Remarks on Middle Triassic (Anisian) scleractinian corals from the Cracow-Silesian region, Poland (Northern Peri-Tethyan realm)

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Abstract: This paper deals with the mode of occurrence, growth forms, skeletal preservation and the life conditions of some of the oldest, stratigraphically well-documented Anisian (Pelsonian-early Illyrian) scleractinian corals, occurring *in situ*, in shallow-water carbonate rocks in the Lower and Middle Muschelkalk of the Cracow-Silesian region, Southern Poland (northern Peri-Tethys, Central Europe). Among 18 species (from 14 genera; some of the generic names require emendation), one of the important Anisian coral species is *Pamiroseris silesiaca* (Beyrich) (= former *Thamnastraea Silesiaca* Beyrich), frequently occurring and widely distributed in the Peri-Tethyan (Germany, Poland) and found in the Tethyan provinces (Alps and S. China). The paper also presents skeletal growth bands of *P. silesiaca* and its septal microarchitecture, important because of high morphological homeomorphy of thamnasterioid corals, e.g., *Pamiroseris*, *Thamnasteria*.

Key words: Scleractinia, Middle Triassic, Peri-Tethys, Cracow-Silesian region, Poland

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1. INTRODUCTION

The occurrence of the "oldest" Triassic scleractinian corals has been noted in several locations in the westernmost part of the former Tethys Ocean and its northern, peripheral zone (Peri-Tethys, Central Europe) as well as in the eastern Tethyan branch from China.

The oldest, stratigraphically well-documented scleractinian corals, occurring *in situ*, are those from southern Poland, from the Muschelkalk succession of the Cracow-Silesian region (MORYCOWA, 1988, here also older bibliography; BODZIOCH, 1997; SZULC, 2000). The age of the coral-bearing rocks, assessed on the basis of conodonts, corresponds to Anisian, namely to the interval from Pelsonian to early Illyrian (ZAWIDZKA, 1975). The Peri-Tethyan (Germany, Poland) coral faunas are relatively poor in specimens and species and played a subordinate role as components of the sponge-crinoid-coral biohermal structures, similarly as in other Anisian cases noted in the western Tethyan zone (e.g. SENOWBARI-DARYAN et al., 1993; FOIS & GAETANI, 1984; FLÜGEL & SENOWBARI-DARYAN, 1996).

The Anisian corals from the Muschelkalk represent most probably zooxanthellate ("hermatypic" according to WELLS, 1933) scleractinians (see MORYCOWA, 1988; BODZIOCH, 1997a; SZULC, 2000). Thus, zooxanthellate scleractinians might be older than those described recently by HELMLE & STANLEY (2003) from the Ladinian from central Nevada, USA.

The scleractinian corals from the Muschelkalk of the Cracow-Silesian region, mainly from Upper Silesia, have been mentioned in the literature for about 150 years (e.g. BEYRICH, 1852; ECK, 1865, 1879; ROEMER, 1870; AHLBURG, 1906; WEISSERMEL, 1926; SCHMIDT, 1928, 1938; ASSMANN, 1937; MORYCOWA, 1981, 1988, 1990; MORYCOWA & RONIEWICZ, 1986). The hitherto gathered collections comprise about 100 specimens representing about 18 species. The most common, both in the old and contemporary collections, is *Pamiroseris silesiaca* (BEYRICH) (=former *Thamnastraea Silesiaca* BEYRICH). This is known also from the western German subbasin (e.g. ECK, 1879; SCHMIDT, 1938), as well as from the Tethyan province from the Alps (SCHAUROTH, 1859, see also ECK, 1879 and WEISSERMEL, 1926) and from southern China (DENG & KONG, 1984; QI, 1984).

2. MATERIAL

2.1. Collections

The hitherto gathered collections from the Lower and Middle Muschelkalk of the Cracow-Silesian region comprise about 100 specimens representing 14 species + 4 identified on generic level only (see MORYCOWA, 1988, tab. 1, 2). About half of these specimens are housed in the Naturkunde Museum, Humboldt University in Berlin, among them is the very important Weissermel collection. The remaining specimens collected mainly by

Morycowa, are housed in the Museum of the Institute of Geological Sciences, Jagiellonian University, Kraków. It should be noted that several coral colonies and about a dozen small solitary corals, not identified to date, were collected in recent years from Lower and Middle Muschelkalk by Dr. A. Bodzioch from the Poznań University.

