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SUPPLEMENTAL DATA ON TRIASSIC (ANISIAN) CORALS FROM UPPER SILESIA (POLAND)

Elżbieta MORYCOWA

Institute of Geological Sciences, Jagiellonian University, Gronostajowa St. 3a, 30-387 Kraków, Poland; e-mail: elzbieta.moryc@uj.edu.pl

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Abstract: About twenty species of scleractinian corals are known from the shallow marine epicontinental deposits (Middle Triassic: Anisian, Muschelkalk) of Kraków-Upper Silesia region. Four of them require taxonomic revision**.** On the basis of partly preserved micromorphological features and the microstructure of the skeletons two of them are corrected, i.e. *Coelocoenia*? *assmanni* Weissermel, 1925 and *C. exporrecta* Weissermel, 1925, from Kamień Śląski, near Opole (Upper Silesia). *Coelocoenia*? *assmanni* was incorporated into *Eckastraea prisca* (Weissermel, 1925), family Eckastraeidae Morycowa, 2006, in Morycowa and Szulc (2006) and *C. exporrecta* is assigned to a new genus *Opolestraea* nov. gen., family Eckastraeidae.

Key words: Scleractinia, taxonomy, Peri-Tethyan basin, Middle Triassic, Upper Silesia, southern Poland.

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INTRODUCTION

Corals from Kraków-Silesian Middle Triassic sediments are represented by 18 species from about 15 genera. They belong to the order Scleractinia, except for one genus and species created by Weissermel (1925). Some Anisian coral taxa described from the Muschelkalk limestones in the western part of the Silesian-Kraków Upland require modern taxonomic revision, i.a. two species created by Weissermel (1925) and belonging to the genus *Coelocoenia* Volz, i.e. *Coelocoenia*? *assmanni* and *C. exporrecta*, which were quoted later by Assmann (1937) and Schmidt (1938). They come from Kamień Śląski near Opole (Fig. 1).

The generic name *Coelocoenia* Volz, 1896, is a junior synonym of *Koilocoenia* Duncan, 1884 (Vaughan and Wells, 1943). The morphology and microstructure of the type species *Coelocoenia decipiens* (Laube, 1865) are described by Cuif (1972), who shows a perfect, thick trabecular septa of this coral. The two Anisian species described as *Coelocoenia* (= *Koilocoenia),* but without the diagnostic features of this genus, are the subject of the present paper.

It should be emphasized that the coral skeletons of the present study are recrystallized, with only traces of septal microstructure and micromorphology presented; these served as the basis for the taxonomic revision and systematic**s** of the corals presented here.

GEOLOGICAL SETTING AND PALAEOECOLOGICAL REMARKS

During the Middle Triassic, the Silesian–Kraków region belonged to the northern periphery of the western Tethys Ocean, which is called the Peritethys. This basin was closed from the north and open to the south through tectonically controlled gates (Senkowiczowa, 1962; Szulc, 2000). The open marine type of sediments and faunal diversity (i.a. scleractinian corals) indicate direct influence on this region by Tethys waters, mainly by way of the Silesian-Moravian Gate. The region was situated within the subtropical zone (ca. 22−24°) of northern palaeolatitude (Nawrocki and Szulc, 2000).

A lithostratigraphical division of the Middle Triassic (Muschelkalk) of Silesia was established by Assmann (1944, fig. 2), who subdivided it into "Schichten" (Beds), some of which are now formally defined as "Formations" (Bodzioch, 1997a).

The corals studied derive from well-developed, shallow marine limestones, which occur in the Lower Muschelkalk of western Upper Silesia. They belong to the Karchowice Beds (= Karchowice Formation; Kamień Śląski Limestone Member; Bodzioch, 1997a) at Kamień Śląski (in older literature: Gross Stein) near Opole (Weissermel, 1925, pp. 22−25).

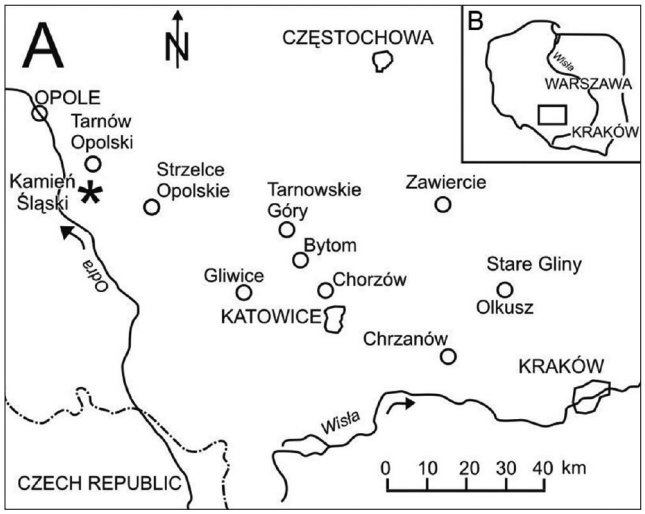

Fig. 1. Location map of the study area. **A**. The asterisk marks the location of the Kamień Śląski quarry. **B**. Inset shows position of the region in Poland.

