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Tithonian (Upper Jurassic) crinoids from central Poland

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with 1 figure and 1 plate

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Abstract

Crinoid remains from shallow water deposits of Tithonian strata (Upper Jurassic) of the central Poland are described for the first time and referred to the following taxa: Millericrinina fam. et gen. et sp. indet., *Isocrinus* sp., *Balanocrinus* sp., *Balanocrinus subteres*, Comatulida indet. and Thiolliericrinidae gen. et sp. indet. The description is supplemented with a list of Tithonian taxa known hitherto from the northern margin of the Polish sector of the Tethys (Pieniny Klippen Belt of the Western Carpathians and Tatra Mountains). *Balanocrinus subteres* represents one of the most cosmopolitan isocrinid species in the Jurassic and Cretaceous succession. Palaeogeographic distribution of other crinoids is strongly limited by ecological factors.

Zusammenfassung

Erstmals werden Crinoiden aus Flachwassersedimenten des Tithons (Oberjura) Mittelpolens beschrieben und folgenden Taxa zugeordnet: Millericrinina fam. et gen. et sp. indet., *Isocrinus* sp., *Balanocrinus* sp., *Balanocrinus subteres*, Comatulida indet. und Thiolliericrinidae gen. et sp. indet. Die Beschreibungen werden durch eine Auflistung aller tithonischen Taxa ergänzt, welche bislang vom Nordrand des polnischen Abschnittes der Tethys (Pieninische Klippenzone der Westkarpaten und Tatra Gebirge) bekannt sind. *Balanocrinus subteres* repräsentiert eine der am weitesten verbreiteten Spezies in jurassischen und kretazischen Abfolgen. Die paläogeographische Verbreitung anderer Crinoiden ist stark durch ökologische Faktoren limitiert.

1 Introduction

Tithonian crinoids of the Tethyan part of Poland (Pieniny Klippen Belt and Tatra Mountains), have been subject of research interest many times. First, it was ZITTEL (1870) and ZARĘCZNY (1876), who mentioned several cyrto-

crinids, isocrinids and millericrinids from the Pieniny Klippen Belt. Amongst the more recent papers, are those of BIRKENMAJER & ZNOSKO (1955), KOTAŃSKI & RADWAŃSKI (1960), LEFELD & RADWAŃSKI (1960), LEFELD (1968, 1974), PISERA & DZIK (1979) and KASIŃSKI et al. (1981). GŁUCHOWSKI (1987), utilizing the knowledge of the previous researchers and his own field observations stated that in the Jurassic-Cretaceous deposits of the Pieniny Klippen Belt and Tatra Mountains, there are 50 crinoid taxa, the half of which belongs to cyrtocrinids.
In contrast to the Tethyan segment of Poland, Tithonian crinoids from the epicontinental basin have never been described. On the one hand, it is an effect of the scarcity of the outcrops exposing deposits of that age; on the other hand, it is caused by the generally low biodiversity of these echinoderms. Thus, the most important aim of the present paper is to show the taxonomic composition of the Tithonian crinoids from central Poland, compare it with the Tethyan assemblage and discuss the palaeoecology – mainly with respect to the stalked forms.

2 Geological setting and locality

Investigated deposits are confined to the Tomaszów Syncline, which is developed in the north-western part of the Mesozoic margin of the Holy Cross Mountains in central Poland (fig. 1).

