleton is well preserved, including the external wall. Most of its intra-skeletal spaces are filled with precipitated calcite, but some are filled with two kinds of sediment. The skeleton is coated with an irregular, thin layer of sediment, slightly different from the surrounding deposits (Fig. 29B). 3) The coral skeleton lacks an external wall, short minor septa, and part of the dissepimentarium (Fig. 30A–C). The peripheral ends of the major septa and broken dissepiments are sharp and protruding into the surrounding deposits. A batostomellid bryozoan colony overgrows a section of the corallite directly, but it is partly separated by the detritus from the coral skeleton (Fig. 30C). The peripheral part of the bryozoan colony is damaged and covered by a layer of black mud. 4) The coral and bryozoan skeletons were deposited next to each other as separate bioclasts and were coated with sediment similar to, but slightly different from the surrounding deposits (Fig. 30B). The individual coral skeletons and groups of clasts described are completely or in part surrounded by dark mud (Figs 29B, 30A, upper left, B–D).

The positions of the coral skeletons analyzed here within the deposits (Figs 29, 30) and their preservation as fragments prove them to be bioclasts. The exclusive occurrence of corals with thin skeletons indicates selection during transportation, excluding their preservation *in situ*. The first type of skeleton-sediment relationship is shown in the specimens illustrated in Figure 29A. These corals were interpreted as having been removed from their life positions, when their intra-skeletal loculi were not yet filled with precipitated calcite. However, some of the loculi were broken,