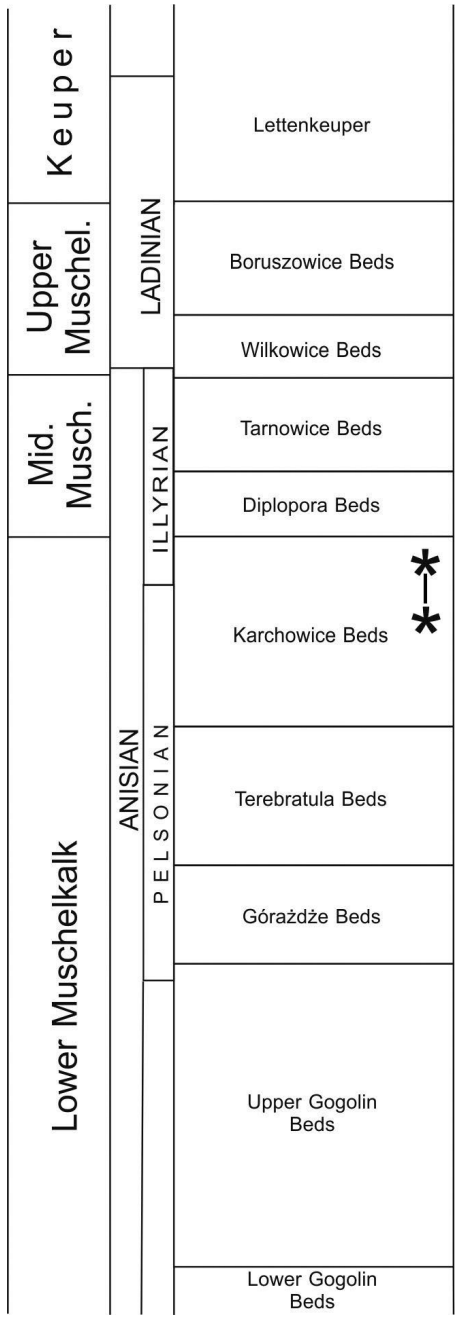

Fig. 2. Lithostratigraphic log of the Middle Triassic in the Kraków-Silesia region. Asterisks mark position of the corals studied rom Kamień Śląski.

These deposits are dated precisely as late Pelsonian–early Illyrian (e.g., Zawidzka, 1975; Narkiewicz and Szulc, 2004). These limestones contain coral buildups, preserved *in situ* (Morycowa, 1974, 1988, 1990; Szulc, 2000; Morycowa and Szulc, 2007, 2010; Bodzioch, 1997b), which are of 3 to ca. 10 m in diameter and several centimetres up to 1.5 m in height. The developments of corals succeeded sponge buildups following shallowing trend in the basin.

Corals from Kamień Śląski

One of the old, now non-existent quarries (the "northern quarry" in Morycowa, 1988; Fig. 3) was composed of organogenic, massive, porous limestones with corals. It occurred in the upper part of the Karchowice Beds at Kamień Śląski (Morycowa, 1988, fig. 2, 1990, fig. 20). In the upper part of this bioherm, lamellar colonies, mainly *Pamiroseris silesiaca* (Beyrich, 1852) were grouped in a layer 30−40 cm thick. It is noteworthy, that this Anisian species has a wide palaeogeographic range in the Peritethys deposits in Poland and Germany, in the Tethys deposits of the Alps (Schauroth, 1859; see Weissermel, 1925) and in southern China (Deng and Kong, 1984: Qi, 1984).

Several other coral taxa have been collected from this bioherm (Table 1), including *Eckastraea prisca* Weissermel, *Morycastraea opoliensis* Morycowa, *Silesiastraea weissermeli* Morycowa, *Chevalieria tenuiseptata* Morycowa, *Stylophyllopsis* sp. and rare solitary corals *Omphallophyllia triasina* (Dunker) are present (Morycowa, 1988).

From Kamień Śląski, Weissermel (1925) listed *Coelocoenia*? *assmanni* and *C. exporrecta*, both revised in this paper, and *Phylocoeniella globosa* Weissermel, not re-examined up to now. It is not clear whether they came from the Kamień Śląski bioherm.

The corals in the bioherm are accompanied by rich invertebrate faunas, e.g., crinoids, sponges, polychaetes, brachiopods (*Decurtella decurtata* (Girard), bryozoans, and microbial structures such as *Crescentiella* Senowbari-Daryan *et al.,* 2008 (= "*Tubiphytes*")

Anisian corals of the region

The oldest Triassic scleractinian corals occur only at a few localities in the westernmost part of the Tethys and in its northern peripheral zone (Central European Perithetys) as well as in the eastern Tethyan branch in China. About 20 species are present in the Muschelkalk of the Kraków-Silesian region, where they played a subordinate role as component of sponge-crinoidal-coral bioherms (e.g., Morycowa, 1988; Bodzioch, 1997b; Szulc, 2000).