2.2. Corallum morphology and skeletal preservation

The colonies from the Muschelkalk of the Cracow-Silesian region are most commonly small, platy-like, several centimeters (rarely more) in diameter and mainly one to six, rarely up to ten centimeters in thickness. Among platy-lamellar colonies, high-integrated thamnasterioid forms dominate. Phaceloid-dendroid large coralla (up to 1 m in height) and solitary, small (mainly up to 1 cm in diameter), frequently discoid forms, are rather rare. In the better preserved Anisian (Pelsonian/Illyrian) coral colonies traces of thin holotheca with regular, dense growth bands have been preserved (Pl. 1, Fig. E).

The Anisian scleractinian skeletons deriving from the Peri-Tethyan area, like those from the West Tethyan province, are poorly preserved, strongly recrystallized, dolomitized or preserved only as natural casts of calicular surfaces. That is why the microstructure of these corals is still insufficiently recognized. However, the preserved remnants of original skeletal microstructure and microarchitecture (e.g. Morycowa, 1988) suggest that these first scleractinian corals did not differ or differed only slightly from the Late Triassic ones. Results of the microstructure analysis based on recent and older studies of the Triassic scleractinians can be found in Roniewicz & Morycowa (1989, 1993). Four main basic types of skeletal microstructure have been distinguished: minitrabecular including several microstructural groups, thick-trabecular, pachythecal and stylophyllid types, with thick-trabecular and stylophyllid microstructural types dominating.

Exceptionally well-preserved and more abundant Anisian scleractinian corals from the Eastern Tethyan area, i.e. from Southern China (e.g. Deng & Kong, 1984; Qi, 1984; Qi & Stanley, 1989), may, after more detailed study, provide valuable information on their taxonomy, skeletal microstructure and microarchitecture as well as palaeogeographic relations with faunas from the Western Tethyan and Peri-Tethyan (European) provinces.

3. SCLERACTINIAN CORALS IN THE LOWER AND MIDDLE MUSCHELKALK

Scleractinian corals derive from the middle and upper Karchowice Beds and from the lower *Diplopora* Dolomite Beds (Fig. 1 B).

The age of the Karchowice Beds, established on the basis of conodonts (Zawidzka, 1975), corresponds to middle Anisian, namely to the interval from Pelsonian to early Illyrian (*Neospathodus kockeli* Zone to *Gondolella excelsa* Zone), while the age of the *Diplopora* Dolomite corresponds to early Illyrian only. Although almost all corals come from the Karchowice Beds and from the *Diplopora* Dolomite, the occurrence of a few solitary corals has been noted also in the lower Lower Muschelkalk deposits (Weissermel, 1926), i.e. from the Górażdże Beds (early Pelsonian).

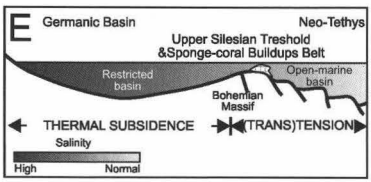
3.1. General setting

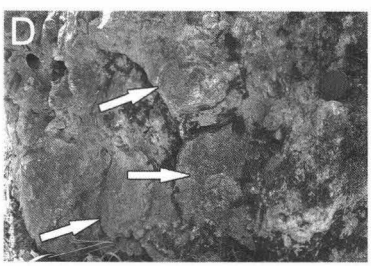
The scleractinian corals from the Karchowice Beds come from organogenic limestones building bioherms in the western part of the Silesian-Cracow Upland (Fig. 1 A). The maximum thickness of the Karchowice Beds is about 15 m (Dżułyński & Kubicz, 1971).

