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Tabulate corals from the Devonian Fukuji Formation, Hida Gaien belt, central Japan — Part 1 —

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Abstract

The Fukuji area, in the Hida Gaien belt (HGB), is one of the most significant areas for Paleozoic stratigraphy in Japan. The Devonian Fukuji Formation of this area yield abundant, well-preserved coral fossils, however, the biostratigraphy and paleobiogeographical significance of this fauna still remain unclear and precise details of the Devonian situation of the HGB have yet to be revealed. In order to understand the Paleozoic history and geological framework of the HGB better, the stratigraphy and faunal assemblages of this formation have been reexamined.

Limestone and muddy limestone samples amounting to some 420 kg from seven horizons (Locs. 1 to 7) along the Ichinotani Valley, Fukuji area, Gifu Prefecture, central Japan have been studied here. The tabulate coral fauna from the Loc. 1 (N36˚13.17' E137˚31.37') comprises the following 17 species: *Favosites goldfussi, F. flexuosus, F.* sp. A, *Squameopora hidensis, S. zhanwaensis fukujiensis* subsp. nov., *S.* cf. *zhanwaensis, Sapporipora kamitakaraensis* sp. nov., *Sa. karatanioum* sp. nov., *Heliolites wenxianicus, H.* cf. *gemina, H. ichinotaniensis* sp. nov., *H.* ? sp., *Helioplasma takayamaensis* sp. nov., *Pseudoplasmopora okuhidaensis* sp. nov., *P.* cf. *arguta, Striatopora* sp., *Gertholites* ? sp.
This paper describes these tabulate corals from the Loc. 1.

Introduction

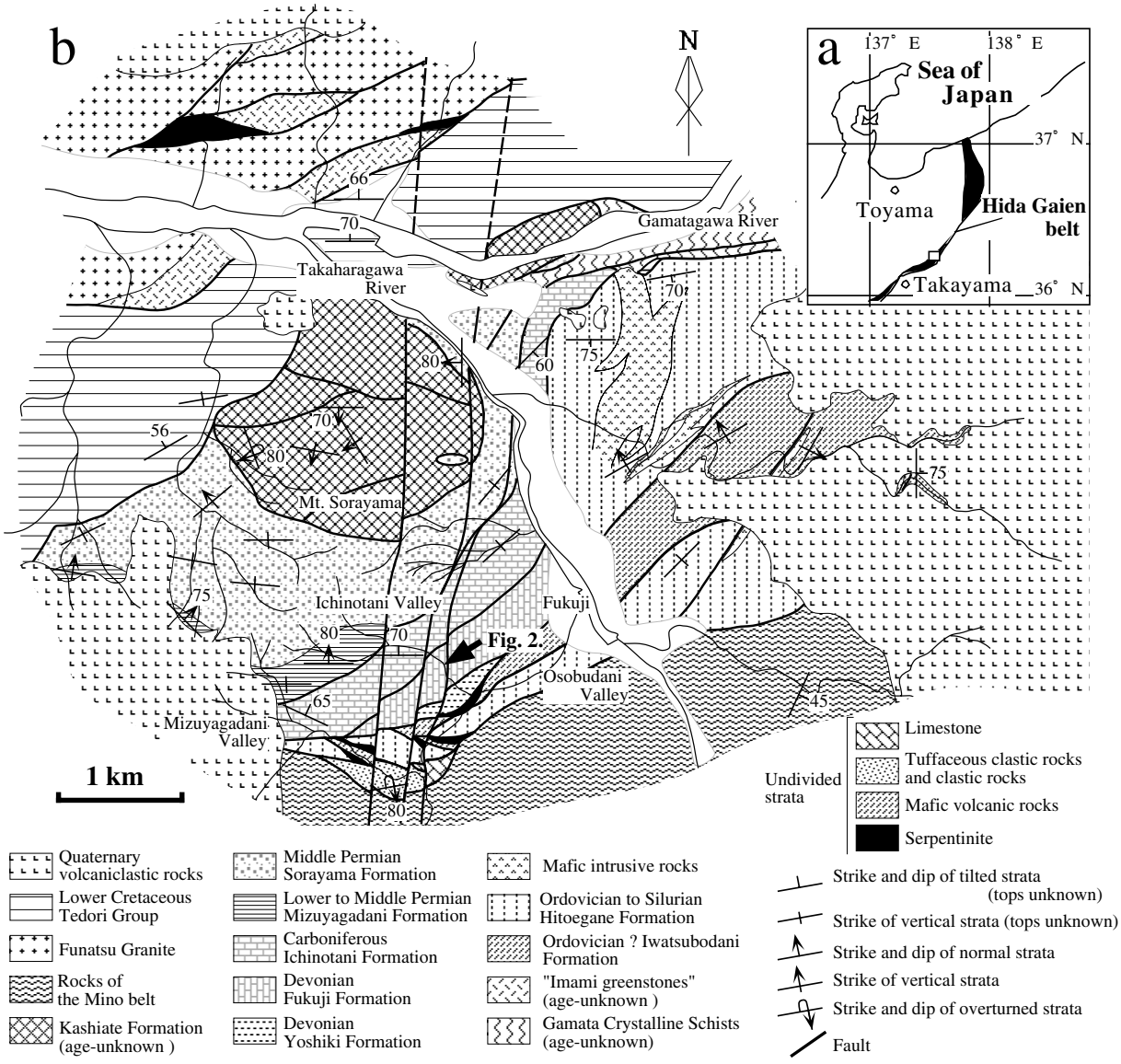
The Fukuji area, in the Hida Gaien belt (HGB), is one of the most significant areas for Paleozoic stratigraphy in Japan. It was first defined as a complex zone between the Hida and the Mino belts by Kamei (1955a) and was redefined as a belt composed of fault-bound blocks of Paleozoic-Mesozoic shelf facies rocks (Tsukada *et al*., 2004). In recent work, the Paleozoic shelf facies rocks of the HGB have been divided into the "Fukuji type" and the "Moribu type" based on their lithostratigraphy (Tsukada, 1999; Tsukada, 2003; Tsukada *et al*., 2004).