These Silesian Anisian scleractinians appear to have been of zooxanthellate type, as suggested by Morycowa (1988), Bodzioch (1997b), Szulc (2000), Morycowa and Szulc (2007, 2010) and Kołodziej *et al*. (2018). Helmle and Stanley (2003) and Stanley and Helmle (2010) also suggest that photo symbiosis was present in the Middle Triassic corals at a very early stage in their Mesozoic history.

The morphologies of the corals range from phaceloid, phaceloid-cerioid, cerioid, plocoid, thamnasterioid to solitary types. The most frequent genera and bioherm builders include *Pamiroseris* Melnikova, 1971 (thamnasterioid colonies), *Volzeia* Cuif, 1967 (phaceloid) and *Eckastraea* Morycowa, 1988 (cerioid).

The predominance of large, branching coral skeletons of *Volzeia* occurring in the lower part of a bioherm at Tarnów Opolski, near Kamień Śląski (directly over the sponge facies), indicates that they developed in slightly deeper and quieter water, while the platy and encrusting colonies dominating in the middle and higher parts of the bioherm indicate gradual shallowing of the ambient environments an increase in water turbulence. The final emersion in Illyrian times resulted in the cessation of coral buildups.

SYSTEMATIC PALAEONTOLOGY

Material and terminology

The specimens discussed are housed in the Grundy Collection of the Museum of the Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin, Germany; specimen: X 10135 is the type of *Coelocoenia*? *assmanni* and specimen C. X 10136 is the type of *C. exporrecta*. Thin sections of these specimens were prepared by the present author.

Table 1

Scleractinian corals from the Anisian (late Pelsonian – early Illyrian) at Kamień Śląski near Opole (Upper Silesia region).

Taxa	Growth form and type of colony
Order Scleractinia Bourne, 1900 Family Cuifastraeidae Melnikova, 1983	
Silesiastraea weissermeli Morycowa, 1988	thamnasteriod-meandroid
Family Eckastraeidae Morycowa, 2006	
Eckastraea prisca (Beyrich, 1852)	cerioid
Opolestraea exporrecta (Weissermel, 1925)	phaceloid
Family Tropiastraeidae Cuif, 1977	
?*Chevalieria tenuiseptata* Morycowa, 1988	thamnasteriod-meandroid
Family Pamiroseriidae Melnikova, 1984	
Pamiroseis silesiaca (Beyrich, 1852)	thamnasterioid
Morycastraea opoliensis Morycowa, 1988	phaceloid
Family Conophylliidae Alloiteau, 1952	
Omphalophyllia triasina (Dunker, 1851)	solitary
Family Stylophyllidae Frech, 1890	
Stylophyllopsis sp.	phaceloid
Unrevised genus	
Phyllocoeniella globosa Weissermel, 1925	cerioid-phaceloid