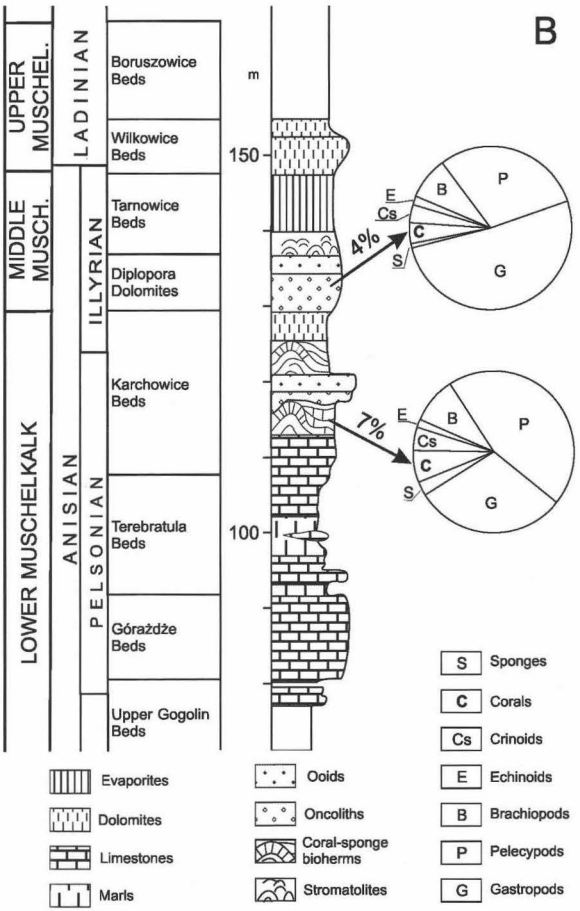
The corals occur in the western (Silesian) part of a 150 km long sponge/crinoid/coral buildup belt stretching from the western Upper Silesia to the western Holy Cross Mts. The belt is composed mainly of sponge bioherms that reach up to 10 meters in height. The sponge-coral buildups display vertical variability of their composition reflecting ecological successions of reef constructors typical of "catch up reefs" (sensu James & McIntyre, 1985). The buildups began to develop during the highstand phase of the Pelsonian transgression and the succession of the buildup constructors reflects the gradual shallowing trend in the basin (Bodzioch, 1997; Szulc, 2000). The buildup construction commenced by folded platy hexactinellid sponges which stabilised subaquatic bioclastic dunes. During the colonisation phase sponges started to form biostromal and biohermal fabrics reaching up to 8 m in height (Bodzioch, 1991). The appearance of the colonies of dendroid-phaceloid corals (*Volzeia szulci*) is characteristic for the diversification stage when also other organisms like calcareous algae, crinoids, brachiopods, annelids, and encrusting organisms, contributed to the "reef" community. The final stage of "reef" growth is marked by platy colonies, mainly *Pamiroseris silesiaca*. The Silesian buildups show a significant proportion of cryptocrystalline and peloidal carbonate fabrics dominating within the spongean components. The muddy fabrics display characters of typical automicrite produced by bacterially mediated calcification of sponge bodies (Reitner, 1993). It should be noted that coral bioherms known to date, for example those from Kamień Śląski, Tarnów Opolski and Izbicko (Opole region, Fig. 1 A) vary in dimensions, quality and quantity of biotic components. Some of these bioherms may be classified as crinoid-coral, the others as sponge-coral buildups. Generally, scleractinian corals play a subordinate role as biocomponents of these buildups. They occur there in life position and platy colonies belonging to *Pamiroseris* dominate. The coral community of these bioherms is characterized by relatively low generic diversity (one to five genera). One of the coral-crinoid bioherms, presented by Morycowa (1988, Fig. 2) from the

