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CASEARIA QUENSTEDT AND *CYPELLIA* POMEL (HEXACTINELLIDA, PORIFERA) FROM THE JURASSIC OF THE SHOTORI MOUNTAINS, EAST-CENTRAL IRAN

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Abstract. The hexactinellid sponge genera *Casearia* Quenstedt, *Caseispongia* Quenstedt, and *Cypellia* Pomel are all morphologically similar and externally annulated. *Caseispongia* is internally a chambered sponge, like the hypercalcified genus *Amblysiphonella*. The internal construction of almost all externally annulated specimens illustrated as *Casearia* by Quenstedt and some other authors is not known enough. Despite of this lack of knowledge the genus name *Caseispongia* is synonymized with *Casearia* based on observations of Müller and the description of Schmidel. Both genera were described originally from the Upper Jurassic of southern Germany. Hexactinellid sponges, described in this paper, are reported for the first time from the Jurassic of the Shotori Mountains in east-central Iran. The following species are new to science: *Casearia tabasensis*, *Cypellia irregularis*, *C. cylindrica*, and *C. tabulata*.

Riassunto. I generi di spugne hexactinellidi *Casearia* Quenstedt, *Caseispongia* Quenstedt e *Cypellia* Pomel sono tutti morfologicamente simili e annulati esternamente. *Caseispongia* tuttavia presenta internamente delle camere, come il genere ipercalcificato *Amblysiphonella*. L'impalcatura interna di quasi tutti gli esemplari esternamente annulati, illustrati come *Casearia* da Quenstedt e da altri autori, non è abbastanza conosciuta. Ma nonostante questa carenza di conoscenze, il genere *Caseispongia* è posto in sinonimia con *Casearia,* in base alle osservazioni di Müller e la descrizione di Schmidel. Entrambi i generi furono descritti inizialmente dal Giurassico Superiore della Germania meridionale. Le spugne hexactinellidi, descritte in questo articolo, vengono segnalate per la prima volta nel Giurassico delle montagne Shotori situate nell'Iran centro-orientale. Le seguenti specie sono nuove alla scienza: *Casearia tabasensis*, *Cypellia irregularis*, *C. cilindrica* e *C. tabulata*.

Introduction

The polyphyletic group of chambered sponges, called "Sphinctozoa" Steinmann, 1882 or "Thalamida" Laubenfels, 1955 evolved independently several times in different sponge groups during the life history. Representatives of demospongid hypercalcified sponges are abundant in late Palaeozoic and Mesozoic reefs, especially in the Permian and Triassic time interval (Senowbari-Daryan 1990). Heteractinid chambered sponges are known from the Cambrian (*Nucha, Wagima, Jawonia*: Pickett & Jell 1983; Kruse 1987; Picket 2002) and calcispongid chambered sponges from the Jurassic-Cretaceous (Sphaerocoeliida Vacelet, 1979: e.g., *Barroisia*, *Muellerithalamia*; see Senowbari-Daryan 1990, 1991; Senowbari-Daryan & Rigby 2011). Hexactinellid chambered sponges are not known from the Palaeozoic, with possibly exception of the family Tadassiidae (uncertain class) described by Zhuravleva & Pyanovskaya (1995) from the Cambrian of Russia.

Chambered hexactinellid sponges, however, occur in the Late Triassic and Late Jurassic time interval in the Tethyan realm. The best known chambered hexactinellid sponge is *Casearia* – *C. articulata* – described originally as *Spongia articulata* by Schmidel (1780) from the Upper Jurassic of southern Germany. The original descriptions of *Casearia* by Goldfuss (1826), Quenstedt (1858, 1878) and by some other authors are based on their annulated outer morphology. The illustrations of the specimens by these authors do not give detail information about the internal construction of the specimens. Information about the internal construction of *Casearia* has also not been put forward by later authors (Mehl 1992; Pisera 1997). Mehl (1992: pl. 13, fig. 2) illustrated an annulated specimen as *C. articulata* (Schmidel), describing it as internally chambered con-

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struction without sectioning it. The description of Schmidel (1780: 17), however, refers to a chambered construction of *Casearia articulata*. He notes: "Die ganze äußere Fläche derselben ist mit einem zarten Netze überzogen,.... welches nicht nur die äußere Fläche umstrickt, sondern auch zwischen die Vergliederungen hineindringt und die Abteilungen derselben machet" (The outer surface is covered with a delicate lattice,... which covers not only the outer surface, but enters also between the segments producing the partition). Therefore the chambered construction of *C. articulata* (Schmidel) is indirectly derived. Müller (1974) illustrated two photographs of a chambered sponge under the name *Casearia articulata*, which show clearly the chambered construction of these sponges.

Three specimens of *Spongites articulatus* of Quenstedt (1878: pl. 120, figs 9, 9a and 10) are deposited in the palaeontological collections of the University of Tübingen. These specimens were illustrated by Quenstedt (1878). All three specimens are small-sized. The internal construction of these specimens of *C. articulata* is unknown. We obtained these specimens on loan and asked for permission to cut one of them with a stone-saw blade less than 1 mm thick. Our request was, however, refused ("for conservational reasons the specimens illustrated by Quenstedt should not be altered"; e-mail from Phillipe Havlik, July 8, 2010).

Quenstedt (1858) established the genus *Casearia* for the sponge described by Schmidel (1780: 19, pl. 4, fig. 5) as *Spongia articulata*. A morphologically similar sponge was described by Goldfuss (1826: 9-10, pl. 3, fig. 8a-c) as *Scyphia articulata*. In 1878, Quenstedt (p. 106) established the genus *Caseispongia* and attributed the Goldfuss species *Scyphia articulata* to this genus. The species of Goldfuss (pl. 3, fig. 8a) is externally well annulated, but the internal construction, whether chambered or non-chambered, is unknown. Several specimens were illustrated by Quenstedt (1878: pl. 120, figs 12-19) as *Caseispongia articulata*. One of Quenstedt's specimens, illustrated in his pl. 120, fig. 17 has been re-illustrated by Reid (2004: 510, fig. 5a-c) and in Pl. 2, fig. d in this paper. This specimen is morphologically clearly annulated with a thin dermal layer, but the internally chambered construction is not sure. The outer dermal layer of this specimen is identical with that of other specimens of the genera *Caseispongia* and *Casearia*. The outer dermal layer continues to the thick wall containing indistinct inhalant and exhalant canals as shown by Quenstedt (1878: pl. 120, fig. 17). Such inhalant and exhalant canals are not known in the thin wall of *Casearia*. The specimen illustrated by Quenstedt (1878) on his pl. 120, fig. 18 is definitely a chambered sponge and is re-illustrated in Pl. 1, fig. f and Pl. 2, figs a-b in this paper. We assume that the other specimens of *Caseispongia articulata* illustrated by Quenstedt are also chambered sponges. Therefore, *Caseispongia articulata* is here defined as a chambered sponge with ring-shaped chambers like *Amblysiphonella* Steinmann with exo- (outer wall), inter- (wall between the successive chambers), and endowalls (wall of spongocoel).

A summarized definition of the genus *Caseispongia* is given by Reid (2004: 508; most probably based on the specimen re-illustrated by him). The author gives the following characteristics of the genus: "Annulate, chambered sponge with deep, broad spongocoel; thick walls with layered, dictyid skeletal structure;....". Because one specimen of *Caseispongia articulata*, illustrated by Quenstedt (1878) is clearly chambered, the chambered construction of *Caseispongia* appears to be certain.