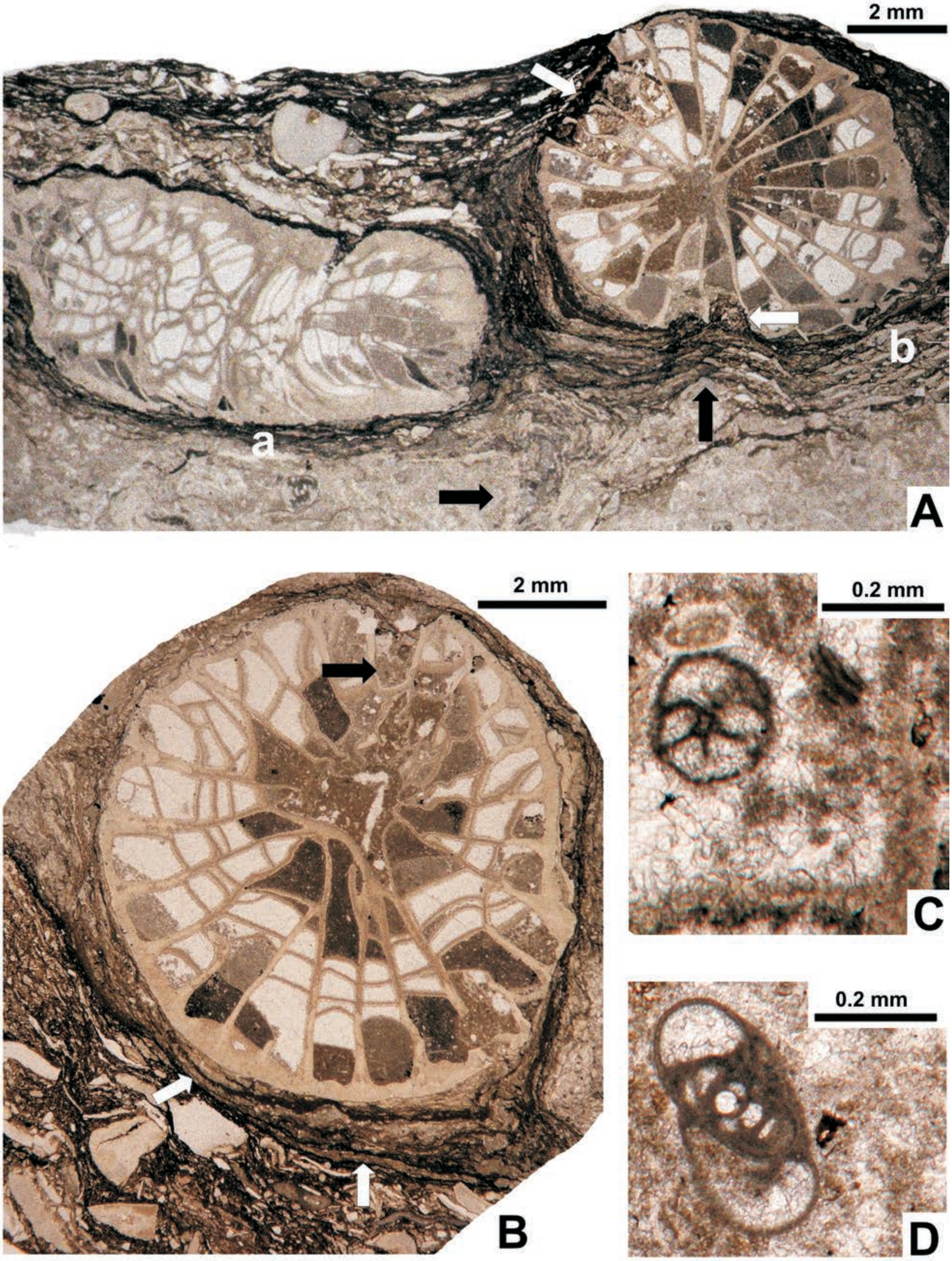


Fig. 29. Chełm IG-2. Drill core, depth 1294.0 m. Limestone F. **A.** Two corallites of *Chelmia radiata* (a, b), fragmented, and corroded in parts (corallite ‘b’, white arrows), surrounded partly by grainstone with fragmented crinoid ossicles and brachiopod and bivalve shells (upper left), partly be incrusting algae (right corallite, lower, right black arrow). Both rest on and partly intruded (left black arrow) into finer-grained, marly limestone, unconsolidated at the time of deposition mentioned. **B.** *C. radiata* surrounded by thin grained grainstone (white arrows); broken fragments of skeleton (upper [black arrow] and axial part) felt with grainstone and diagenetically deformed. **C.** Small Foraminifera between rugose coral major septum (right) and dissepiment (lower). **D.** Small Foraminifera as loose bioclast.