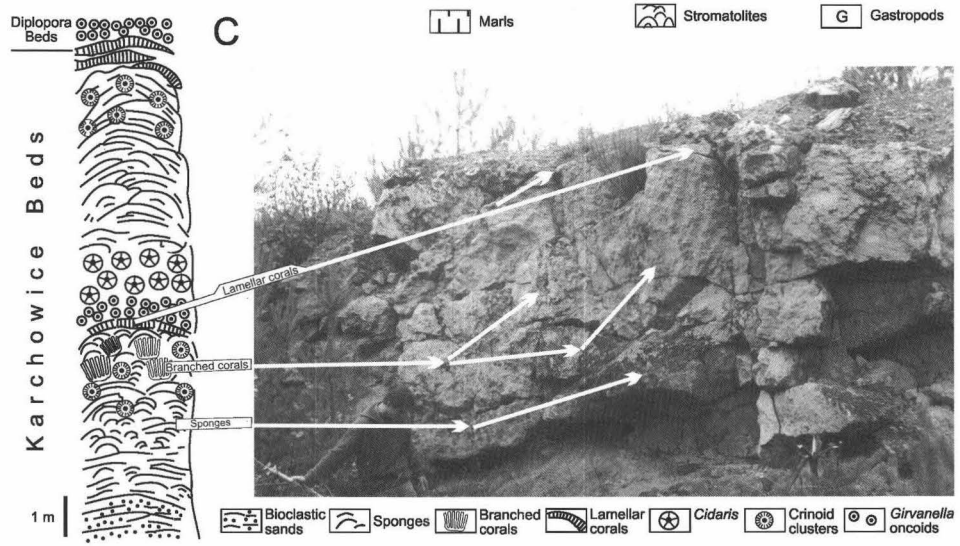
Fig. 1: A: Location of coral-bearing carbonates; coral sites shown by ▲. Insert shows position of the region in discussion. B: Lithostratigraphy and faunal composition of a part of the Anisian sequences in the Cracow-Silesian region. Coral-bearing sediments are indicated by arrows (after Szulc, 2000, simplified and modified). C: Fragment of the sponge-coral buildup (bioherm, Karchowice Beds) in Tarnów Opolski, Upper Silesia (after Szulc, 2000, simplified and modified). In the lower part of the bioherm large branching corals (*Volzeia szulci*) occur *in situ* above the sponge zone and in its highest part platy colonies (*Pamiroseris silesiaca*) dominate. D: Upper surface view of the platy coral colonies of the bioherm presented in C (camera cap for scale). E: Schematic model of the basin dynamics and circulation regime within the Northern Peri-Tethys domain (after Szulc, 2000, Fig. 30). Occurrence of sponge-coral buildups belt is marked.


A
CZĘSTOCHOWA
WARSZAWA
KRAKÓW
OPOLE
Tarnów Opolski
Izbicko
STRZELCE OPOLSKIE
Kamień Śląski
TARNOWSKIE GÓRY
ZAWIERCIE
BYTOM
GLIWICE
CHORZÓW
Stare Gliny
KATOWICE
OLKUSZ
CHRZANÓW
KRAKÓW
Pogorzyce
Wisła
CZECH REPUBLIC
0 10 20 30 40 km


E
Germanic Basin
Neo-Tethys
Upper Silesian Treshold
&Sponge-coral Buildups Belt
Restricted basin
Open-marine basin
Bohemian Massif
THERMAL SUBSIDENCE
(TRANS)TENSION
Salinity
High
Normal


D


UPPER MUSCHEL.
MIDDLE MUSCH.
LOWER MUSCHELKALK
LADINIAN
ILLYRIAN
ANISIAN
PELSONIAN
Boruszowice Beds
Wilkowice Beds
Tarnowice Beds
Diplopora Dolomites
Karchowice Beds
Terebratula Beds
Górażdże Beds
Upper Gogolin Beds
m
150
100
4%
7%
E
Cs
C
S
B
P
G
B
Evaporites
Dolomites
Limestones
Marls
Ooids
Oncoliths
Coral-sponge bioherms
Stromatolites
S Sponges
C Corals
Cs Crinoids
E Echinoids
B Brachiopods
P Pelecypods
G Gastropods


Diplopora Beds
C
Karchowice Beds
Lamellar corals
Branched corals
Sponges
1 m
Bioclastic sands
Sponges
Branched corals
Lamellar corals
Cidaris
Crinoid clusters
Girvanella oncoids

Karchowice Beds in Kamień Śląski near Opole (uppermost Lower Muschelkalk) shows in its upper part lamellar coral colonies, mainly *Pamiroseris silesiaca*, grouped in a 30–40 cm thick layer. From this bioherm *Silesiastraea weissermeli*, *Stylophyllopsis* sp. and very rare solitary corals, *?Conophyllia* sp., are recorded. The accompanying fauna is composed of numerous crinoid stems, thin-shelled bivalves, less numerous gastropods and brachiopods (including *Decurtella decurtata* (Girard), skeletal elements of echinoids (mainly spines) and dasycladacean algae.

A slightly different type of bioherm (sponge-coral buildup) occurs in the Tarnów Opolski quarry (Karchowice Beds; Fig. 1 A). The large delicate phaceloid-dendroid corals *Volzeia szulci* (up to 1 m high) occur in the lower part of the bioherm above the sponge structures. In the highest part of the bioherm, platy colonies, mainly *Pamiroseris silesiaca*, dominate (Fig. 1 C, D). The corals are accompanied by rich invertebrate faunas (Bodzioch, 1997; Szulc, 2000) and rare dasycladacean algae.