Based on the descriptions by Schmidel (1780) and Müller (1974) most specimens of *Casearia articulata* (e.g., Mehl 1992), despite their unknown internal construction, should be also chambered hexactinellid sponges. Both genera (*Casearia* and *Caseispongia*) are most probably synonyms as listed by Müller (1974), but his description is inadequate to show the chambers and therefore the chambered construction of the sponge in a longitudinal section. The radial section of a specimen, illustrated in pl. 3, fig. 4 by Müller (1974) shows the one side of two chambers documenting the chambered construction of his specimens.

Several chambered hexactinellid sponges have been described as *Casearia*: from the Upper Triassic (Carnian) by Rigby et al. (1998), from the Norian-Rhaetian of Caucasia by Boiko (1990), from the Norian of the Alps (Senowbari-Daryan & Zankl 2010), and from the Nayband Formation of Iran by Senowbari-Daryan & Hamedani (1999) and by Senowbari-Daryan & Amirhassankhani (2012).

Depository. The studied material (sponge pieces and thin-sections) is housed in the Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany, under the prefix BSPG 2012 I 78 – I 86.

Localities

The material comes from two localities in the Shotori Mountains. One locality is situated northwest of the village Esfak (N34°02′17″, E57°10′13″). The sponges occur in a thin debris flow close to the base of the Korond Formation (Oxfordian-Kimmeridgian), together with abundant corals and some bivalves and brachiopods. The Korond Formation is a basinal deposit (Wilmsen et al. 2009), and the debris flow is derived from the margin or upper slope of an adjacent shallow-water carbonate platform. The second locality is situated S of Kuh-e Bagh-e Vang (N33°56′, E56°47′), south of the road leading from Tabas to Boshrouyeh. The

sponges occur in the Echellon Member (Callovian) of the Kamar-e Mehdi Formation, at the base of a large carbonate platform - shelf lagoon system (Wilmsen et al. 2010), associated with microbialites.

Palaeontology

Class **Hexactinellida** Schmidt, 1870

Order **Innaecoeliida** Boiko, 1990

Remarks. The order Innaecoeliida was defined as chambered sponges with hexactinellid lattice by Boiko (1990: 124). One family only – Innaecoeliidae – was attributed to this order by her.

The Innaecoeliidae have been synonymized – with question mark – with the subfamily Caseariinae Schrammen (ex Caseariidae Schrammen, 1937) in favour of the family Craticulariidae Rauff, 1893 by Reid (2004). The chambered construction, the main feature of the genus *Casearia* is, however, not known from other genera of the family Craticulariidae. Therefore, to separate the chambered from non-chambered hexactinellid sponges, the order Innaecoeliida Boiko (1990) is accepted here to separate the chambered hexactinellid from the non-chambered representatives.

Family Caseariidae Schrammen, 1936

Synonymys: Innaecoeliidae Boiko, 1990, Monilispongiidae Wu, 1990; Dracolychniidae Wu, 1990.

Discussion. The family Caseariidae Schrammen, 1937 is considered to be a subfamily and has been attributed to the family Craticulariidae by Reid (2004). He noted on page 476, that three subfamilies – Craticulariinae, Laocoetidinae, and Leptophragmatinae – are included in the family Craticulariidae, but the subfamily Caseariinae is also placed in this family. Because of the chambered construction of the representatives of the Caseariidae, this family is considered to be an independent family with the type genus *Casearia* Quenstedt, 1858. The families Innaecoeliidae Boiko, 1990 – including the three genera *Caucasocoelia, Pseudoverticillites*, and *Innaecoelia* – Monilispongiidae Wu, 1990, and Dracolychniidae Wu, 1990 are added as junior synonyms to the Caseariidae Schrammen (1937).

Genus *Casearia* Quenstedt, 1858

Synonym: *Caseispongia* Quenstedt, 1878; *Innaecoelia* Boiko, 1990.

Emended diagnosis: Externally deep annulated, internally a chambered sponge like the hypercalcified genus *Amblysiphonella* with thin exo-, endo-, and interwalls. Chamber walls are thin and consist of two or more hexactine layers. Chamber interior is whole (without filling skeleton). The outer surface is built by a dermal layer consisting of a hexactine lattice composed of quadrangles. Spine-like elements may extend from the wall of the pore walls of the quadrangles into the pores.

Type species: According to Kolb (1910: 187), Müller (1974: 3), and Mehl (1992) *Spongia articulata* Schmidel (1780) is the type species of *Casearia*, but Reid (2004: 486) gives *Scyphia articulata* Goldfuss, 1826 as the type species of the genus. Goldfuss (1826: 9) described a sponge species as "*Scyphia articulata* nobis" and illustrated two specimens of this species on his pl. 3, fig. 8 (and maybe pl. 9, fig. 9) mentioning on page 10 the name " *Jsis reticulata* Schmidel" only. *Scyphia articulata* Goldfuss was attributed to *Caseispongia articulata* by Quenstedt (1878).

Occurrence and stratigraphic range of *Casearia articulata* (Schmidel). *Casearia articulata* seems to be an abundant sponge in Upper Jurassic limestones of southern Germany and has been described by several workers (see Müller 1974; Mehl 1992; Pisera 1997). Trammer (1989: 74) described a "very large-sized... plate- or barrel-like" fragment of the genus as *Casearia* sp. from the Upper Jurassic (Oxfordian) of Poland. The genus *Casearia* has been reported from the Middle Triassic of Germany by Freyberg (1928) and from the Upper Triassic (Carnian) of the Cassian Formation (Southern Alps) by Keupp et al. (1989) with question-mark. Rigby et al. (1998) described the species *C. articulata* from the Carnian of north-central Sichuan (China). The specimens, described as *C. articulata* by Senowbari-Daryan & Hamedani (1999) from the Norian-Rhaetian Nayband Formation of central Iran, were attributed to the new species *C. iranica* by Senowbari-Daryan & Amirhassankhani (2012).

Below all previous descriptions and illustrations of *Casearia articulata* and *Caseispongia articulata* are listed in synonymy, even though of some of them the internal construction, chambered or non-chambered, is not known:

1780 *Spongia articulata* Schmidel: 19, pl. 4-5.

1826-1833 *Scyphia articulata* nobis - Goldfuss: 3, fig. 8, pl. 9, fig. 9

1858 *Casearia articulata* - Quenstedt: 680-681, pl. 82, fig. 9.

1878 *Spongites articulatus* - Quenstedt: 106, 110, 114, pl. 120, figs 8-18, 20-24.

1878 *Caseispongia articulata* - Quenstedt: 106, 109-114, pl. 120, figs 11-19

1937 *Casearia articulata* Bourq sp. - Schrammen: pl. 14, fig. 5.

1910 *Casearia articulata* Bourquet sp. - Kolb: 187, pl. 12, figs 15-22, pl. 13, figs 1-6.

1974 *Casearia articulata* (Schmidel, 1780) - Müller: 3-10, figs 1-6, pl. 1-4. (cum syn.)

1992 *Casearia articulata* (Schmidel, 1780) - Mehl: 78, pl. 13, fig. 2. (cum syn., partim)

1992 *Casearia articulata* (Schmidel) - Keupp et al.: pl. 2, fig. 3.

1997 *Casearia articulata* (Schmidel, 1780) - Pisera: 55, pl. 11, fig. 3, p. 35, figs. 6-9.