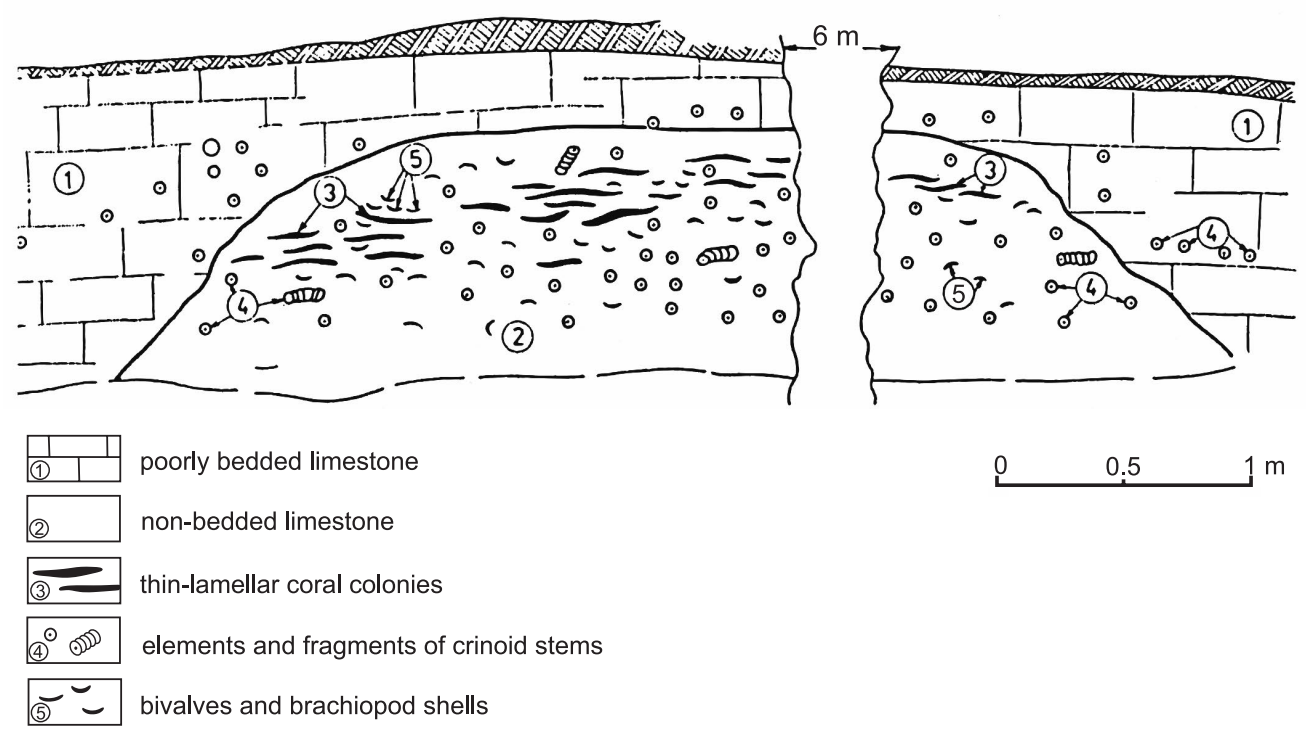

Fig. 3. Sketch of the bioherm with corals in the Karchowice Beds at Kamień Śląski (after Morycowa, 1988, fig. 2).

The following abbreviations and terminology are used in the text and figure descriptions:
D − diameter of corallum;
H − height of corallum;
d − corallite diameter (d1– corallite diameter, d2 – in internal stereozonal wall;
c-c − distance between calicular centres;
s − number of septa or costo-septa;
S1-Sn − septa of the succeeding size orders;
s den − septal density (number of septa per millimetre);
d end − density of endotheca elements;
den trab − density of trabecular centres per 100 µm**;**
d tr − diameter of trabeculae. Trabecular diametres are given after Morycowa & Roniewicz 1995)**:** small trabeculae − to 50 µm, medium-sized trab. − 50 to ca. 100 µm and thick trabeculae with diameters over 100 µm;
(…) − rare values given in parentheses.

Family Eckastraeidae Morycowa, 2006
in Morycowa and Szulc, 2006

Genus typicum: *Eckastraea* Morycowa, 1988.
Emended diagnosis: Radial elements compact, built of a row of small to medium-sized trabeculae, rarely, in their external part, of large complex trabeculae. Lateral trabecular expansions more or less regularly developed. Internal septal edges in higher order septa wedge- or club-shaped, occasionally dissociated into lobes. Lateral ornamentation of radial elements in the form of granules or pennules, in places, join linearly and form meniana-like structures. Lonsdaleoid septa and synapticules rare. Endotheca large vesicular in peripheral corallite part and smaller in central part. Septothecal corallite wall in cerioid colonies and pellicular in phaceloid ones. Internal stereozonal wall occurs in places. Budding intracalicular, marginal, rarely by asymmetrical corallite division.
Genera included: The family comprises two genera: cerioid *Eckastraea* Morycowa, 1988 and phaceloid, in places with corallites interconnected: *Opolestraea* new genus.

Genus *Eckastraea* Morycowa, 1988

Type species: *Isastraea prisca* Weissermel, 1925, pp. 18–19, pl. 1.
Remarks: Diagnosis of this genus after Morycowa in: Morycowa and Szulc, 2006. The genus *Eckastraea* appears to be closest to the Late Triassic (early Norian–Rhaetian) *Pamirastraea* Melnikova, 1975 (junior synonym: *Gablonzeria* Cuif, 1976, family Gablonzeriidae Roniewicz, 1989). *Eckastraea* differs from it**,** in the type of the colony increase ("*Gablonzeria* – through subequal division of calices"; Roniewicz, 1989) and in the structure of the wall, which in *Eckastraea* is septothecal, as in *Isastrea***,** whereas *in Pamirastraea* Melnikova (= *Gablonzeria* Cuif, 1976) it is trabecular. With regard to the septal microstructure and lateral septal ornamentation, they show rather similar build (Roniewicz, 1989, p. 33).