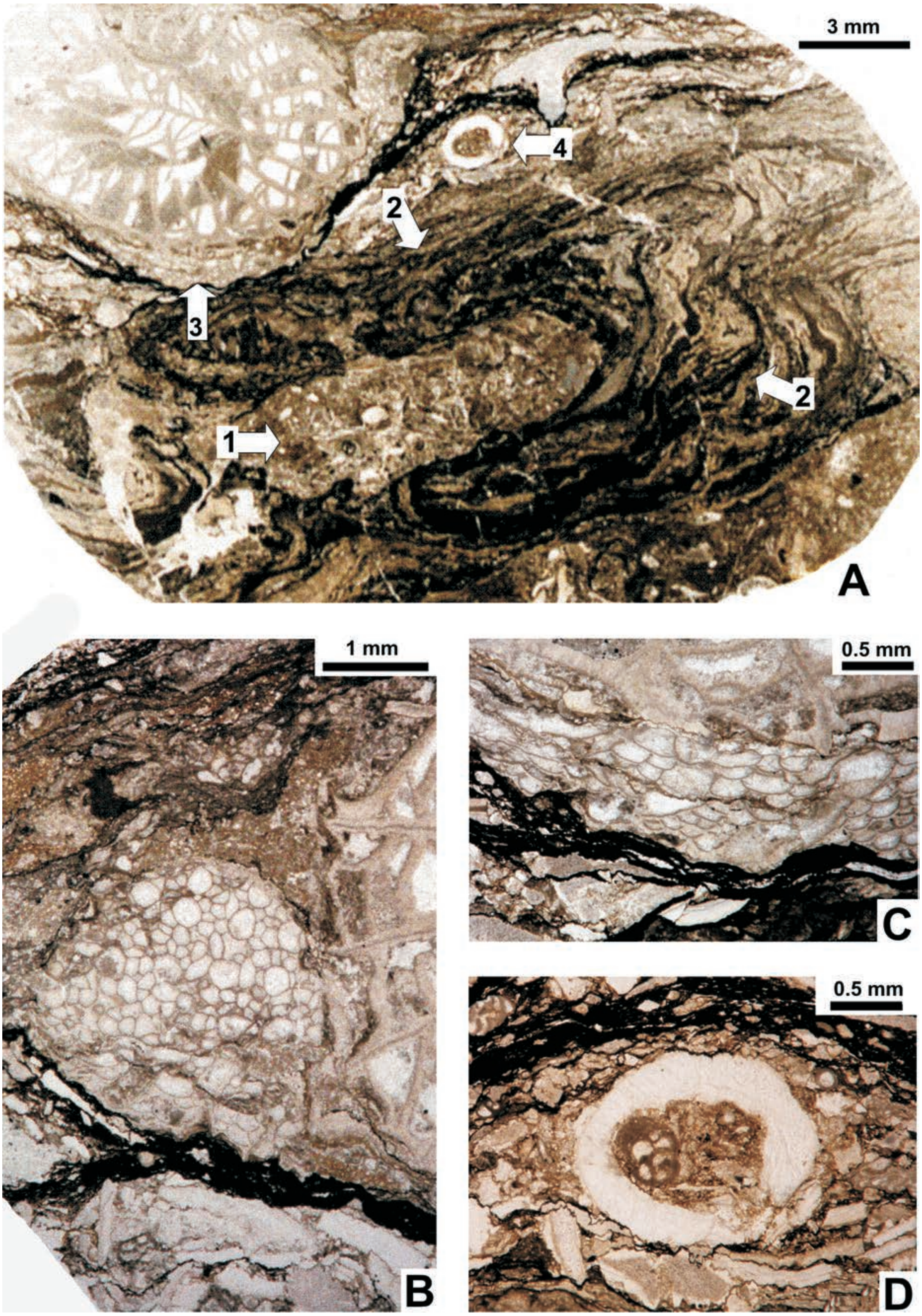


Fig. 30. Chełm IG-2. Drill core, depth 1294.0 m. Limestone F. **A.** Fragment of rock with *Dibunophyllum* ?*bipartitum* and bryozoan colony attached to its lower surface (arrow 3), umbo of brachiopod (arrow 4) , and unconsolidated clast (arrow 1) surrounded by incrusting algae (arrow 2), squeezed a little. **B.** Peripheral skeleton of *D.* ?*bipartitum* (right) and transverse section of bryozoan colony (left), deposited close to it. **C.** Bryozoan batostomellid colony attached to corroded skeleton of *D.* ?*bipartitum* (enlarged from A). **D.** Umbo of brachiopod with small foraminifera inside (enlarged from A).

allowing the surrounding mud to invade part of the skeleton. The sediment surrounding these coral bioclasts differs both from the aforementioned infillings and from the underlying deposits. Thus the corals analyzed probably were initially removed from their first depositional site and later were mixed with the incoming coarser-grained matrix, which filled the damaged parts of their skeletons. Once transported, these specimens were redeposited along with the matrix at their ultimate destination. The energy in the environment was great enough to disturb the sediment below, soft at that time (Fig. 29A, left black arrow), and to break the algal mats growing on the host sediment. Some of their broken fragments (Fig. 29A, right black arrow) were pushed between two coral skeletons.

The rugose coral skeleton, described above as the second type of relationship with the sediment, can be interpreted as having been removed from its life position. Some of its intra-skeletal rooms were at that time penetrated by very fine-grained sediment, possibly in the *in situ* area. Then a slightly coarser-grained sediment penetrated its broken parts (Fig. 29B, black arrow). Some particles of the coral coating are elongated light bodies, perhaps remnants of encrusting algae (Fig. 29B, white arrow). All of this unconsolidated or partly consolidated material, i.e. the coral skeleton and its sediment coat, was afterwards deposited in a coarser-grained, but perhaps unconsolidated sediment (Fig. 29B, lower).

The dibunophyllid corallite and its surrounding sediments (Fig. 30A–C) offered a base for the third and fourth type of coral-sediment relationship, mentioned in the description above. Thus, both these types are interpreted jointly. The preservation of the coral indicates a lack of abrasion. If the coral skeleton had been moved or rolled over the sea floor, the peripheral ends of its major septa would have been abraded and would not have protruded into the surrounding sediment. However, had it remained *in situ* and in the growth position, it would not have been exposed to such damage. Therefore, it must have been initially transported. The movement of the skeleton over a relatively short distance and its exposure to corrosion on the sea floor is indicated as the first step in its history. The corrosion ended with the overgrowth of the coral skeleton by a bryozoan colony, which is considered to be the second step (Fig. 30C). The coral-bryozoan unit was then transported, while either surrounded by a sediment coat or suspended in a mud flow, and deposited. Only the coating or suspension prevented the corroded surface from abrasion. Transportation is also indicated by the presence of another bryozoan colony, deposited close to the corroded surfaces of the corallite skeleton, but obviously not attached to it (Fig. 30B). The growth position of the bryozoan skeleton, perpendicular to the coral, and the sediment between the two skeletons indicate that they were separate bioclasts, deposited next to one another and perhaps transported together afterwards.

The forthcoming discussion permits the conclusion that all of the corals and other fossils preserved well enough to be identified were transported and redeposited. The entire process was interpreted as almost contemporary events, taking place on the unconsolidated sea floor near or just above the wave base. The time required for these processes was perhaps short enough to permit use of the fossils as age indicators, whereas the current-driven dispersal of the coral fragments makes reconstruction of their life environment impossible.

The lithology of limestone band D from Telatyn IG-1 (depth 1,286.0 m) resembles that of limestone band F in the Chełm IG-2 well, described above. There are other similarities, such as encrusting bryozoans, numerous small foraminifera and the preservation of rare corals (Fig. 31A, B). The taxonomy of the corals differs and the limestone resembles packstone (Fig. 31C–E) with numerous fragments of algae and rather poorly preserved small Foraminifera, surrounded by a mass of small, undeterminable detritus and marly mud. Thus, this site is treated as a supplement to the forthcoming detailed discussion and is not described in detail.