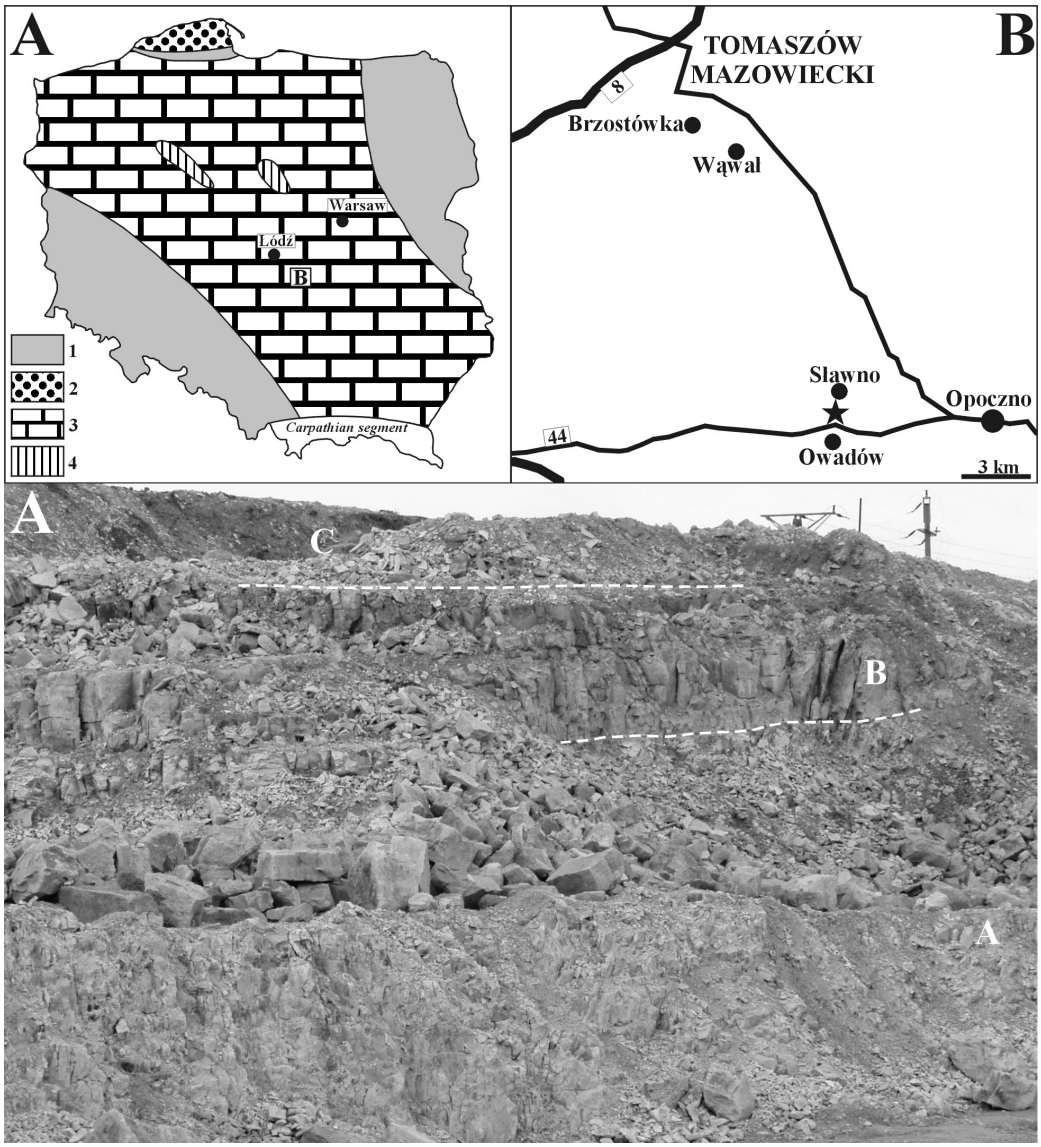

Fig. 1: A. Palaeogeographic map of Poland during the Late Tithonian (after GAŹDZICKA, 1998; slightly simplified); 1 – carbonate shelf (including carbonate platform), 2 – siliclastic shelf, 3 – carbonate rocks (undivided) and marls, 4 – silts, siltstones, clays and shale. B. Location sketch of the investigated Sławno-Owadów Quarry. C. A quarry wall showing well-visible complex A and B, and the heap of the rocks belonging to the complex C.