Eckastraea prisca (Weissermel, 1925)
Fig. 4A−H

*1925 *Isastraea prisca* n. sp. – Weissermel, pp. 18–19, pl. 1, fig. 9.
1925 *Coelocoenia* (?) *Assmanni* n. sp. – Weissermel, pp. 22–23, pl. 2, fig. 5. 1937 *Isastraea prisca* Weissermel – Assmann, p. 16, pl. 3, fig. 9.
1937 *Coelocoenia* (?) *assmanni* Weissermel – Assmann, pp. 16–17, pl. 3, fig. 7.
1938 *Isastraea prisca* Weissermel – Schmidt, p. 15, fig. 218a.
1938 *Coelocoenia Assmanni* Weissermel – Schmidt, p. 15, fig. 218b.
1988 *Eckastraea prisca* (Weissermel) – Morycowa, p. 114, pl. 10, figs 1a, b, 2a, b, text-figs 11A–C, tab. 5.
2006 *Eckastraea prisca* (Weissermel) – Morycowa and Szulc, pp. 731–732, figs 2A–D, 3A–D, 4E.
2006 *Eckastraea prisca* (Weissermel) – Morycowa *et al*., pp. 714–717, tab. 1, figs 1–5.

Table 2

Measured dimensions (in mm) of *Isastraea prisca* Weissermel, 1925; from Morycowa (1988) and Morycowa *et al*. (2006).

Taxon and specimen	Measurements
Isastraea prisca Weissermel, 1925, holotype X 10136	D (length) 6.5 cm d 5.0–5.5 mm S 40–44
Isastraea prisca Weissermel, 1925, thin section from the holotype: X 10136a, b.	D (length) 6 x 7 cm d 4.0–4.5 (6) S ca. 40
Eckastraea prisca (Weissermel, 1925). Syntype: UJ 34P/39; Stare Gliny – Diplopora Dolomite (Morycowa, 1988)	d 4.0–4.5 (6) S (32) 36–46 (48); S1–S3
Coelocoenia assmanni after Weissermel, 1925, specimen: X 10135	D 40 x 60 d1 ("in Aussenraum") 5–6 d2 ("in Innenraum") 2.0–3.5 c-c 4–6 S 44–48
Coelocoenia assmanni Weissermel, 1925; specimen X 10135 and thin sections X 10135a, b (measured by Morycowa).	D ca. 40 x ca. 60 d1 3–7 d2 2.0–4.0 c-c 4–7 S to ca. 48 ds 5/2 mm d trab. 40–100 (130) µm den trab. (1) 2–3 (4) per 100 µm