Devonian strata of the "Fukuji type" yield abundant, well-preserved fossils which have been studied by many geologists and paleontologists (e.g. Fujimoto *et al*., 1962; Hamada, 1959a, b; Kamei, 1952, 1955b; Kamei and Igo, 1955; Kobayashi and Igo, 1956; Koizumi and Kakegawa, 1970; Kozu, 1911; Kuwano, 1986, 1987; Niikawa, 1980; Niko, 2001; Ohno, 1977; Okazaki, 1974; Research Group for the Paleozoic of Fukuji, 1973). Nevertheless, the paleobiogeographical significance of this fauna still remains unclear and precise details of the Paleozoic tectonic history of the HGB have yet to be revealed.

In order to understand the Paleozoic history and geological framework of East Asia better, the stratigraphy and faunal assemblages of the Devonian Fukuji Formation have been reexamined in the Fukuji area of Gifu Prefecture, central Japan. This paper describes the tabulate corals from the Upper Member of that formation.

Geological framework

Paleozoic rocks in the Fukuji area are divided into the following five formations (Text-Fig. 1.): (1) Lower to Middle (?) Devonian Yoshiki Formation, (2) Lower to Middle (?) Devonian Fukuji Formation,



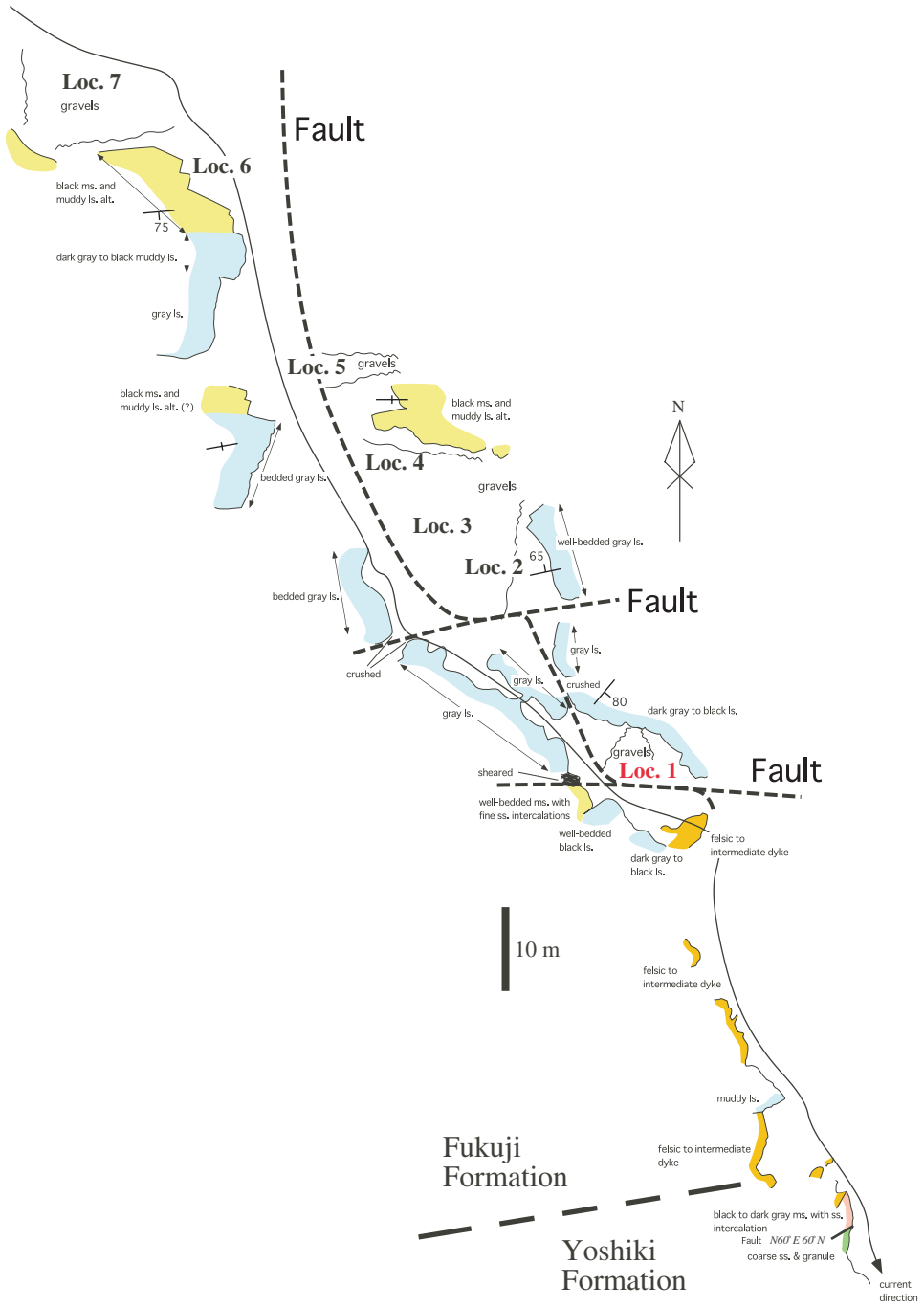
Text-Fig. 1. Index (a) and geological (b) maps of the Fukuji area (after Tsukada and Takahashi, 2000).