The Upper Jurassic in the Tomaszów Syncline consists of Oxfordian to Tithonian limestones and marls, which are underlain by the Bathonian sandstones and mudstones, and Callovian 'chalcedonites' (MATYJA et al., 1988). The axis of the syncline is filled with Lower (conglomerates, limy mudstones, mudstones and marly claystones) and Upper Cretaceous deposits (carbonates). The Tithonian deposits are divided in two lithostratigraphic units: Brzostówka marls and Sławno limestones. The Brzostówka marls, c. 65 thick, consist of marls, clayey limestones, clayey mudstones and mudstones. In the lowest and upper part of the Brzostówka marls, the Kimmeridgian–Tithonian and Middle–Upper Tithonian boundaries occur, respectively (see MATYJA et al., 1988). The Sławno limestones consist of marly limestones with intercalations of marls. The lower part of the unit represents the upper part of the Scythicus Subzone of the Scythicus Zone (lower part of the Upper Tithonian) (see KUTEK & ZEISS, 1997; MATYJA et al., 1988).
The investigated Tithonian deposits are outcropped at the Sławno-Owadów Quarry, located c. 1.5 km south of Sławno (fig. 1). ZIELIŃSKA (2003) divided the deposits into three complexes: A – light-grey-yellowish pelitic and thick-bedded limestones, c. 6.6 m thick, with a rich macrofauna, consisting of bivalves, brachiopods, ammonites and serpulids; B – grey-yellowish, pelitic and thick-bedded limestones, c. 2.5 m thick; and C – light-grey-yellowish pelitic, mainly thin-bedded '*Corbula* limestones', rich in monospecific assemblage of bivalves *Corbula*. The ammonites of the species *Zaraiskites zarajskensis* (MICHALSKI) and *Zaraiskites* cf. *zarajskensis* (MICHALSKI), found in the complexes A, B and C by one of us (AK; see also ZIELIŃSKA, 2003), indicate the Upper Tithonian (Scythicus Zone, Scythicus Subzone; see KUTEK & ZEISS, 1997). It is worth mentioning that the Sławno-Owadów Quarry is the only one place in Poland where the Tithonian sediments can be investigated. The site at Brzostówka in central Poland (see KUTEK & ZEISS, 1974, 1997; DZIK, 1990) does not exist any more, and the quarry at Świętomarz (see DZIK, 1995) in northern Poland is unavailable because it is filled with water.

3 Materials and methods

Sampling process was divided into two phases. At the beginning, we collected the bulk samples (40 kg each) of weathered rock from each complex A to C, to find out the general presence and quantity of the crinoid ossicles. After washing it occurred that the majority (but still not many) of the ossicles is confined to the complex A. In the complex B we found only a single one, and in the complex C, we found none. Therefore, we focused on the complex A and gathered additional samples, consisting of weathered, as well as whole rock material, the weight of which equaled 150 kg as a whole. The well-weathered samples were washed under the hot water, and the whole rock samples were treated by Glauber's salt (boiling and freezing). After this procedure, the rocks completely broke down. After drying, the specimens were picked under the microscope binocular. The chosen specimens were photographed using ESEM Philips. They are housed at the Department of Palaeontology & Biostratigraphy, Faculty of Earth Sciences in Sosnowiec, under the catalogue acronym GIUS 8-3424/T1-171.

4 A crinoid assemblage from the Tithonian of Poland

4a Palaeontological description of the present findings

Systematics after RASMUSSEN (1978).

Order Millericrinida SIEVERTS-DORECK, 1952
Suborder Millericrinina SIEVERTS-DORECK, 1952
Millericrinina fam. et gen. et sp. indet.
(pl. 1/A)

Material: 31 columnals, 3 pluricolumnals. GIUS 8-3424/T1-34.

Description: Columnals large and circular. Radiating, long and thick crenulae on the articular surface; articular surface covered with small tubercles in some cases. Lateral surface smooth. Lumen is large, circular or pentagonal.

Discussion: According to HAGDORN & GŁUCHOWSKI (1993) and HAGDORN (1996) only complete millericrinid (dadocrinid) cups allow proper classification on the genus and species level (see also SALAMON & ZATOŃ, 2005).

Order Isocrinida SIEVERTS-DORECK, 1952
Family Isocrinidae GISLÉN, 1924

Genus *Isocrinus* VON MEYER in AGASSIZ, 1836

Type species – *Isocrinites pendulus* VON MEYER, 1836

Isocrinus sp.
(pl. 1/B)

Material: 10 columnals, 13 brachial plates, 19 cirrals. GIUS 8-3424/T35-77.

Description: Columnals subpentagonal to stellate. Petal floors are elongated, drop-like, with well developed crenularium. Crenularium consists of 14–16 crenulae per petal. Crenulae of radial part nearly touch each other and sometimes leave narrow slits. Lateral surface smooth. Lumen is small and circular.