? 1998 *Casearia articulata* (Schmidel, 1780) - Rigby, Wu & Fan: 134, pl. 5, fig. 5. (cum syn., partim)

non 1999 *Casearia articulata* (Schmidel, 1780) - Senowbari-Daryan & Hamedani: 94, pl. 7, figs 1-4. (see Senowbari-Daryan & Amirhassankhani 2012)

2004 *Casearia articulata* (Goldfuss) - Reid: 486, fig. 3a-b (re-illustration of Quenstedt's 1858 specimen).

Further species of *Casearia*: Jurassic: *Casearia depressa* Kolb, 1910, *Casearia eurygaster* Zittel, 1878; Triassic: *Casearia alpina* Senowbari-Daryan & Zankl, 2010, (*C. articulata* has been also described from Triassic by Rigby et al. 1998), *C. decursiva* (Wu, 1990), *C. delijanensis* Senowbari-Daryan & Amirhassankahni, 2012, *C. iranica* Senowbari-Daryan & Amirhassankahni, 2012, *C. kurtekia* (Boiko, 1990), *C. oblata* (Wu, 1990), C. *pamirica* (Boiko, 1990), and *C. vezvanensis* Senowbari-Daryan & Amirhassankhani, 2012.

C. depressa Kolb (1910) and *C. eurygaster* Zittel (1878) were synonymized with *Casearia articulata* by Mehl (1992) and by Rigby et al. (1998). Following the opinion of Pisera (1997) we do not accept the synonymy list of Mehl (1992). According to the description and illustration of a specimen by Kolb (1910: pl. 20, fig. 2) *C. depressa* surely cannot be synonymized with *C. articulata* as done by Mehl (1992). *C. depressa* is a cup- or bowl-shaped sponge with only some horizontally lines on one side. Most probably this sponge is wrongly attributed to the genus *Casearia*.

The "plate- or barrel-like" species of *Casearia*, reported by Trammer (1989) from the Oxfordian of Poland, clearly differs from other known species of the genus. The Triassic species *C. oblata* and *C. decursiva* were described originally by Wu (1990) and attributed to the genus *Monilispongia*. *Monilispongia* was synonymized with *Casearia* by Rigby et al. (1998).

Several specimens of externally annulated hexactinellid sponges have been collected from the Jurassic of Iran during several field campaigns. Morphologically they are almost identical, but differ completely in their internal construction and in the structure of their wall. Fig. 1 shows the wall structure of the morphologically similar genera, described as *Caseraria* Quenstedt and *Cypellia* Pomel in this paper. All specimens were cut longitudinally and studied either as polished slabs or as thin-sections.

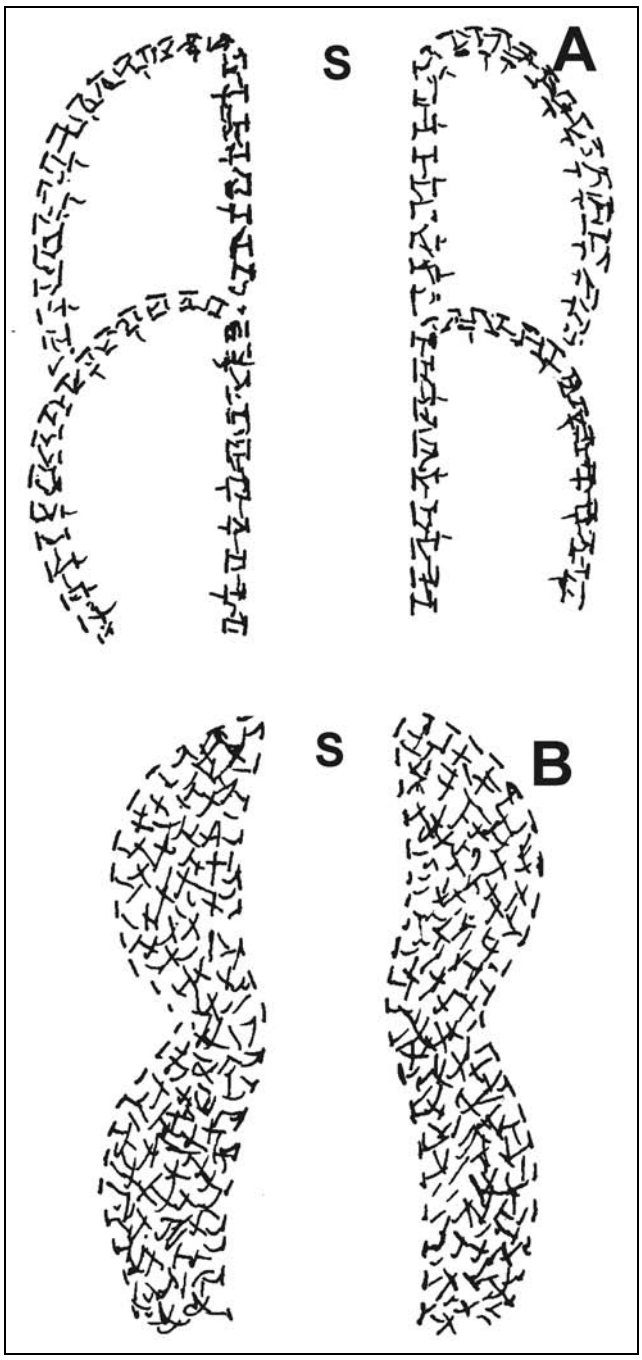

Fig. 1 - Wall structure of the chambered sponge *Casearia* (A) and of the non-chambered *Cypellia* (B). In both genera the walls are composed of hexactine spicules. S shows the spongocoel. Schematic, not to scale.

Casearia tabasensis n. sp.

Pl. 1, figs. a-e; Pl. 2, figs. e-h

Derivatio nominis: Named after the town Tabas in the vicinity of the type locality.

Holotype: Specimen BSPG 2012 I 78, illustrated on Pl. 1, figs. a-e.

Paratype: Specimen BSPG 2012 I 78 illustrated on Pl. 2, figs. e-h.

Locus typicus: North of Tabas, south of Kuh-e Bagh-e Vang.

Stratum typicum: Echellon Member, basal Kamar-e Mehdi Formation (Callovian).

Diagnosis: Small species of *Casearia* with ring-like chambers arranged around the axial spongocoel. Spongocoel of retrosiphonate type. Chamber walls thin and composed of two or several layers of hexactine lattice. Outer surface covered with lattice of hexactine spicules. Pores between hexactine lattice of the dermal layer circular, rarely irregularly polygonal.

Material: Two specimens (BSPG 2012 I 78-80).

Description. The holotype (Pl. 1, figs a-e) of this species of *Casearia* reaches a diameter of 10 mm at the base and 17 mm at its youngest part (Pl. 1, fig. a). Mor-

phologically, it is weakly annulated and composed of seven chambers which are oriented obliquely to the sponge axis. The youngest chamber is broken and incomplete. Chamber height varies between 6 and 7 mm. The sponge is clearly chambered with a thin exo-, inter-, and endowall (Pl. 1, figs. b, d-e). A retrosiphonate-type axial spongocoel (*sensu* Seilacher 1962) with a diameter of about 7 mm in the youngest part passes internally through the sponge. The outer surface of the sponge is covered with a hexactine lattice and pores. The interlattice pores are circular (rarely oval) having usually a diameter of 0.1 mm (range: 0.05-0.18 mm). Chamber interiors are usually without any hexactine spicules. In some chambers, however, rare spicules are embedded within the interior (Pl. 2, fig. e).