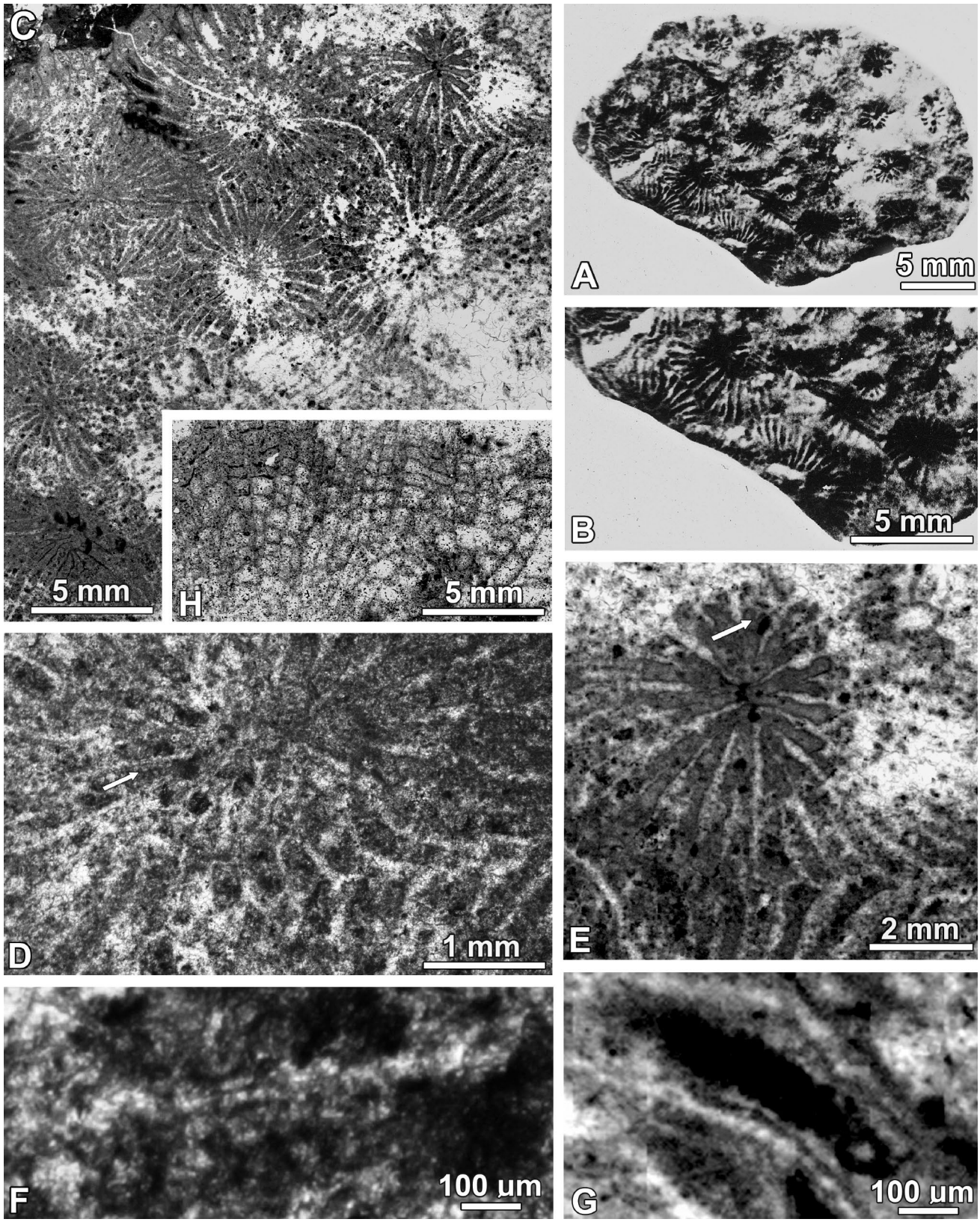

Fig. 4. *Eckastraea prisca* (Weissermel, 1925) from Kamień Śląski (Grundey Collection, Museum of the Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin X 10135). **A**. Incomplete colony with morphology of the upper colony surface, in places well preserved. **B**. Detail from calicular surface in **C–G**. Transverse thin sections (X 10135a) of the same specimen. C. Transverse thin section showing cerioid corallites with straight or slightly zigzag septothecal or rare septo-parathecal wall and their internal calices between stereozonal wall; D. Detail from the same transverse thin section showing a type of corallite wall. E. Same thin section showing rare lonsdaleoid septa (arrow) and traces of the septal trabeculae. F, G. Details of D showing (arrows) lateral septal ornamentation (in F – granules and subpennules, in G. – menianes). **H**. Fragment of longitudinal colony section showing (in the upper right hand corner) large, lateral dissepiments.

Material*:* The holotype of *Isastraea prisca* Weissermel, Grundey Collection, BGR, Berlin, X 10132, 2 thin sections X 10132a–b; specimens no. UJ 34P/39 – 40 from the Diplopora Dolomite of Stare Gliny and specimens ING UJ 134P/50 from the Karchowice Beds of Tarnów Opolski. One colony fragment (holotype) of *Coelocoenia*? *assmanni* Weissermel, 1925, coll. Grundey, BGR, Berlin No. X 10135, 2 thin sections X 10135a–b.

Measurements: d cor. (adults) 4–6 (7) mm; S (24)32–40 (44–48) mm; d trab. 40–100 (120) μm, den trab. (1)2–3(4) per 100 μm.

Description: Colonies cerioid with deep corallites and tectiform, straight or slightly zigzag shaped wall, in places slightly elevated corallites with depressed wall. Diameters of adult corallites 4.5 to 7.0 mm (sporadically more) and the inner stereozonal spaces from 2.3 to 4.0 mm. Commonly 40 to 44 septa, compact, fine, straight, nonconfluent, differentiated into three or four size orders**.** The 6–8 S1 septa reach to the centre, the S2 are almost equal to S1, S3 and S4 significantly shorter, if present. Inner margin of long septa with small trabecular projections. The lateral septal ornamentation is irregular, with sharp granules or pennules, in places fused into meniana-like forms. Lonsdaleoid septa rare**.** Endotheca composed of large, vesicular lateral dissepiments, and smaller and flat in central part. Budding intracalicular marginal without septal connections with the centre of the maternal form. In some colonies, adult corallites are observed with several juvenile ones arranged at the circumference (see Morycowa, 1988, pl. 10, figs 1, 2).

Microstructure: Diameters of septal trabeculae generally small to medium sized (from ca. 40 to 100 μm), in places, in the peripheric septal part, complex trabeculae (100 to 200 μm in diameter; see Morycowa and Szulc, 2006, fig. 4G) occur. The septal trabeculae are arranged in a single straight line. Lateral short trabeculae occur perpendicularly to the median septal zone. Wall built of vertical trabeculae of peripheral parts of septa, in places with additional endothecal elements.

Remarks: A small colony fragment described and illustrated by Weissermel (1925) as *Coelocoenia* (?) *Assmanni,* owing to its slightly convex, polygonal corallites, rather depressed wall and traces of microstructure, could be incorporated into the synonymy of *Eckastraea prisca.* In *Eckastraea prisca,* apart from colonies of typically polygonal, deep corallite calices with tectiform wall (see Morycowa, 1988), a colony with a fragment showing convex corallites and slightly depressed wall was observed (Morycowa et al., 2006, fig. 2B.