Disscussion: It is hard to decide, which representative of the genus *Isocrinus* is present in the interval studied. PISERA & DZIK (1979) did not mention any representative of the genus *Isocrinus* from the Tithonian of the Pieniny Klippe Belt. Later, GŁUCHOWSKI (1987) documented ?*Isocrinus* sp. from the Domerian–Hauterivian interval. The only one specimen illustrated by GŁUCHOWSKI (1987, pl. XXIX, fig. 5) certainly represents a juvenile form. On the other hand, the youngest Jurassic (Kimmeridgian) isocrinid, presented from epicratonic Poland so far, is *Isocrinus pendulus* (= *amblyscalaris*; RADWAŃSKA, 2005, p. 279, fig. 8/4, 5; but see discussion in HESS, 1975). The columnals described here, certainly do not belong to the species mentioned above. Due to the unique morphological features of the articular facet of *Isocrinus pendulus*, it can not be mistaken with any of the isocrinid species (for details see HESS, 1975, p. 55, Text-fig. 8, pl. 19, fig. 4).

Genus *Balanocrinus* AGASSIZ in DESOR, 1845

Type species – *Pentacrinites subteres* MÜNSTER in GOLDFUSS, 1826-1833

Balanocrinus sp.
(pl. 1/D)

Material: 8 columnals. GIUS 8-3424/T78-86.

Description: Columnals pentagonal. Triangular and drop-like petal floors on the articular surface; in some cases articular surface strongly abraded. Every petal floor surrounded with 5?, 6–9? marginal crenulae. Lateral surface smooth and straight. Lumen is small and circular.

Discussion: We have decided to refer the described columnals to *Balanocrinus* sp. because of the pentagonal columnal shape and poor state of preservation of the articular surfaces.

Balanocrinus subteres (MÜNSTER in GOLDFUSS, 1826–1833)
(pl. 1/C)

1870 *Balanocrinus subteres* (MÜNSTER in GOLDFUSS) – ZITTEL, p. 274, pl. 39, figs. 13, 14

Material: 7 columnals. GIUS 8-3424/T787-94.

Description: Columnals circular. Triangular and large petal floors on the articular surface; petal floors are separated with thin adradial crenulae. Every petal floor is surrounded with 6–8 marginal crenulae. Lateral surface smooth and straight. Lumen is small and circular.

Discussion: The presence of *B. subteres* in the sediments investigated is not surprising. This species was mentioned from various environments of Jurassic–Cretaceous age in the world (e.g., RASMUSSEN, 1978; GŁUCHOWSKI, 1987; KLIKUSHIN, 1992; see also literature cited in the section 4b "Tithonian crinoids from the Tethyan part of Poland"). However, as far as the species of the genus *Balanocrinus* are known only from the isolated ossicles (RASMUSSEN, 1978), there is no certainty, whether the elements of the Jurassic–Cretaceous interval belong to the same species. It is not excluded that in reality this parataxon consists of several species, in fact characterized by shorter durations, which can only be distinguished by their calyces which, unfortunately, are unknown.

Order Comatulida A.H. CLARK, 1908
Comatulida indet.
(pl. 1/E–H)

Material: 51 cirrals, 24 brachial plates. GIUS 8-3424/T95-170.

Description: Proximal cirrals are relatively short and oval in outline; in some cases almost square. Distal cirrals are rather long, slender and circular in outline. Syzygial distal side and muscular proximal side of U-, and V-shaped brachial plates.

Discussion: In the light of the report of RADWAŃSKA (2005), in the Upper Jurassic of the central Poland (Holy Cross Mountains), there only occur the representatives of the family Solanocrinitidae. So, it is highly probable that the described cirrals belong to the one of the representatives of the family Solanocrinitidae. RADWAŃSKI (1977) and RADWAŃSKA (1987) also mentioned the representatives of the family Comasteridae and Himerometridae from the same region, though, their stratigraphic ranges are confined only to the Cenozoic deposits.

Family Thiolliericrinidae A.H. CLARK, 1908
Thiolliericrinidae sp. et gen. indet.
(pl. 1/I)

Material: 1 columnal. GIUS 8-3424/T171.

Description: Columnal asymmetric. Articular face elliptical. Marginal and fulcral ridges are very distinct, rather high. Lateral surface smooth. Lumen is circular and medium sized.