The paratype illustrated in Pl. 2, figs e-h is a weathered specimen and composed of eight internally well preserved chambers. It reaches a length of 43 mm with a diameter of 17 mm, corresponding to the diameter of the large chamber in the middle of the sponge. Height of the chambers varies between 4 and 6 mm. An axial spongocoel of retrosiphonate type of 6 mm in diameter passes internally through the whole sponge. Chamber walls are up to 1 mm thick and are composed of 2 to 3 hexactine layers. The spongocoel wall is composed of large hexactines forming quadrangle openings between them (Pl. 2, fig. h). Perforation of the outer surface is almost identical to the holotype (Pl. 2, fig. g).

Comparison. Morphologically and dimensionally *C. tabasensis* n. sp. is similar to the small specimens of the type species of the genus – *C. articulata* – but differs from it by the high chambers and specially by the perforation type of the outer dermal layer. The pores between the hexactine lattice in *C. articulata* are usually quadrangular, but circular to oval in *C. tabasensis*. Quadrangular pores of the dermal layer are completely absent in the new species. Also, the new species does not have the spine-like elements in the pores as does in *C. articulata.*

C. tabasensis clearly differs from the various Triassic species of the genus from Iran (Senowbari-Daryan & Amirhassankhani 2012). However, a comparative analysis of the various species of *Casearia* is clearly needed.

Family Cypelliidae Schrammen, 1937

Cypellia Pomel, 1872

Diagnosis: See Pomel (1872: 76) and Reid (2004: 550).

Type species: *Scyphia rugosa* Goldfuss, 1826.

Further species: *C. rugosa* var. *infundibuliformis* (Goldfuss, 1826), *C. annulata* n. sp., *C. irregularis* n. sp., and *C. cylindrica* n. sp.

Remarks. Externally annulated hexactine sponges are known as *Cypellia* Pomel (1872: 76). Pomel attributed both taxa of Goldfuss – *Scyphia rugosa* described by Goldfuss (1826: 9, pl. 3, fig. 6) and *Scyphia rugosa* var. *infundibuliformis* Goldfuss (1826: 87, pl. 32, fig. 2) – to this genus. Both taxa of Goldfuss are externally annulated, but the internal constructions are unknown. The systematic position of *Cypellia* – at least of *C. rugosa* var. *infundibuliformis* as silicospongea or calcispongea is doubtful, since Geinitz (1871: 20) found a calcareous fiber skeleton in this sponge. The following species, described as *Cypellia,* differ from the two taxa of Goldfuss by the perforation pattern of the outer dermal layer (see Goldfuss: pl. 3, fig. 6b).

Cypellia irregularis n. sp.

Pl. 3, figs d-g; Pl. 5, figs a, d, f-g

Derivatio nominis: Named after the irregular arrangement of ring-shaped or half-ring-shaped members.

Holotype: Specimen BSPG 2012 I 84 illustrated in Pl. 3, figs d-g and Pl. 5, figs a, d, f-g.

Locus typicus: Unknown.

Stratum typicum: Echellon Member, Kamar-e Mehdi Formation.

Diagnosis: Hexactine sponge composed of numerous ring-shaped, half-ring-shaped or wedge-shaped members. Internally non-chambered. A wide spongocoel passes internally through the whole sponge. Sponge wall is thick. Wall surrounding the spongecoel not straight. The thin outer dermal layer built by hexactines and intervening pores.

Material: One specimen only (BSPG 2012 I 84).

Description. *Morphology*: this species reaches a height of 56 mm and a diameter of 27 mm (at the youngest part) and is composed of nine ring-shaped, half-ring-shaped or small wedge-shaped members arranged irregularly one above the other around the axial spongocoel. The skeletal lattice of the outer surface is composed of a thin dermal layer build by hexactine spicules. The pores between the hexactine lattices of the dermal layer are circular to oval with a diameter of 0.12-0.20 mm (Pl. 5, figs d, f). Additionally, small pores of about 0.02 mm in diameter may occur between the large pores. The wall under the outer dermal layer is composed of a large hexactine lattice with irregularly pores (Pl. 5, fig. d).

Internal characteristics: this specimen is relatively well preserved exhibiting the internal construction of the sponge clearly. Each segment of the outside is recognisable internally by clusters of crowded hexactine spicules appearing as indistinct wall (Pl. 5, figs a, g). A spongocoel of 15 mm in diameter, measured in the youngest part of the sponge passes internally through the whole sponge. The sponge wall is about 6 mm thick. The inside of spongocoel is filled with fine-grained oolitic sediment.

Comparison. See after description of the next two species.

Cypellia cylindrica n. sp.

Pl. 3, figs. a-c; Pl. 5, figs. b-c, e

Derivatio nominis: Named after the cylindrical shape of the species.

Holotype: Specimen BSPG 2012 I 82-83 (Pl. 3, figs. a-c, Pl. 5, fig. b).

Paratype: Specimen BSPG 2012 I 86 (Pl. 5, figs. c, e).

Locus typicus: South of Kuh-e Bagh-e Vang.

Stratum typicum: Echellon Member, Kamar-e Mehdi Formation (Callovian).

Diagnosis: Well and deeply annulated cylindrical sponge with ring-shaped segments. Internally non-chambered. The thick sponge wall is composed of irregularly arranged hexactines. Inhalant or exhalant tubes may occur within the wall. Sponge surface covered with finely perforated and thin dermal layer. Spongocoel wide.

Material: Two specimens (BSPG 2012 I 82-83, I 86).

Description. *Morphology*: morphologically, the holotype is deeply annulated with a dermal layer composed of a hexacine lattice. The specimen is cylindrical-conical in shape, reaching a length of 68 mm and a maximum diameter of 30 mm (at its upper part) and a minimum diameter of 22 mm (the oldest member). It is composed of six clearly annulated members (or segments), clearly visible on the outside (Pl. 3, fig. a). Height of individual members is almost invariably 12 mm, only the first member reaches a height of 8 mm. The dermal layer is pierced by quadrangular pores (rarely circular or rounded) of 0.1-0.16 mm in diameter (Pl. 3, fig. c). The pores are arranged in rows. From each wall of quadrangular pore a spine-like element, 0.01-0.02 long, extends into the pores. Such elements occur also for example in *Casearia articulata* and were illustrated by Müller (1974: pl. 1, fig. 1, pl. 2, fig. 2), and reconstructed by him in his fig. 4 and 6. Also Schrammen (1937: pl. 14, fig. 5) and Pisera (1997: pl. 35, fig. 7) illustrated the dermal lattice of *Casearia articulata* with such spines in the pores.

Internal features: the skeleton of this specimen is strongly recrystallized and the internal structure is not well recognizable (Pl. 3, fig. b). The internal structures observed in thin sections and in polished slabs do not support a chambered construction of the sponge. Only the bottom (3 mm thick) of the last segment (i.e., the roof of the one but last segment; thin-section shown in Pl. 3, fig. b) indicates a possible chambered construction of this specimen. The exowalls, however, are about 4 mm thick and are composed of a very thin outer dermal layer composed of a hexactine lattice and a thick wall inside the dermal layer. Such a wall structure supports the attribution of this sponge to the genus *Cypellia*. The inner dermal layer around the spongocoel is also very thin (Pl. 5, fig. b: small arrows). The wall between two dermal layers is composed of irregularly arranged hexactines with some inhalant and exhalant canals (Pl. 5, fig. b: large arrows).