Occurrence: The specimens of *Eckastraea prisca* (Weissermel, 1925), together with *Coelocoenia*? *assmanni* Weissermel 1925, assigned to this species, come from the Anisian (late Pelsonian–early Illyrian) upper part of the Karchowice Beds at Kamień Śląski. Assmann (1937) and Schmidt (1938) erroneously assigned these deposits to the Middle Muschelkalk. Some specimens of this species collected by the author, come from the coeval Diplopora Dolomite at Stare Gliny (Morycowa, 1988) and from the Karchowice Beds at Tarnów Opolski (Morycowa *et al*., 2006).

Genus *Opolestraea* gen. nov.

Type species: *Coelocoenia exporrecta* Weissermel, 1925, by monotypy.

Derivation of the name: *Opolestraea* – Kamień Śląski is located in the Opole region.

Diagnosis*:* Corallum phaceloid, in places corallites interconnected. Pellicular wall thin. Stereozonal internal wall present. Radial elements of septal type, costae absent or only rudimentary. Their lateral faces with strongly protruding granules, fused in places in pennula- or meniana-like forms. Radial elements built of trabeculae small to medium sized in diameter, arranged monolinearly, rarely larger in peripheral part. Lateral trabeculae occur perpendicularly to the median septal zone. Endotheca composed of large lateral dissepiments and smaller internal ones. Intracalicular marginal budding. Rarely by asymmetrical corallite division.

Remarks: The same morphological similarity of skeletons can be observed between phaceloid *Opolestraea* nov. gen. and Late Triassic *Retiophyllia* Cuif, 1967 (family Reimaniphyllidae Melnikova, 1975; see Roniewicz, 1989). Their common features, in addition to the similar growth form, are radial elements with ornamentation as granules or short menianes. However, in *Retiophyllia* their slightly smaller septal trabeculae form mid-septal zone from straight to zigzag - the latter not present in the new taxon described here. In two discussed genera, the external and in places internal stereozonal walls, developed. The differences between these genera also occur in the type of budding and in the structure of endothecal elements.

Opolestraea exporrecta (Weissermel, 1925)
Fig. 5A – I

*1925 *Coelocoenia exporrecta* n. sp**.** – Weissermel, pp. 23––25, pl. 2, fig. 6.
1937 *Coelocoenia exporrecta* Weissermel – Assmann, p. 17, pl. 3, fig. 6.
1938 *Coelocoenia exporrecta* Weissermel – Schmidt, p. 16, fig. 218c.

Description: Corallum phaceloid, with corallites in places interconnected. Calices deep, round or slightly elongated with diameters of 4–6 mm and inner diameter, between stereozonal wall from 2.5 to 4.0 mm. Distances between corallite centres 5–7 mm. Radial elements, ca. 40 in number, compact, fine, straight. Lateral faces with protruding granules, partly fused into pennula- or meniana-like forms. Thin pellicular wall rarely preserved. Endotheca vesicular, composed of large lateral dissepiments and smaller internal ones. Budding mainly intracalicular marginal without septal connections with the maternal form, division process rare.

Microstructure: Although the skeleton is recrystallized, the traces of microstructure can be distinguished. Septa (in places with rudimentary costae) composed of small to medium-sized trabeculae (in places larger in peripheral part) and of lateral trabeculae, preserved partly as fibrous bundles.

Measurements: Table 3.