Discussion: According to KLIKUSHIN (1987) only representatives of *Thiolliericrinus*, *Loriolicrinus* and *Heberticrinus* are known from the Upper Jurassic of Europe, so it is very probable that the present finding belongs to one of them.

4b Tithonian crinoids from the Tethyan part of Poland

The Tithonian crinoid assemblage noted from the Pieniny Klippen Belt and Tatra Mountains consists of 29 taxa (see GŁUCHOWSKI, 1987 and literature cited therein). The crinoids are clearly dominated by cyrtocrinids (18 taxa), and the number of isocrinids and roveacrinids is comparable (6 and 5 taxa respectively; see fig. 18 in GŁUCHOWSKI, 1987, p. 63). The dominance of the cyrtocrinids suggests that the crinoid assemblage may have inhabited deep-water marine areas. According to HESS (1975, 1999) and AUSICH et al. (1999), either the fossil and extant representatives of cyrtocrinids are confined to relatively deep-waters (more than 100 m), where they co-occur with sponges and brachiopods. GŁUCHOWSKI (1987) also stressed that in spite of the Smolegowa Limestone Formation (Czorsztyn Succession) in the Pieniny Klippen Belt and Hightatric Succession of the Tatra Mountains investigated by him, brachiopods and sponges were very common (comp. also BIRKENMAJER, 1963). It must be emphasized that also other features (e.g., sedimentology) point to the considerable depth of the Pieniny Klippen Belt Basin (GOLONKA et al., 2003; GOLONKA & KROBICKI, 2004). Additionally, the presence of a few taxa of free-living roveacrinids (saccocomids) in the Tethyan part of Poland can not be surprising, because living as planktic crinoids, they inhabited the upper parts of the water column (HESS, 2002).
Amongst the isocrinids, on the other hand, the assemblage is dominated by the representatives of the genus *Balanocrinus*, the most numerous of which is *B. subteres* (over 500 pluricolumnals and 1000 columnals; see GŁUCHOWSKI, 1987). This form is one of the most well-known and cosmopolitan taxa. It was mentioned many times from the either shallow- and deep-water environments (comp. data in SAMSONOWICZ, 1934; HESS, 1975; MALINOWSKA, 1980; KLIKUSHIN, 1982, 1992; GŁUCHOWSKI, 1987). On the other hand, the presence of some of the isocrinids in water depth exceeding 100 m is not exceptional. It is considered (MEYER, 1985) that during the middle and late Mesozoic, isocrinids started to inhabit the new, deep-water habitats, as an anti-predatory response.
It is also worth mentioning here about the occurrence of millericrinids. According to PISERA & DZIK (1979) and GŁUCHOWSKI (1987), millericrinids do not occur in the Tithonian deposits of the Polish part of the Tethyan Province (Pieniny Klippen Belt and Tatra Mountains). GŁUCHOWSKI (1987) stated that provincialism is responsible for that phenomenon. However, taking into account that millericrinids represent one of the most widespread crinoid groups, either in the epicontinental and the Tethyan basins (see HESS, 1975, 2006; RASMUSSEN, 1978), it seems that it is not an effect of their provincialism. Their absence, if any, must be related with their environmental preferences. However, it must be mentioned here, that these crinoids, although not

illustrated, were mentioned repeatedly from the Pieniny Klippen Belt and Outer Carpathians (see BIRKENMAJER, 1963 and literature cited therein). During the Jurassic–Cretaceous, the area of the Pieniny Klippen Belt was confined to the deep-water Tethyan Province (see GOLONKA et al., 2003; GOLONKA & KROBICKI, 2004). As was pointed out above, such environments are occupied mainly by cyrtocrinids. On the other hand, all the massive millericrinid findings (e.g., *Liliocrinus*, *Millericrinus*, *Pomatocrinus*) are related with hard or firm grounds in shallow-marine environments (see HESS, 1975; AUSICH et al., 1999; RADWAŃSKA, 2005; SALAMON & ZATOŃ, 2005). It must also be remembered that some of the millericrinid skeletal elements (relatively small columnals and brachials only) are also documented in the sub-photic Tethyan environments, where the depths exceeded 100 m (HESS, 2006).