Łuków IG-4 drill core, depth 1,506.1–1,506.7 m

The deposits at this site differ distinctly from those in Chełm and Telatyn in lithology, content, arrangement and preservation of the fossils. The lack of index fossils prevents any firm determination of its stratigraphic position. Thus, these deposits are discussed separately. The study of two samples of the sediment made with the Element Analizer Vario Max CNS in the laboratory of the Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, gave the following mean results: nitrogen total (TN): 0.08, carbon total (TC): 6.71, organic carbon total (TOC): 1.73, inorganic (limestone) carbon total (TIC): 4.98, sulphur total (TS): 2.15, TOC/N (atomic): 24.24, and TOC/S: 0.80. Those data indicate a deficiency of oxygen and, perhaps, a slightly increased salinity (sulphurated hydrogen facies).

Four successive thin sections made from an approximately 6-mm-thick slab and one additional thin section (Fig. 32A–E) characterize these differences well. Dark mudstone with rare, very small crinoid ossicles and rare small organic particles of other, unrecognizable organisms, are crowded with, mostly fragmented and/or compressed rugose coral skeletons. Some of the fragments of corals beneath the calices are strong, pressure resistant, and well-preserved, whereas the calices themselves are flattened; few have calices preserved (Fig. 17C, D). All colonial and suspected protocolonial taxa are fragmented, consisting mostly of individual branches, deposited without any recognizable arrangement. Significant diversification of the rugose coral fauna was recognized. Representatives of four identifiable genera, collected from a fragment of rock, 3 cm thick and 7 cm wide, with many unidentifiable fragments in addition to them, can serve as an example. The corals are accompanied by much less abundant brachiopod and bivalve fragments. Corallite external walls are either well-preserved (e.g., Figs 8C–J, 12G, J) or corroded, but none of the corallites studied display characteristics, typical of long-lasting abrasion.

The position of the rugose coral skeletons within the sediment, the mixture of various taxa accumulated together, and their state of preservation and the rock lithology allow the supposition that the corals were displaced from their life environment, transported and deposited at a location with slow accumulation of dark mud, enriched with sulphur and organic carbon. This site of deposition, isolated from the open sea, probably had been open to the influence of land. Three levels, enriched with the rugose coral skeletons, may have resulted from storms, the waves of which were strong enough to flow over the barrier and to transport coral skeletons. The life environment of the corals was perhaps diversified enough to host a variety of morphotypes: solitary, nondissepimented and dissepimented corals and fasciculate, colonial corals. However, the dimensions of the specimens, identified as *Dibunophyllum bipartitum*, much smaller than the representatives of this species elsewhere (see Systematics), and the occurrence of fasciculate colonial corals, mostly with very thin corallites (see description of *Siphonodendron strzelcense*), may indicate a quiet environment. The accumulation of the corals was perhaps almost contemporaneous with their life. This condensed accumulation was afterwards subjected to pressure, variably squeezing the coral skeletons. The amount of deformation depended on the position of the corallite within the sediment, relative to the direction of the acting pressure and the resistance of their skeletons. Thus, identical skeletons, resting in the sediment with their long dimensions parallel to the direction of maximum pressure are well preserved, whereas those oriented perpendicular to it were destroyed.

PALAEOGEOGRAPHY AND RUGOSE CORAL CONNECTIONS

The remarks that follow are restricted to Viséan and Serpukhovian time and to Polish territory, with comments on the relationships of the Polish rugose coral faunas of that time with the faunas of other European areas, where possible. The areas currently forming Polish territory underwent drastic changes during the upper *Goniatites* to lower *Eumorphoceras* biozones (Fig. 33A, B). In general, north-eastern Poland, the Carpathians and the south-western Sudetes were uplifted terrestrial areas during most of the Viséan, whereas the remaining part of Poland was covered by seas (Fig. 33A). The bathymetry of those seas, in which the deposits accumulated, varied from deep water (mudstones and siltstones) to very shallow (carbonate platforms), temporarily submerged. The differentiated history of different parts of Poland was summarized by Zdanowski and Żakowa (1995, eds). The main conclusions of that summary remain valid and are adequate for general considerations.

Little is known about the early and middle Viséan rugose corals in Poland. They are either absent or have not been recognized in most of the areas marked on the map as Viséan marine deposits (Fig. 33A), including most of the sites, indicated on that map by numbers. A few poorly preserved specimens from the drill cores in Pomerania (Chwieduk, 2005) have been described. The Viséan rugose corals are comparatively rich and diversified throughout the Viséan only in the Kraków region (the author's unpublished data). A few taxa from that area were cited by Fedorowski (1981) and by Poty *et al*. (2007).