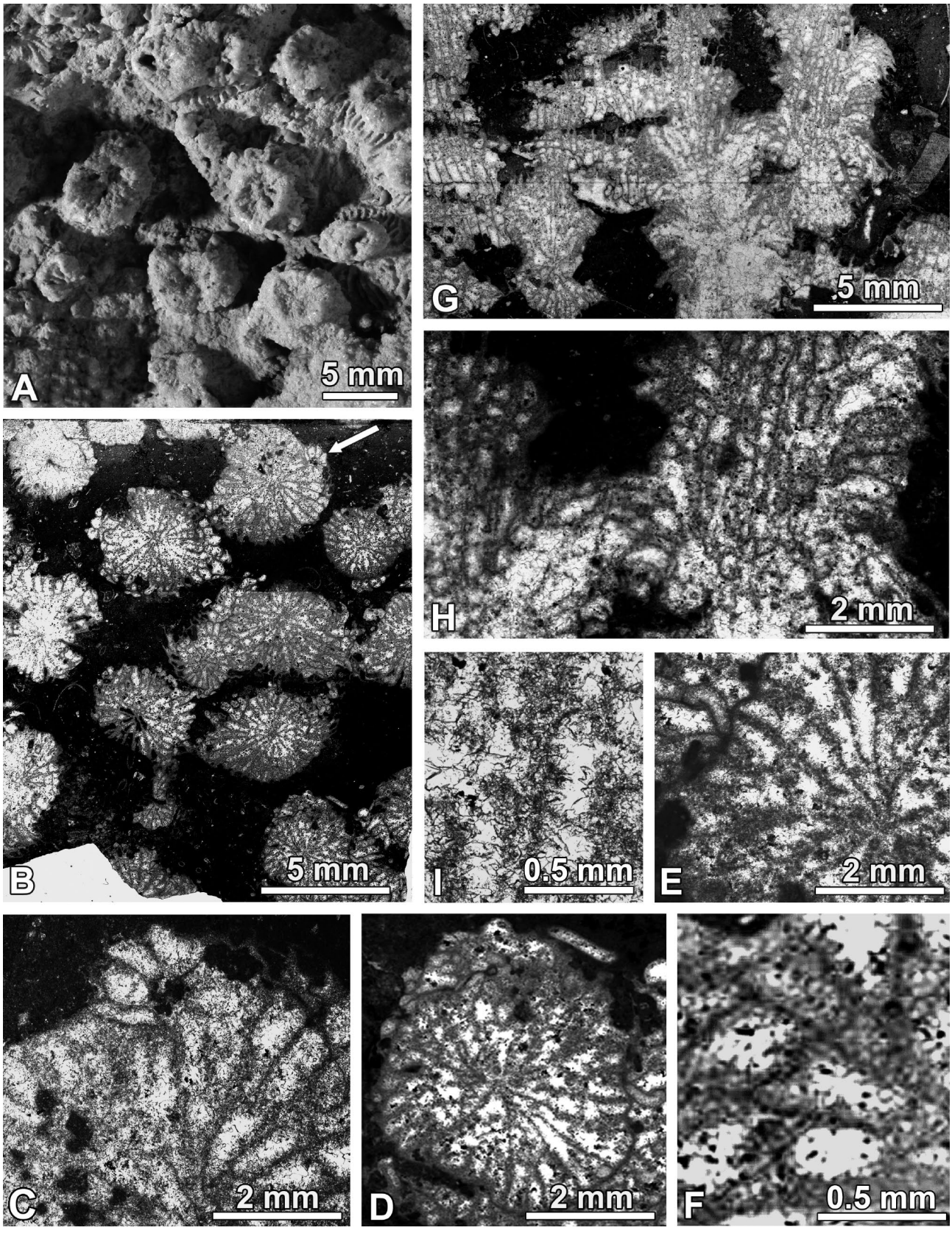

Fig. 5. *Opolestraea exporrecta* (Weissermel, 1925) from Kamień Śląski (Grundey Collection, Museum of the Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin X 10136). **A**. Fragment of the phaceloid colony surface, **B**. Transverse thin section (X 10136a) of colony fragment showing corallites and type of their budding (arrow in upper part). **C**. Detail from B showing, (arrow), the peripheral corallite budding. **D**. Transverse thin section of corallite visible on **E, F**. Fragments of corallite showing arrangement of radial elements (in E) and their lateral ornamentation (F) in form of strong granules, in places united into submenianes. **G–I**. Longitudinal section of corallites (X 10136b). The lines of the corallite connections are clearly visible (G, H) and detail of vertical septal sections with well-developed ornamentation.

Table 3

Measurements of *Coelocoenia exporrecta* Weissermel, 1925.

Specimen: X 10136 (measured by Weissermel, 1925)	Specimen X 10136: thin sections X 10136a, b (measured by Morycowa)
D 3.5 cm x 3.5 cm d1 "in Aussenraum" 6–8 mm d2 "in Innenraum" 4–5 c-c 6.5–9 mm S 30–32	 d1 5–8 mm d2 2.5–5 c-c 6–9 mm S ca. 40

Remarks: *Coelocoenia exporrecta* described by Weissermel (1925) differs from the genus *Coelocoenia* Volz (junior synonym *Koilocoenia* Duncan), i.a. by the colony type (*Koilocoenia* is plocoid or plocoid-cerioid), by the inner margins of septa, which in *Koilocoenia* are decomposed into free trabeculae and by tabuloid endotheca.
Occurrence: *Eckastraea exporrecta* described by Weissermel (1925) comes from the Anisian (late Pelsonian – early Illyrian) of the Silesia region: Kamień Śląski – upper Karchowice Beds (after Assmann, 1937 and Schmidt, 1938, from Middle Muschelkalk, Kamień Śląski).

CONCLUSIONS

The data presented above indicate that two coral species from the Karchowice Beds (Anisian) at Kamień Śląski near Opole (Poland), described by Weissermel (1925) under *Coelocoenia* (junior synonyms of *Koilocoenia)*, represent different genera. *Coelocoenia*? *assmanni* Weissermel was incorporated into *Eckastraea* Morycowa, 1988 as *E. prisca* (Weissermel, 1925), family Eckastraeidae Morycowa, 2006 (in Morycowa and Szulc, 2006). In this paper, *C. exporrecta* (Weissermel, 1925) is included in *Opolestraea* gen. nov., family Eckastraeidae.

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