4c Crinoids from the Tithonian Polish epicratonic basin and environmental remarks

Millericrinid ossicles are the dominant compounds of crinoid remains documented during the current investigations. Their pronounced majority (number of ossicles) comes from the lowermost part of the sequence of the Owadów-Brzeziny Quarry (complex A *sensu* ZIELIŃSKA, 2003). Additionally, the columnals from this part of the section are characterized by their larger sizes (up to 13 mm in diameter). It may be caused by favourable substrate for their settlement, because in the complex A, there are numerous bivalve fauna, as well as brachiopods (ZIELIŃSKA, 2003). Moreover, in the same bottom of the same quarry, the large hard surface built by oysters, brachiopods, serpulids, as well as by gigantic (up to even 200 mm in width) bivalves *Lima*. The same large bivalves served as hard substrate for many encrusters in the Callovian of Zalas (southern part of the Polish Jura, southern Poland).

Simultaneously, in the light of observations of ZIELIŃSKA (2003), the deposits from the lower part of the complex A were deposited below the storm wave-base. Therefore, the environment was shallow which stays in agreement with the ecological preferences of millericrinids (e.g., RADWAŃSKA, 2005) and associated free-living comatulids. MACURDA & MEYER (1977) described dense associations of comatulids from the water depth 1–3 m of the western Caribbean coastal area. Additionally, HESS (1999) stated that comatulids inhabit various ecological niches within reefal environments and their occurrence ranges from 1 to 70 m. In the investigated complex A, comatulid remains outnumber the isocrinid ones.

In the complex B, the number of crinoids drastically drops. Only two columnals of millericrinids and two comatulid brachials have been found. It is interesting because ZIELIŃSKA (2003) also noted the distinct impoverishment of benthic fauna. In this complex only serpulids *Serpula coacervata* BLUMENBACH, two species of brachiopods *Russiella* and *Rhactorhynchia*, and oysters *Nannogyra nana* (SOWERBY) have been noticed. None of the infaunal or semi-infaunal organisms have been noticed (ZIELIŃSKA, 2003). Thus, the environment was still shallow, which is also indicated by the millericrinids and comatulids only, and the general impoverishment of the benthic fauna could have been caused by other factors, e.g., a degree of oxygenation of the sea-bottom (ZIELIŃSKA, 2003).

The highest complex C is completely devoid of crinoids and other echinoderms. ZIELIŃSKA (2003) also did not note any echinoderms in thin-sections investigated. Instead, apart from serpulids and fish remains, the sediments are dominated by huge number of monospecific assemblage of bivalve *Corbula* (ZIELIŃSKA, 2003 and pers. observ.). Such mass-occurrence of a single species is certainly caused by environmental stress which led to the establishment of opportunistic species. ZIELIŃSKA (2003) stated that the main cause could have been salinity, but whether the conditions were brackish or hypersaline is not known yet. Even the recent discovery of well-preserved xiphosuran (horseshoe crab) *Mesolimulus* in this complex by one of us (AK), can not tell much of the salinity regime. Although extant xiphosurans live in nearshore environments, as the fossil representatives did, the latter ones however are found either in facies characteristic for brackish or in lagoonal environments characterised by higher degree of salinity (e.g., RIEK & GILL, 1971; SELDEN & DRYGANT, 1987; FILIPIAK & KRAWCZYŃSKI, 1996; CRÔNIER & COURVILLE, 2005). Thus, the presence of xiphosuran indicates even shallower environment, than during deposition of the sediments of the complex A and B. The finding of a single ammonite *Zarajskites* (by AK, see also ZIELIŃSKA, 2003) may be a product of beaching of its shell.

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Plate 1

Tithonian crinoids from Poland; Owadów. Scale bar equals 1 mm.

Fig. A: Millericrinina fam. et gen. et sp. indet., columnal, articular surface. GIUS 8-3424/T1.