The skeletal characteristics of the paratype (Pl. 5, figs c, e) correspond to that of the holotype.

Comparison. See after description of the next species.

Cypellia tabulata n. sp.

Pl. 4, figs. a-d

Derivatio nominis: Named after the tabulae-like, irregularly arranged skeletal elements within the spongocoel.

Holotype: Specimen BSPG 2012 I 85+I 85/S illustrated in Pl. 4, figs a-d. (The original specimen was dissected to produce a thin-section. The remaining material consists of two pieces).

Locus typicus: North of Tabas, south of Kuh-e Bagh-e Vang.

Stratum typicum: Echellon Member, Kamar-e-Mehdi Formation (Callovian).

Diagnosis: Externally deep annulated and internally non-chambered hexactinellid sponge. Outer dermal layer thin and composed of a hexactine lattice similar or almost identical to representatives of the genus *Casearia*. The thick sponge wall is composed of hexactines. Inhalant and exhalant canals occur within the wall. Wide spongocoel passes internally through the sponge. Cross elements occur within the spongocoel. Without internal dermal layer around the spongocoel.

Material. One specimen (BSPG 2012 I 85+I 85/S).

Description. This species is externally deeply annulated. The height of annulations with about 11 mm is relatively constant. The holotype is a fragment reaching a diameter of 35 mm and is composed of at least four annulations, where by the annulation at one end is shorter (Pl. 4, fig. b: bottom). From the holotype a thin-section was made (Pl. 4, fig. a), which shows internally the non-segmented construction of the sponge. The sponge wall is about 6 mm thick and a wide spongocoel of about 22 mm in diameter passes internally through the whole sponge. The sponge surface is covered by a thin dermal layer of hexactine lattice. The pores between the hexactines of the dermal layer are circular to oval with a diameter of 0.10-018 mm, similar to the preceding species. The wall underneath the dermal layer is composed of large spicules, not properly identifiable in shape. Locally, branched inhalant and exhalant canals pierce the sponge wall (Pl. 4, figs c-d). Two oblique partitions are developed within the spongocoel (Pl. 4, fig. a). These partitions do not connect to the annulated points and do not reflect the outer annulations. Therefore they do not correspond to interwalls (wall between two chambers) in chambered sponges. Apparently these partitions stabilized the skeleton of the sponge, but they cannot be defined as chamber roofs of thalamid sponges. An internal dermal layer around the spongocoel is completely lacking.

Comparison. *Cypellia tabulata* n. sp. differs from *Cypellia irregularis* n. sp. by regularly annulation of the sponge. In addition, the wall structure of both species is completely different (compare Pl. 4, figs c-d and Pl. 5, fig. g). *C. cylindrica* differs from *C. irregularis*

also by the wall structure. *C. tabulata* differs from *C. cylindrica* by the skeletal partitions within the spongocoel and by the lack of an internal dermal layer in the former. The perforation pattern of the outer dermal layer of all three species is similar or almost identical.

Conclusions

Middle to Upper Jurassic rocks of the Shotori Mountains, east-central Iran, locally contain abundant sponges, most of them as isolated specimens. The majority of the collected sponges are non-chambered calcisponges with some representatives of chaetetids. Some calcispongid taxa have been described by Senowbari-Daryan et al. (2011a, b). Calcispongid or demospongid chambered sponges could not be found in several Jurassic exposed localities. Some annulated hexactinellids of internally chambered and non-chambered sponges occur rarely in Middle-Upper Jurassic carbonates and marls near the base of an incipient carbonate platform – shelf lagoon system and at the base of overlying basinal deposits which received material from neighbouring shallow-water carbonate platforms (Wilmsen et al. 2011). They are described as *Casearia* (internally chambered) and *Cypellia* (internally non-chambered) in this paper.

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PLATE 1

Figs. a-e - *Casearia tabasensis* n. sp. Holotype BSPG 2012 I 78. a) The view of the outer surface shows the weak annulation corresponding to the internal chambers. The specimen was cut in longitudinal direction and is illustrated as polished slab in Fig. b. b) The polished slab of the longitudinal section shows the axial spongocoel and the individual ring-shaped chambers (see also Figs. d and e). The chamber walls are extremely thin, appearing as thin lines. c) The top of holotype shows the spongocoel and the raised, white appearing outer dermal layer and inner dermal layer around the spongocoel. d) Magnification of Fig. b (bottom of the sponge) showing a large opening in the roof of the first chamber. e) Magnification from the middle part of Fig. b showing the chambers and the thin exo-, inter-, and endowalls around the chambers. Within the upper right chamber some dark appearing spicules are embedded which are interpreted as broken off parts of exo- or endowalls.

Fig. f - *Casearia articulata* (Quenstedt). Specimen Qu.120/18 of Quenstedt (1878) from the collection of Tübingen University and described as *Caseispongia articulata* by him. The internal bottom of the specimen illustrated in Pl. 2, Fig. a shows two chambers with extremely thin exo-, inter-, and endowalls similar to Fig. e. Black arrows indicate the thin endowalls, white arrows the interwalls of the chambers. The endowalls on the left side show some zigzag-like arrangement, which are interpreted as a diagenetic feature.

Scale = 5 mm.

PLATE 2

Figs. a-d - *Casearia articulata* (Schmidel). a) Side view of specimen "Qu.120/18" of Quenstedt (1878: pl. 120, fig. 18) deposited in the collections of Tübingen University and described as *Caseispongia articulata* by him. The sponge is composed of four ring-shaped chambers with thin exo-, inter-, and endowalls. For a longitudinal section of two chambers showing the internal chambered construction see Pl. 1, fig. f. b) Top of the specimen illustrated in Fig. a. c) Quenstedt's (1878: pl. 120, fig. 13) specimen of *Casearia articulata* (= *Caseispongia articulata* Quenstedt, 1878). The annulated sponge is composed of six members. The internal construction of the specimen is unknown, but the character of outer dermal layer is identical with that of *Casearia articulata* (Schmidel). d) *Caseispongia articulata* of Quenstedt (1878: pl. 120, fig. 17) [= *Casearia articulata* (Schmidel)]. The specimen has been re-illustrated by Reid (2004: fig. 335/5a).

Figs. e-h - *Casearia tabasensi* n. sp., paratype BSPG I 79-80. e) Longitudinal section composed of at least eight ring-shaped chambers, similar to the hypercalcified sponge *Amblysiphonella*. Chamber walls are thin and composed of a hexactine lattice. Thin-section photograph. f) Side-view of the outer surface showing that the outer annulation of the sponge corresponds to the internal chambers. g) Magnification of the lowermost chamber showing the outer surface with small and circular pores between the hexactine lattice. Top towards the right. h) Magnification of Fig. e (rectangle) showing the hexactine lattice of the spongocoel wall.

Scale in a-f = 10 mm, in g-h = 4 mm.

PLATE 3

Figs. a-c - *Cypellia cylindrica* n. sp., holotype BSPG 2012 I 82-83. a) View of the outer annulation. For the fine perforation of the outer dermal layer see Fig. c. b) Longitudinal section showing internal recrystallization. For the thick chamber walls see Pl. 5, Fig. b. c) Magnification of Fig. a showing the perforation pattern of the outer dermal layer. The pores between the hexactine lattic are quadrangular and arranged in rows.