The peak in the development of rugose coral faunas in Poland took place during the *Goniatites crenistria* Biozone. Corals were developed in abundance and in great diversity in four areas (Fig. 33A, numbers 1–4 respectively): around the Góry Sowie Mountains in the Sudetes, in the Kraków area, north-east of the city of Kraków, in the Gałęzice Syncline, SW of Kielce in the Góry Świętokrzyskie (Holy Cross) Mountains, and in the Lublin Basin (Fedorowski, 1968, 1970, 1971, 1981; Khoa, 1977; the author's unpublished data). Only part of the fauna from the Góry Świętokrzyskie Mountains and the Kraków area has been described. The most abundant genera among the undescribed taxa from those areas are: *Axophyllum* Milne Edwards and Haime, 1850, *Corwenia* Smith and Ryder, 1926, *Cyathaxonia* Michelin, 1847, *Diphyphyllum* Lonsdale, 1845, *Lithostrotion* Fleming, 1828, *Palaeosmilia* Milne Edwards and Haime, 1848, *Rotiphyllum*, Hudson, 1942, *Siphonodendron* McCoy, 1849, and a diversified group of dissepimented solitary corals, resembling *Bothrophyllum* Trautschold, 1879, *Caninophyllum* Lewis, 1929, or *Haplolasma* Semenoff-Tian-Chansky, 1974. Since the morphologically similar taxa from other areas were variously named, the author prefers not to name these corals without a thorough and complete study. All the Polish Brigantian rugose corals taxa, especially at the species level, indicate a provenance similar to that of the Western European and the North African taxa. Thus, Fedorowski (1981) included all of them together in the Western European Province. Some cosmopolitan taxa present in that fauna prove an open connection between the seas of Europe, Asia, North Africa and the easternmost part of North America (Nova Scotia).

A great majority of the rugose coral taxa disappeared from most of the European territory above the *Goniatites granosus* Biozone or slightly earlier, as the result of environmental changes, caused by the Sudetic orogeny. At that time, most of the present Central and Western European territories were elevated above sea level. The remnants of the seas offering an environment suitable for corals remained only in southern Scotland, some areas of Spain and northern Africa

The drastic changes in the sea-land relationships in Poland (Fig. 33B) were part of the palaeogeographic changes mentioned above. Very rich and diversified rugose coral faunas, flourishing during the Brigantian time in the Kraków area, the Góry Świętokrzyskie Mountains and the Sudetes, disappeared before the end of that Stage. Only the rugose coral fauna in the Lublin Basin persisted until the end of the Brigantian, while some taxa of that fauna crossed the Brigantian-Pendleian boundary. However, in the early Pendleian, the Lublin Basin became a westward extension of the Eastern European seas (Fig. 33B), possibly isolated from the Western European seas and from the Upper Silesia Basin. The latter basin was submerged until the late Viséan. Paralic environments were developed there in the latest Viséan (Malinowickie Beds) with the first coral-bearing marine deposits present in the so-called Štur Marine Horizon. Marine transgressions were noted in the Upper Silesia Basin during the Namurian. Rugose corals continued to occur, but only until the middle Arnsbergian (Fedorowski and Machłajewska, 2014).

The Pendleian rugose coral fauna of the Lublin Basin was separated from the western seas by areas impassable for corals (Fig. 33B), but roots of most taxa of that fauna are common with Western and Central European coral faunas.