The corals from the *Diplopora* Dolomite usually occur as dispersed colonies or aggregates composed of 2 to 4 coralla. Most of them probably are not in life position, but are undoubtedly an autochthonous component of the sediment. The corals come from the quarries at Stare Gliny and Pogorzyce, and from boreholes in the vicinity of Zawiercie (Fig. 1 A). Most often they are small colonies or only their natural surface casts like *Pamiroseris silesiaca* and *Eckastraea prisca* (former *Isastraea prisca* Weissermel; see Morycowa, 1988), rarely other colonial corals (*Coelocoenia* cf. *decipiens* (Laube), *Cyathocoenia* sp., *Silesiastraea weissermeli* Morycowa) and solitary forms (e.g., *Conophyllia* sp.)

3.2. Anisian corals (and coral buildups) in the Silesian basin and their paleobiogeographical and paleobiological implications

The incipient Triassic buildups are believed to have inhabited deeper and protected settings dominated by muddy substrate (Fois & Gaetani, 1984) beneath the photic zone (Stanley, 1988). The Silesian "reefs" differ distinctly from the Alpine ones both in energy level and substrate characters. From the sedimentary context and from the reef structural pattern itself we can learn that the bioherms were formed above the storm wave level. Early meteoric diagenetic imprints and direct succession of the reefs by algal carbonates evidence that the reefs grew up within the photic zone. Szulc (2000; see also Morycowa, 1988 and Bodzioch, 1997) postulated a possible algae-coral association, denied hitherto for the early scleractinian corals (Stanley, 1988). And indeed a recent study of skeletal growth bands (annual ?) of Middle Triassic, but slightly younger (Ladinian) corals (Helmle & Stanley, 2003), seems to confirm the suggestion that they are zooxanthellate.

From the paleobiogeographical point of view, the Anisian Silesian sponge-coral buildup belt should be treated as a Tethys marginal "reefal" rim dividing the offshore Tethyan open marine zone from the backreef area (i.e. the Germanic Basin s.s.) (Fig. 1 E). Thus, they represent a segment of the circum-Tethyan "reef" belt that fortuitously avoided later subduction or other diastrophic subtraction. The region under discussion

was situated during Anisian times within the subtropical zone strongly influenced by storm activity.

3.3. Taxonomic remarks on *Pamiroseris silesiaca* and some other Anisian scleractinians from the Muschelkalk

Among about 18 species from 14 genera (some of the generic names require emendation, e.g., *Montlivaltia*, *Thecosmilia*), one of the important Anisian coral species is *Pamiroseris silesiaca* (Beyrich) (=former *Thamnastraea Silesiaca* Beyrich), frequently occurring and widely distributed in the Peri-Tethyan (Germany, Poland) and in the Tethyan provinces (Alps and S. China). According to Eck (1865, p. 86) and Weissermel (1926, p. 8) the Alpine species *Thamnastraea Bolognae* Schauroth should be placed in the synonymy of *T. silesiaca*.

The specimens of this important Anisian species have been described and mentioned in the literature but without photographic documentation of their skeletal microarchitecture. The septal microstructure and microarchitecture based on the original remains, given in a schematic drawing in Morycowa (1988, Fig. 6B), have been verified thanks to the well preserved specimen presented here in Pl. 1, Figs. G and I. Radial elements (built by simple thick trabeculae with rather rare lateral ones) show in their lateral faces both granulae and pennula-like forms (Pl. 1, Figs. G, I). Detailed knowledge of these features is important because of high morphological homeomorphy of thamnasterioid corals. The presence of skeletal growth bands in this specimen (Pl. 1, Fig. E) may be also of palaeobiological importance.

Another species mentioned (e.g. by Weissermel, 1926) in Anisian Muschelkalk and in the Alps (Recoaro) is *Montlivaltia triasina* Duncan. Morycowa (1990) described the species under the generic name *?Omphalophyllia* (junior synonym of *Conophyllia*). It seems, however, that not all small solitary corals from the old collection classified as *Montlivaltia triasina* represent the genus *Omphalophyllia;* some of them seem to belong to other genera, but not to *Montlivaltia* (some of them perhaps also to ?Stylophyllidae). Thus, without redescriptions of the type-specimens, a generic identification of this species is uncertain.

It should also be noted that the cerioid colonies which frequently occur in the *Diplopora* Dolomite belong to the genus *Eckastraea* Morycowa, 1988 (*Eckastraea prisca* (Weissermel) and show close affinities to cerioid specimens of the genus *Ceriostella* (according to the diagnosis and illustrations in Roniewicz & Stanley, 1998) from the Ladinian of Central Nevada, USA.