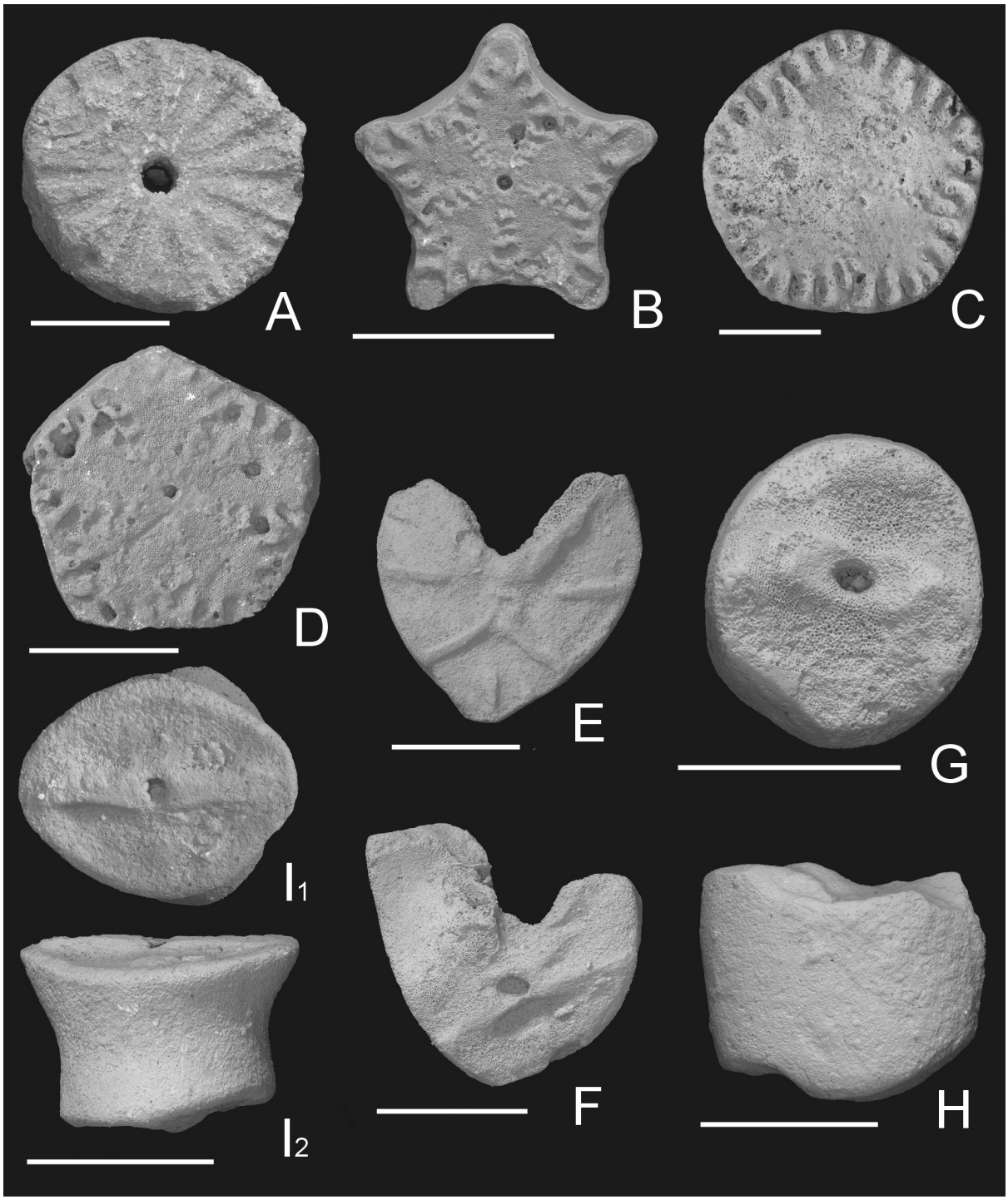
Fig. B: *Isocrinus* sp., columnal, articular surface. GIUS 8-3424/T35.

Fig. C: *Balanocrinus subteres*, columnal, articular surface. GIUS 8-3424/T787.

Fig. D: *Balanocrinus* sp., columnal, articular surface. GIUS 8-3424/T78.

Figs. E–H: Comatulida indet., brachial plates and cirrals.
E – brachial plate proximal syzygial surface. GIUS 8-3424/T95; F – brachial plate distal muscular surface. GIUS 8-3424/T96; G – cirral articular surface. GIUS 8-3424/T150; H – cirral lateral surface. GIUS 8-3424/T151.

Fig. I: Thiollericrinidae gen. et sp. indet., columnal. GIUS 8-3424/T171. I_1 – articular surface. I_2 – lateral view.


A
B
C
D
E
G
I1
I2
F
H

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