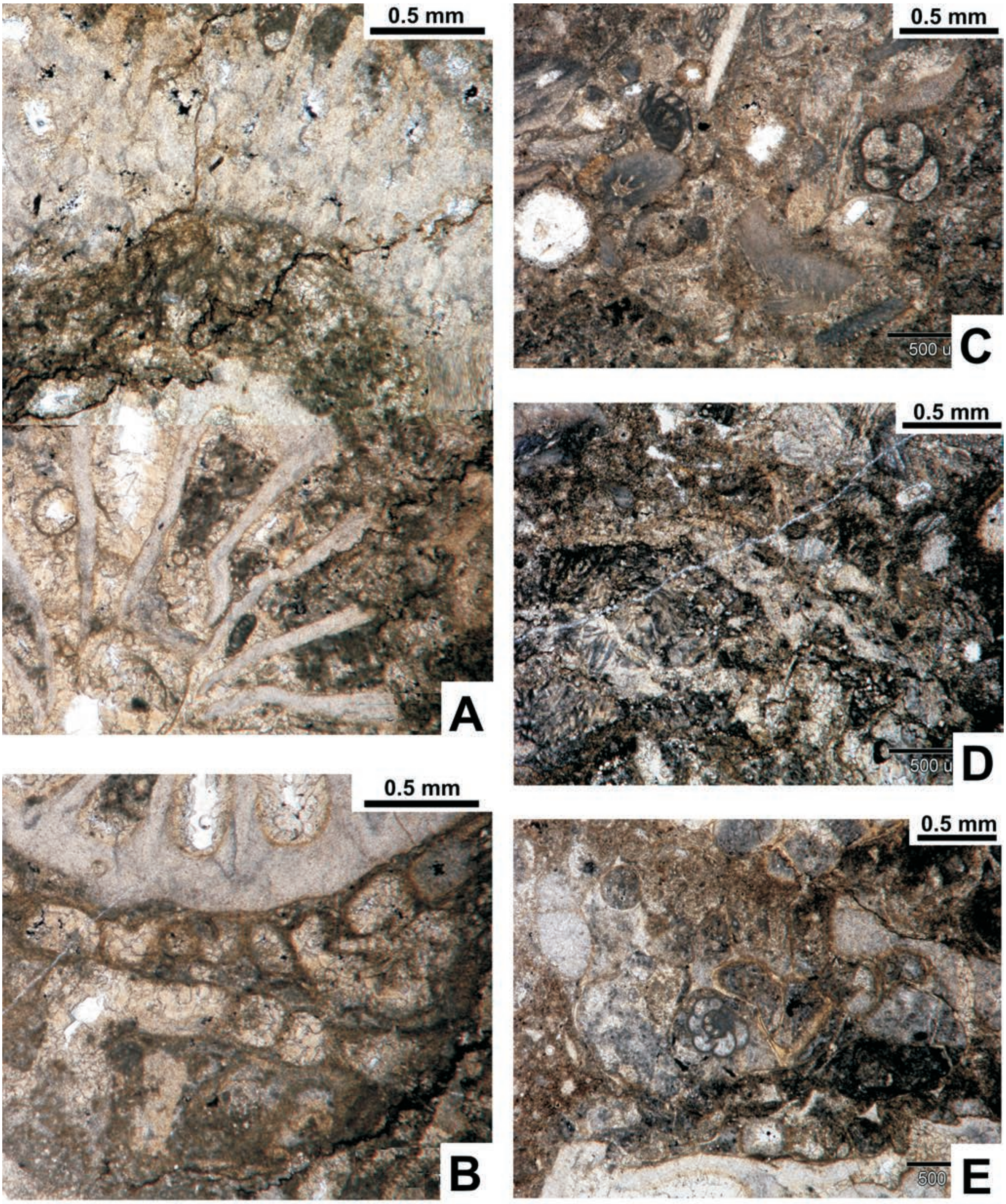
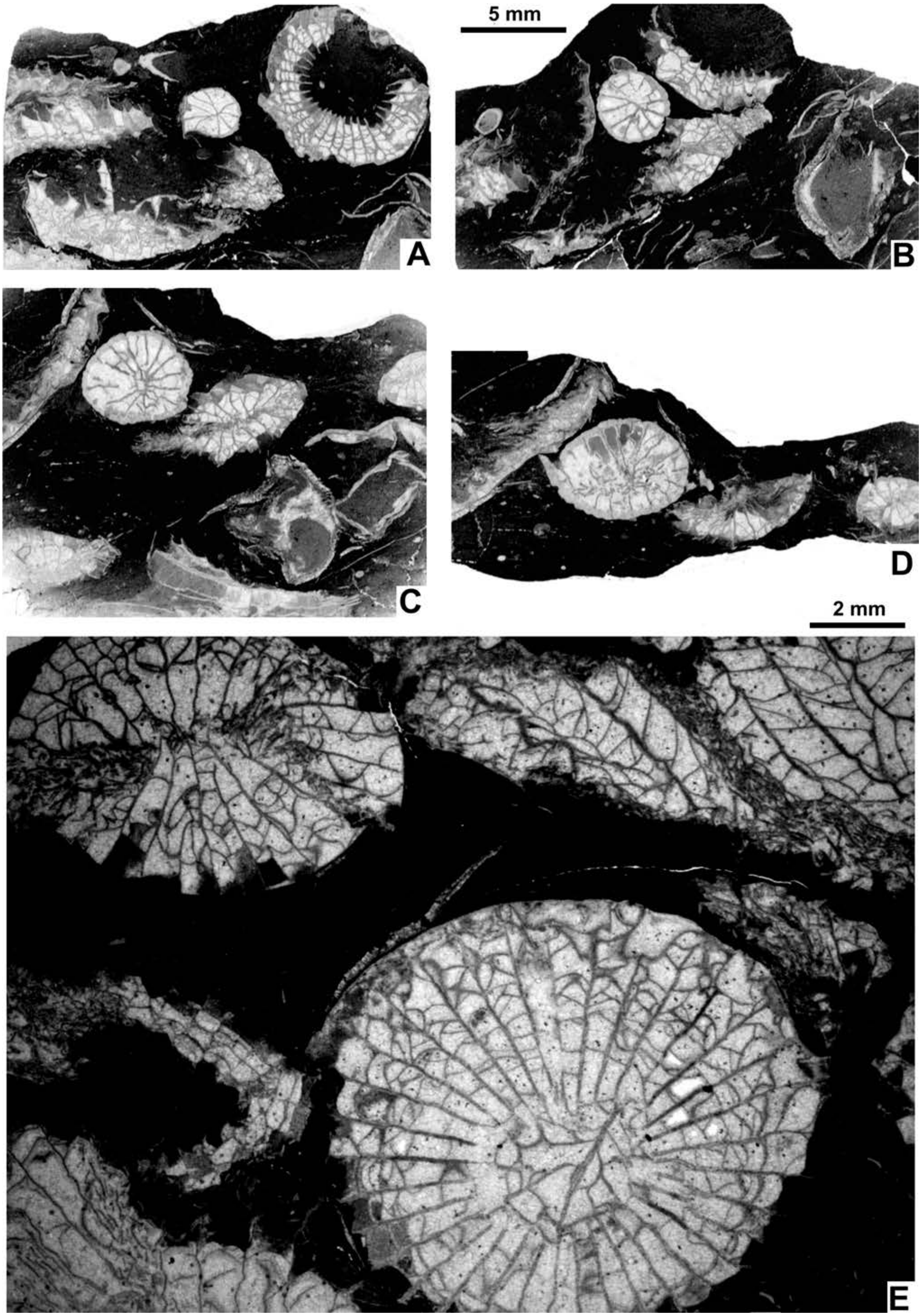