It is worth mentioning that *Coelocoenia* cf. *decipiens* (Laube) from the Cracow-Silesian region is very similar to *C. decipiens* (Laube) described from the Carnian of the Southern Alps (Laube, 1865; Frech, 1890; Volz, 1896; Cuif, 1972). Other taxonomic, stratigraphic, and paleobiological remarks concerning Anisian corals from Cracow-Silesian region were published elsewhere (e.g. Morycowa, 1988; Hagdorn et al., 1999).

In summary, the Anisian scleractinian corals from the Southern Polish Peri-Tethyan region (Lower Muschelkalk) show, like several other micro- and macrofossil groups (e.g. Kotański, 1994; Głazek et al., 1973; Gaździcki et al., 1975; Hagdorn & Głuchowski, 1993) a connection with the Tethyan faunal province.

4. CONCLUSIONS

1. Anisian scleractinian coral assemblages from the carbonate sediments of the Cracow-Silesian region (Southern Poland, Peri-Tethys subprovince) are relatively scarce. They comprise about 100 specimens representing ca. 18 taxa.
2. Corals under discussion occur in carbonate rocks as components of bioherms (in higher parts of the Karchowice Beds) or as dispersed specimens (in the *Diplopora* Dolomites).
3. Growth forms of these scleractinian corals are varied. They are solitary, colonial (mainly lamellar and incrusting) and/or pseudocolonial (phaceloid-dendroid forms).
4. The traces of original skeletal microstructure and microarchitecture suggest that these first corals did not differ (or differed only slightly) from the Late Triassic ones. In the Anisian corals four main types of microstructure were found (Roniewicz & Morycowa, 1993, with bibliography).
5. Scleractinian corals occurring in the Lower and Middle Muschelkalk of the Cracow-Silesian region coincide with the Pelsonian-early Illyrian interval. In contrast to the other Middle Triassic corals (e.g. those from China), the age (late Pelsonian-early Illyrian) of the Silesian sponge/crinoid/coral buildups is well established on the basis of conodonts (Zawidzka, 1975) and by means of magnetostratigraphy (Nawrocki & Szulc, 2000). That means that the Silesian coral bioherms are so far the oldest *in situ* found Mesozoic buildups in the West Tethyan domain. Another Anisian coral assemblage is the Illyrian reef community from the Dolomites, described by Fois & Gaetani (1984). Other Anisian reefs are either reconstructed after preserved reef debris (e.g. Senowbari-Daryan et al., 1993) or their age is not definite (see the discussion by Senowbari-Daryan et al., 1993).
6. Among about 18 species (among them 4 identified only on the generic level) representing 14 genera (some of the generic names require emendation, e.g. *Montlivaltia*, *Thecosmilia*), one of the most important Anisian coral species is *Pamiroseris silesiaca* (Beyrich) (= former *Thamnastraea Silesiaca* Beyrich), frequently occurring and widely distributed in the Peri-Tethyan (Germany, Poland) and found in the Tethyan provinces (Alps and S. China).
7. The oldest scleractinian assemblages from the western Tethys and Peri-Tethys differ from those of the East Tethyan province (South China). In the European Anisian there are considerably fewer solitary corals, but more thamnasterioid ones. High proportions of endemic scleractinian taxa are noted in both provinces. This may be a result of still insufficient knowledge of these coral faunas.

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Plate 1

A – C: *Volzeia szulci* MORYCOWA (UJ 34P/2), Tarnów Opolski. Polished fragments of large branching corals from the bioherm presented in Fig. 1 C.

A: Transverse section of several corallites.

B: Longitudinal section of several corallites.

C: Enlarged transversal section of a corallite.

D-G, I: *Pamiroseris silesiaca* (BEYRICH) (UJ 34P/46) from Tarnów Opolski quarry, Karchowice Beds.