Figs. d-g - *Cypellia irregularis* n. sp., holotype BSPG 2012 82-83. d) View of the outer surface showing irregularly arranged segments. For the non-chambered internal structure see Pl. 5, Figs. a, e) Side view. The white arrow indicates the area magnified in Pl. 5, Fig. d. f) Top view. g) Magnification of Fig. e showing colonisation by another sponge.

Scale = 10 mm, except for c = 0.5 mm.

PLATE 4

Figs. a-d - *Cypellia tabulata* n. sp., holotype BSPG 2012 I 85,+85/S. a) Longitudinal section showing the lack of internal segmentation of the sponge. The two oblique skeletal elements are oriented between two annulations and do not correspond to the outer annulations. The sponge wall is thick and pierced by inhalant and exhalant canals. Because of re-crystallization the type of hexactine needles is not recognizable. b) External view showing the deep annulation of the sponge. c) Magnification of the quadrangle 2 in Fig. a showing the sponge wall and one oblique element and the exhalant canals in details. d) Magnification of the quadrangle 1 in Fig. a showing the wall of an annulation with inhalant and exhalant canals.

Figs. e-f - *Casearia articulata* (Schmidel). e) Magnification of Fig. f showing the perforation of the outer dermal layer. The pores between the hexactine lattices are arranged in rows. f) Magnification of two annulations of the specimen illustrated in Pl. 4, Fig. b.

Scale in a-b, f = 10 mm, c-d = 5 mm, e = 1 mm.

PLATE 5

Figs. a, d, f-g - *Cypellia irregularis* n. sp. Holotype BSPG 2012 I 84. a) Polished longitudinal section showing the internal non-chambered construction. The vaulted structure of the sponge wall is produced by the arrangement of hexactine spicules in rows (for magnification of the area marked with the white rectangle see Fig. g). d) Magnification of the outer dermal layer covering the thick wall with a hexactine lattice (for magnification see Fig. f). f) Magnification of Fig. d showing the outer dermal layer and the pores between the hexactine lattice. The pores are small and circular. g) Magnification of white rectangle in Fig. A showing the thick wall of the sponge. The annulations of the outer surface are continued as hexactine spicules arranged in vaulted rows.

Figs. b-c, e - *Cypellia cylindrica* n. sp. Paratype BSPG 2012 I 86. b) Polished slab through two annulations showing the thick sponge wall and the inner dermal layers around the spongocoel appearing as thin lines (small arrows). Large arrows indicate the inhalant or exhalant canals within the sponge wall. Sponge axis is towards the right. c) Outer surface of a weathered and broken specimen with three segments. For internal structure see Fig. e. e) Polished longitudinal section showing the thick sponge wall. Arrows indicate the dermal layer appearing as dark line around the spongocoel.

Scale in a, c and e = 10 mm, b, d, g = 5 mm, f = 2 mm.

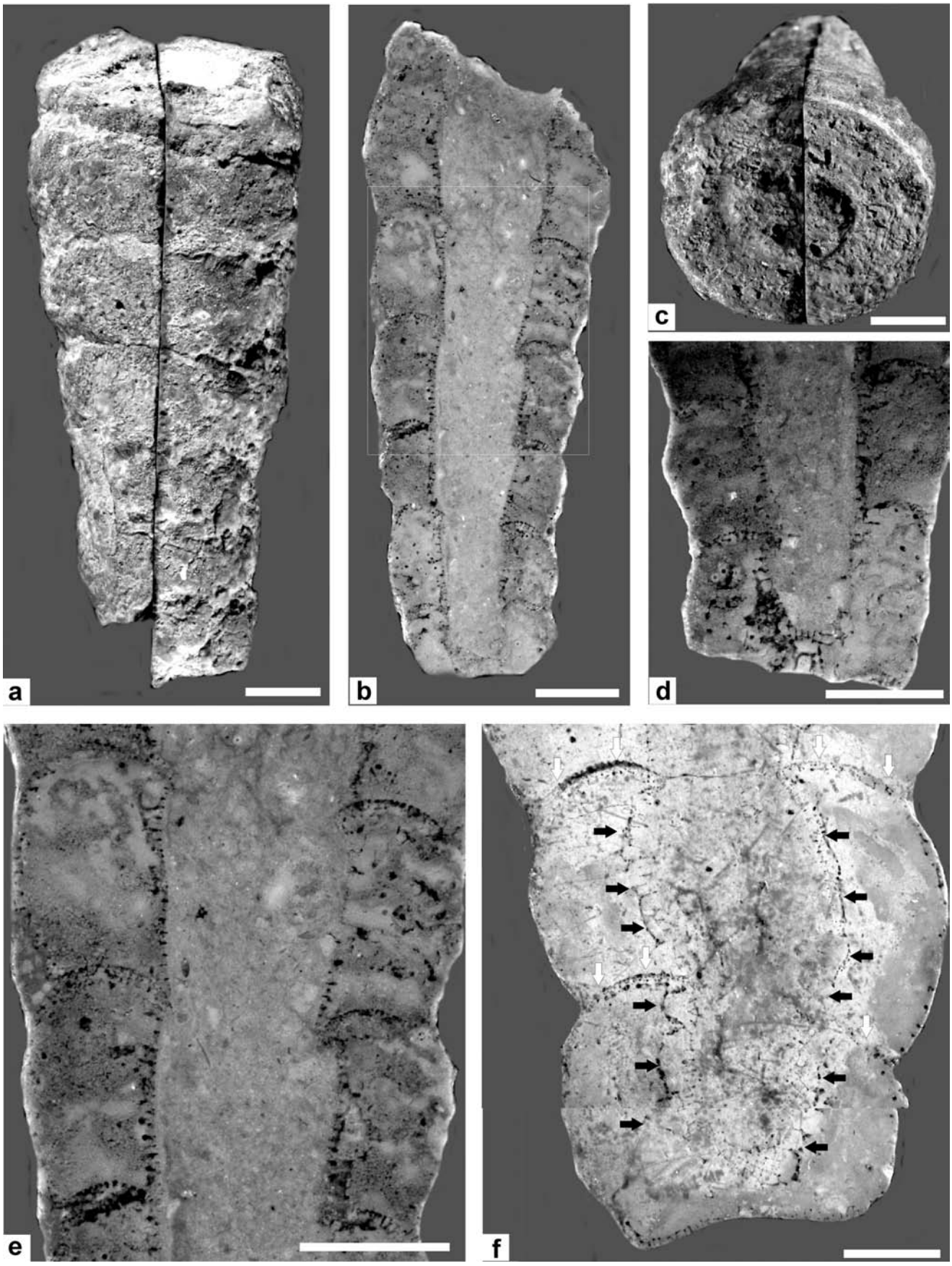
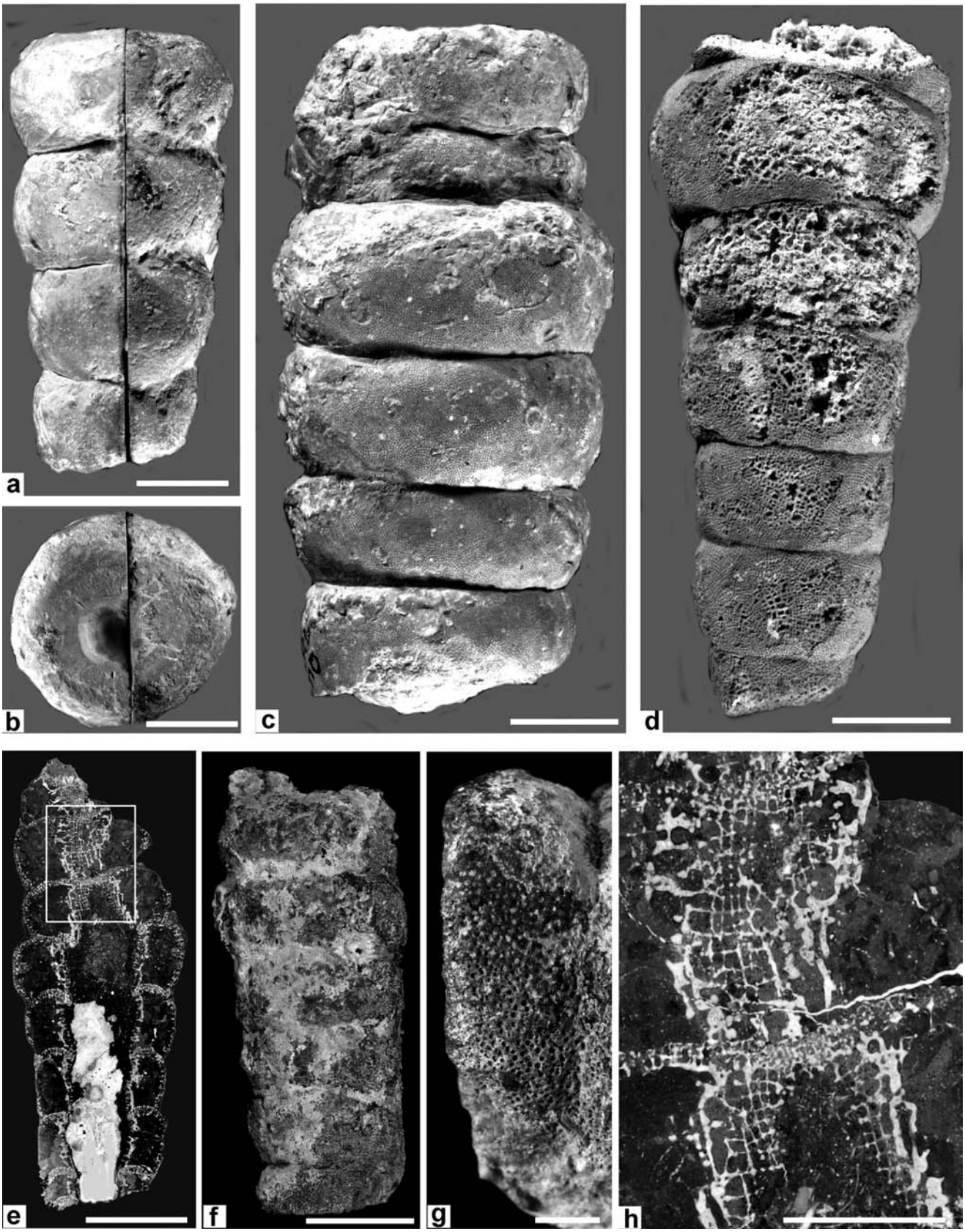