Fig. 31. Telatyn IG-1. Drill core, depth 1286 m. Limestone D. **A**, **B.** *Zaphrufimia* sp. with batostomellid bryozoan colony attached directly to well-preserved external corallite wall (B), but continued to grow on deposits resting on corroded coral skeleton opposite to former side (A). **C**–**E.** Small Foraminifera and algae in grainstone surrounding coral and bryozoan skeletons.

Fig. 32. Łuków IG-4. Drill core, depth 1506.1–1506.7 m. Limestone uncertain. **A**–**D.** Specimen 521_60 successive transverse sections from slab of dark, fine-grained mudstone, approximately 6 mm thick. Fragmented and commonly squeezed rugose corals of various taxa accompanied by squeezed bivalve shells. **E.** Specimen 521_60. Accumulation of variously preserved corallite fragments of *Cordibia* sp.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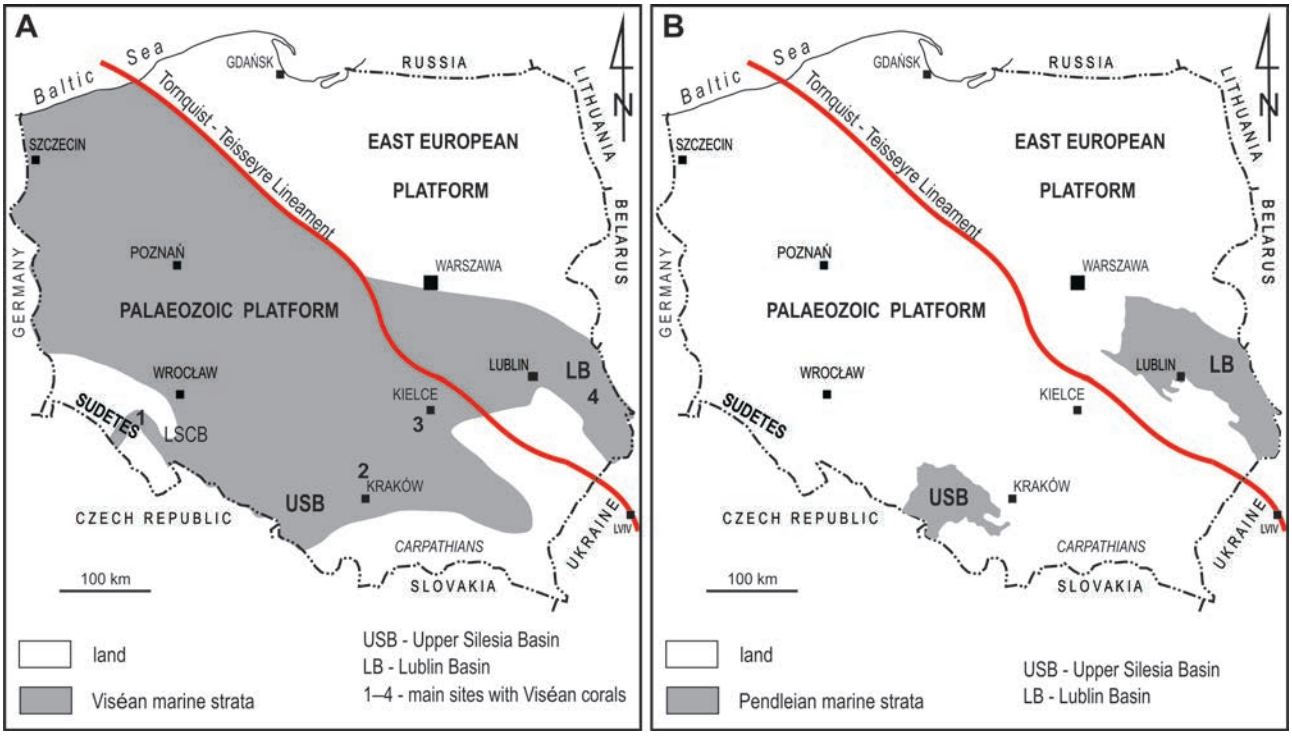