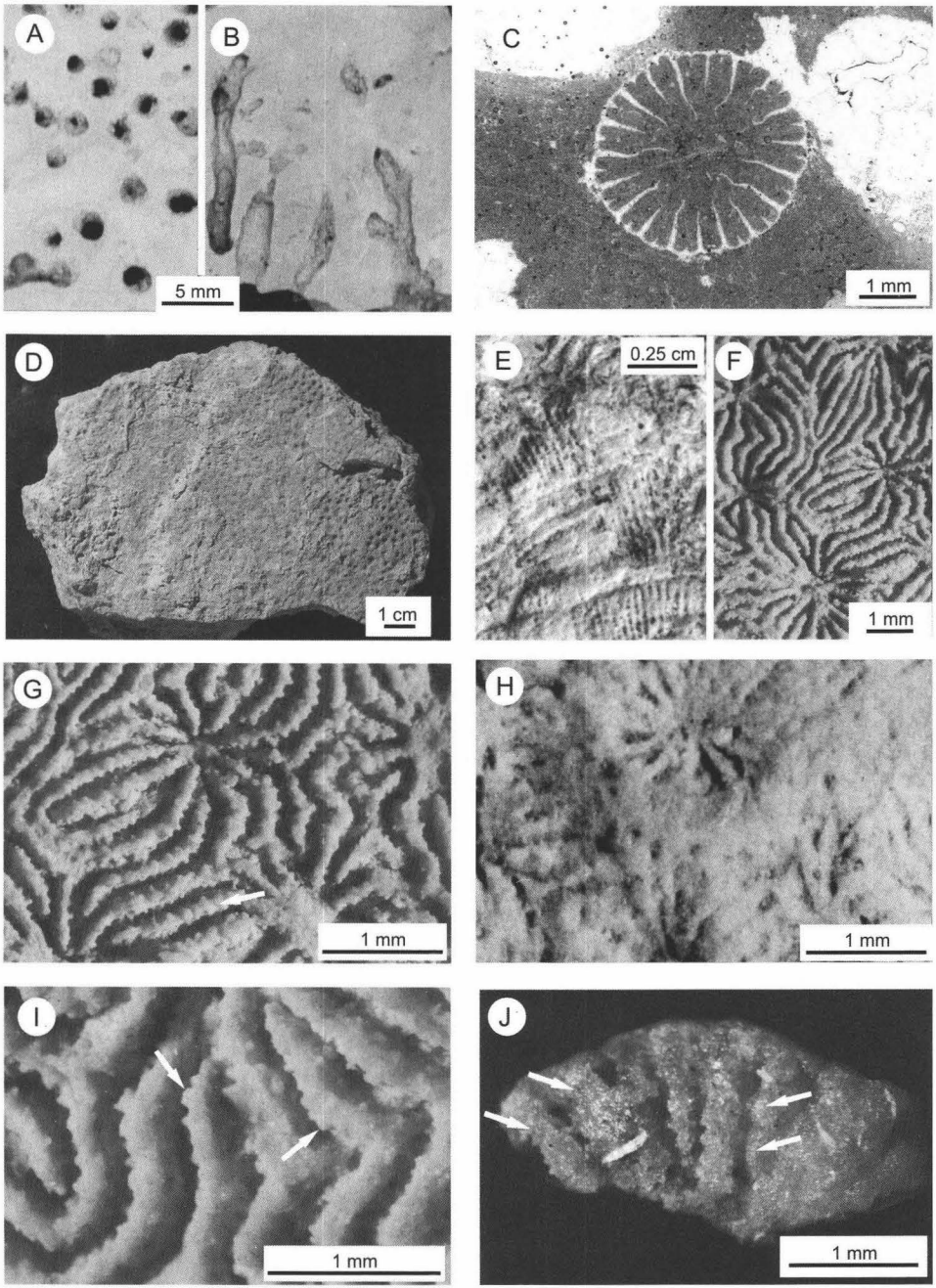
D: Calicular surface of colony; shallow and deep calices can be seen.

E: Lower/lateral surface of colony presented in D, with preserved in place skeletal growth bands.

F, G, I: Enlarged details of D showing disposition (F) and microarchitecture of radial elements; pennula-like forms and flat granules (I) are well visible; distal septal border with rather regular oval denticles (G), perpendicular to the septal blade.

H: *Thamnastraea silesiaca* BEYRICH, Upper Silesia, Karchowice Beds. Specimen from Beyrich's collection, Humboldt University in Berlin. Traces of septal microarchitecture can be observed.

J: ?*Conophyllia* sp. (UJ 24P/49), Kamień Śląski, Karchowice Beds. Fragment of calicular part of corallum; traces of large trabecular centres (arrows) and pennular-like forms are visible.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