PLATE 1



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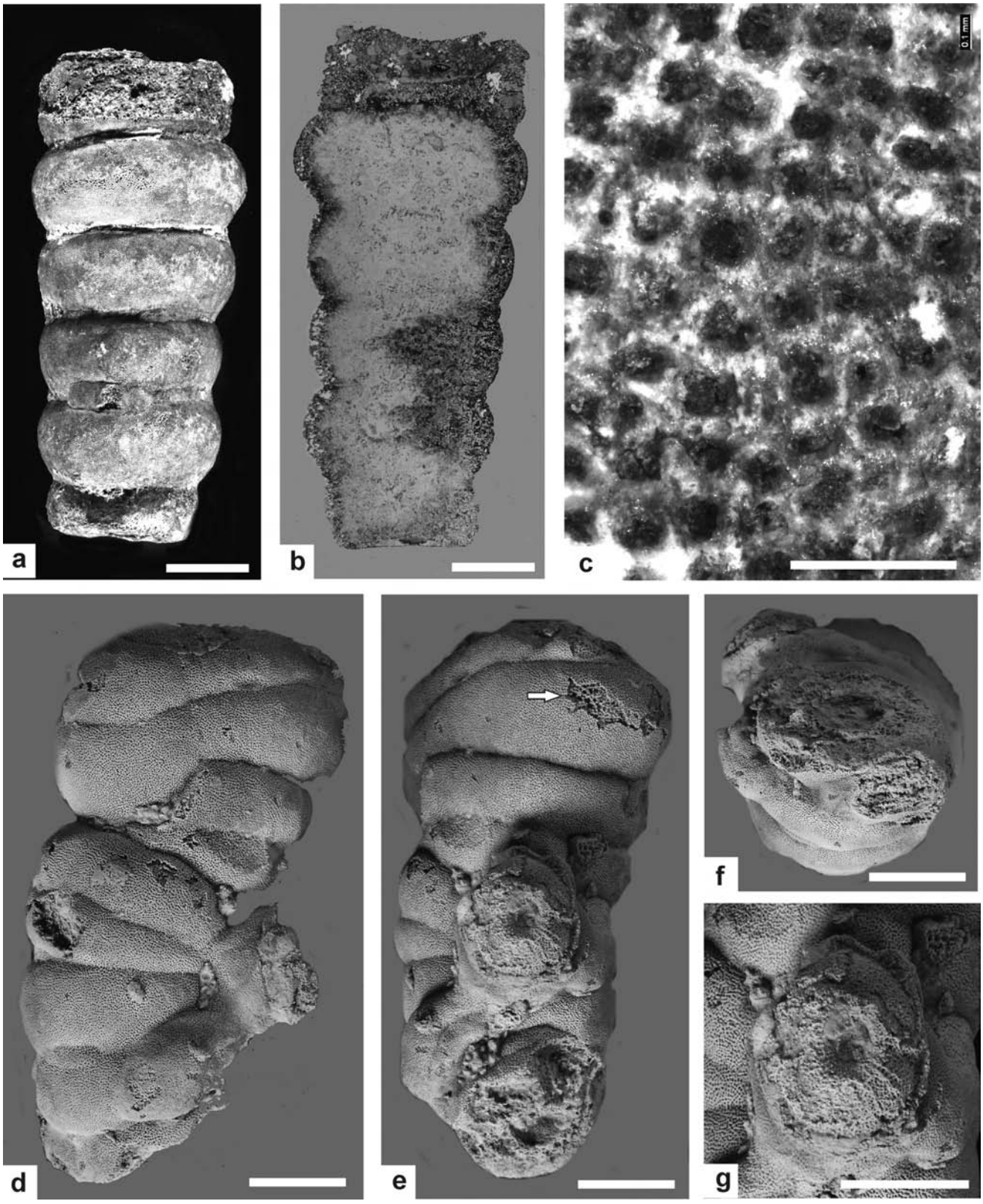