Fig. 33. Maps of Poland showing approximate distribution of marine late Viséan and Serpukhovian strata. **A.** Upper Viséan. Numbers 1–4 correspond to Brigantian rugose coral occurrences. 1 – Góry Sowie Mountains vicinity in the Sudetes; 2 – Kraków area, north of City of Kraków; 3 – Gałęzice Syncline, SW of Kielce; 4 – Lublin Basin. **B.** Coral-bearing Pendleian (LB) and Pendleian–Arnsbergian (USB) strata.

Thus, the corals from that basin should be analyzed from two points of view: first, as remnants of the older faunas from both the east and west, and secondly as either nuclei for the rugose coral faunas, which emigrated into the Eastern European basins, or taxa related to those eastern faunas.

The close relationship of the Polish Brigantian rugose coral faunas with the Western European Province faunas was mentioned above. However, the connection of those coral faunas to the Eastern European faunas is obvious as well. The following species and genera, widespread in the Brigantian of Eastern Europe with the western borders in Poland, are unknown in the basins of Western Europe: *Arachnolasma subpercrassum* (Vassilyuk, 1964), *Dibunophyllum pseudoturbinatum* Stuckenberg, 1904, *D. percrassum* Gorsky, 1951, *D. lissitzini* Vassilyuk, 1960, *D. lonsdaleoides* Vassilyuk, 1960, *Siphonodendron rossicum* Stuckenberg, 1904, *Nervophyllum* Vassilyuk, 1959, *Turbinatocaninia* Dobrolyubova, 1970, and a peculiar, axially offsetting *Siphonodendron*-like genus (e.g., *Lithostrotion (Siphonodendron) dobrolyubovae* Khoa, 1977, closely resembling *Diphyphyllum lateseptatum* M'Coy of Vassilyuk (1960) from the Donets Basin and *Lithostrotion* sp. Dobrolyubova, 1958 from the Moscow Basin. Thus, the Polish Brigantian rugose coral faunas, although included in the Western European Province on the basis of the overwhelming majority of common taxa (Fedorowski, 1968, 1970, 1971, 1981; Khoa, 1977) can also be treated as intermediate between the Western and Eastern European provinces.

The second aspect of the Lublin Basin rugose coral faunas, is indicated by the palaeogeography of that time in the area in question, and by the faunal content established here for the early Pendleian (*Eumorphoceras* E1 Biozone) deposits. The geographic position of the Lublin Basin relative to the Lviv and the Donets basins, its bay-like shape (Fig. 33B) and the number of new taxa at the generic and specific levels mean that it can be interpreted as an area with environmental conditions that favoured evolution.

Such an interpretation is supported by the continuous occurrence of the differentiated Brigantian rugose coral fauna, offering an adequate basis for further evolutionary modifications during Serpukhovian time, and the geographic isolation of the area, making immigration more difficult than emigration. Unfortunately, inadequate knowledge of the early Serpukhovian rugose coral faunas in the coral-bearing deposits of the Eastern European Platform makes this only a suggestion. The rugose corals of the Lviv Basin, adjacent to the Lublin Basin, have never been studied in detail. The rich rugose coral faunas of the Donets Basin have been described by several authors (e.g., Lissitzin, 1925; Fomichev, 1953; Vassilyuk, 1959, 1960, 1964, 1975; Fedorowski and Vassilyuk, 2001, 2011; Fedorowski, 2009a, b; Fedorowski and Ogar, 2013). However, the Serpukhovian solitary non-dissepimented corals from that basin remain mostly undescribed, whereas they predominate in the Lublin Basin.

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