PLATE 3

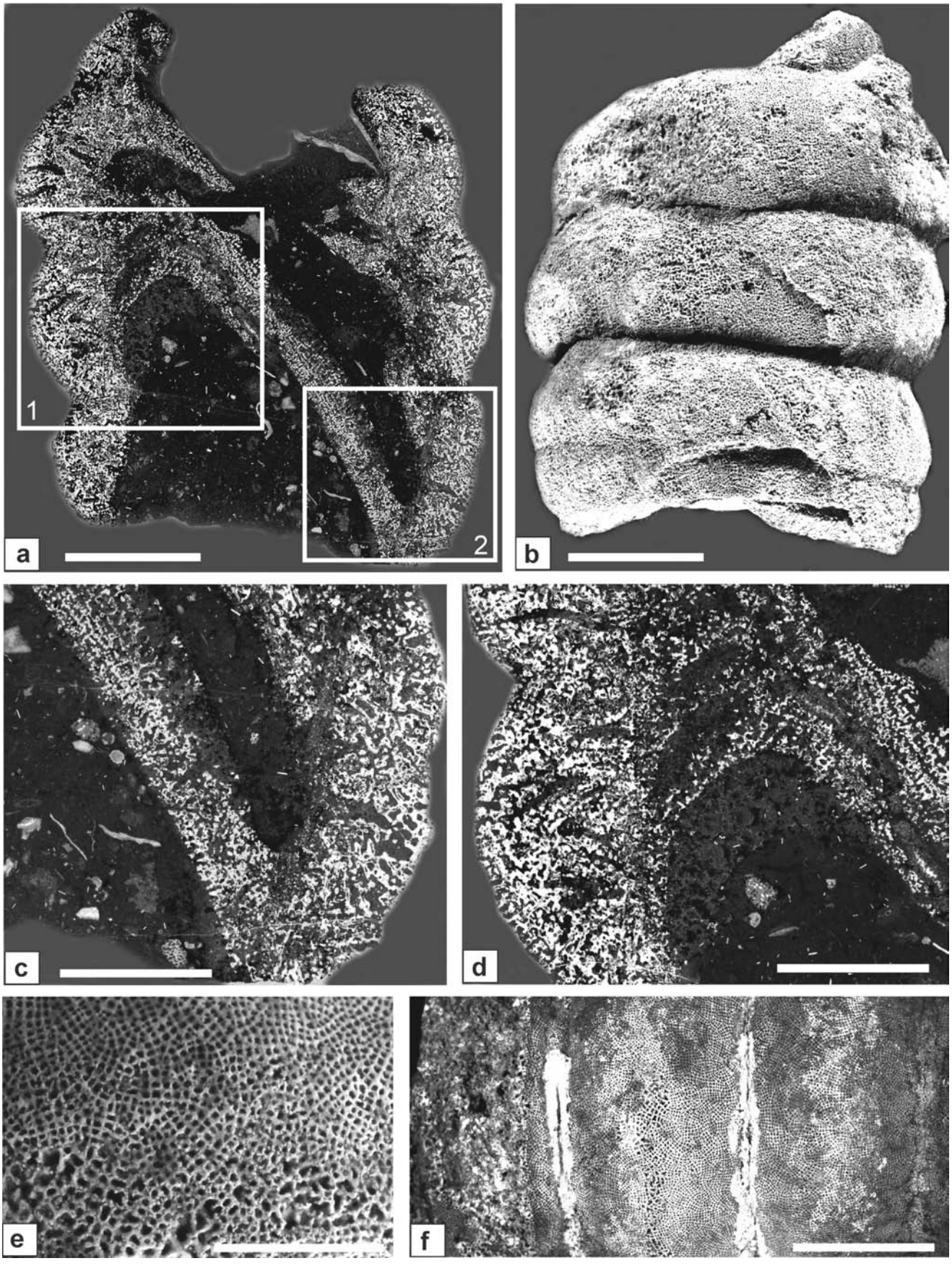

PLATE 4

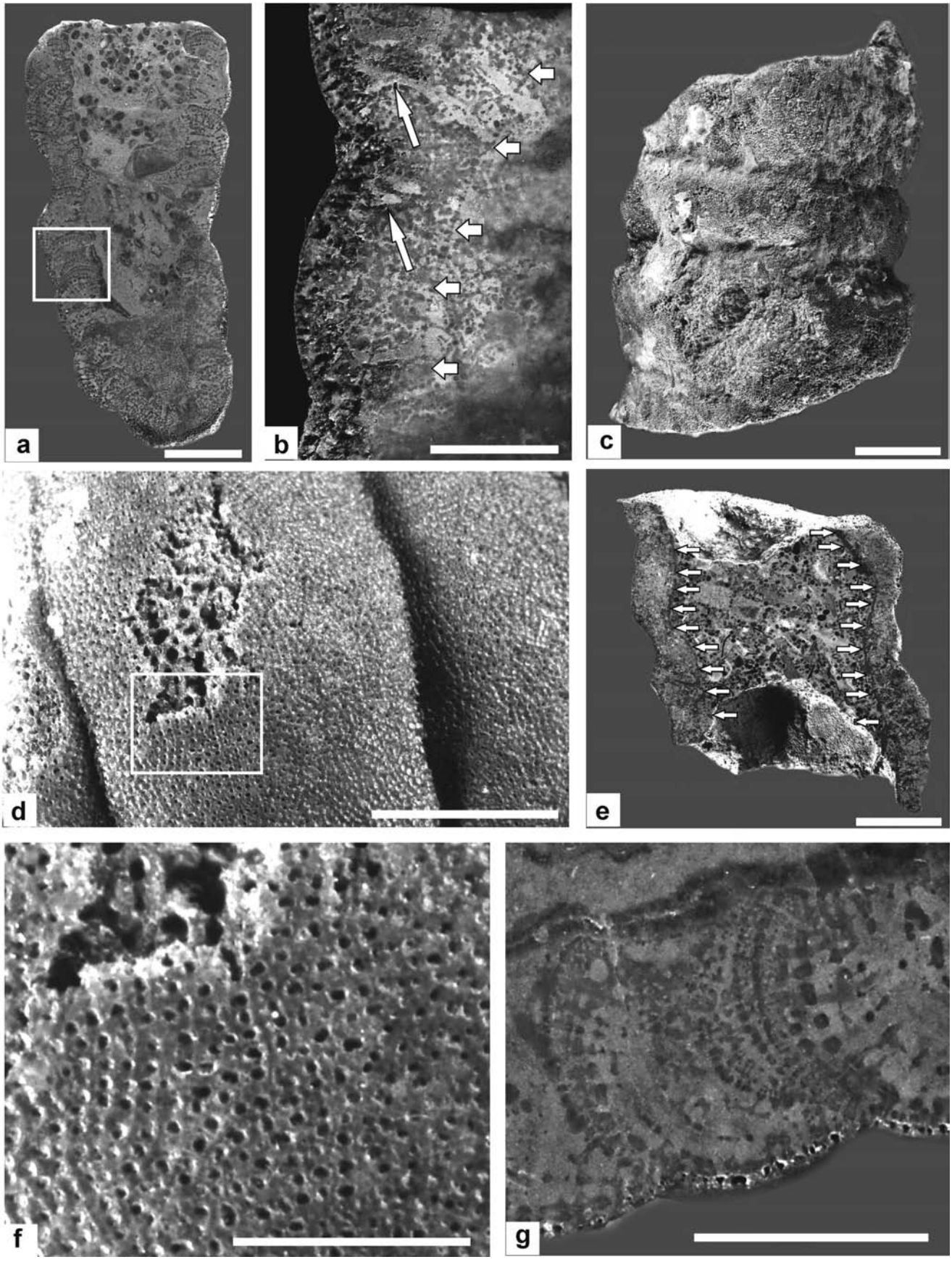

PLATE 5

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