(3) upper Lower to Upper Carboniferous Ichinotani Formation, (4) Lower Permian Mizuyagadani Formation, and (5) Lower Permian Sorayama Formation. The Yoshiki Formation is overlain by the Fukuji Formation (Igo, 1990). Although the Fukuji, Ichinotani and Mizuyagadani Formations are in fault contact with each other, they are likely to form a conformable or unconformable succession primarily because the Mizuyagadani and Sorayama Formations include many limestone clasts that might be derived from the Fukuji and Ichinotani Formations. The Sorayama Formation conformably overlies the Mizuyagadani Formation (Tsukada *et al*., 1999; Tsukada and Takahashi, 2000).

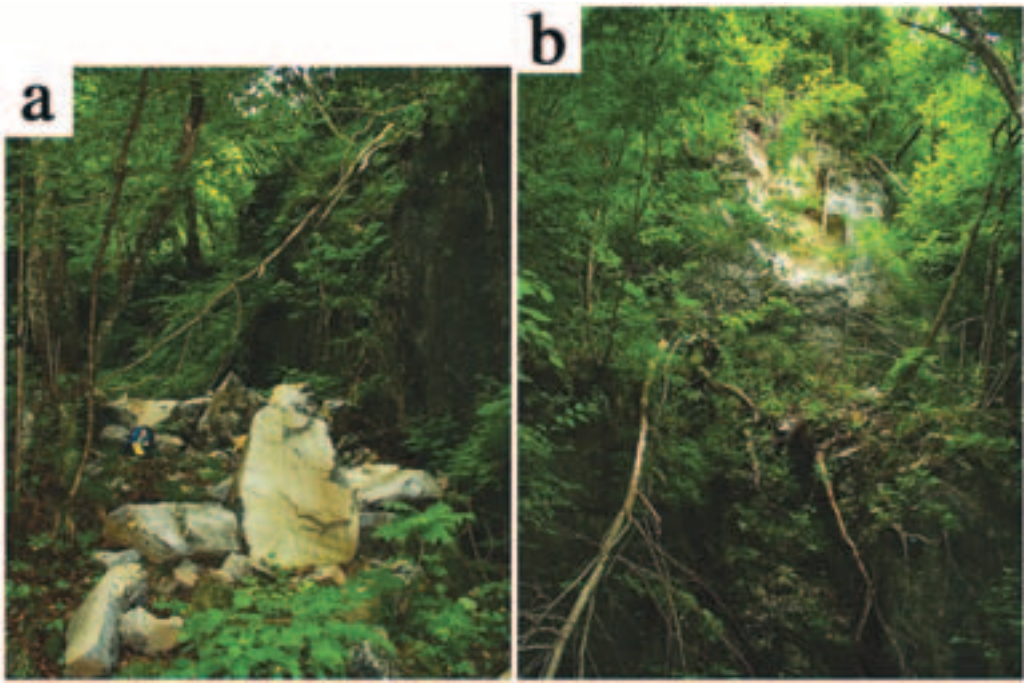
The Fukuji Formation, which consists largely of massive limestone with felsic tuff intercalations in its middle horizon, is well exposed along the Ichinotani Valley in the Fukuji area (Text-Fig. 1). This formation is divided into the Lower, Middle and Upper Members in ascending order (Kamei, 1952; 1955b). The Lower and Upper Members, composed mostly of white, black and light to dark grey limestone, is particularly rich in well-preserved fossils such as corals, stromatoporids, brachiopods, trilobites, bivalves, ostracods, conodonts and others (e.g. Hamada, 1959a, b; Kamei, 1952, 1955b; Kamei and Igo, 1955; Kobayashi and Igo, 1956; Koizumi and Kakegawa, 1970; Kuwano, 1986, 1987; Niikawa, 1980; Ohno, 1977; Okazaki, 1974; Research Group for the Paleozoic of Fukuji, 1973). The limestone is

partly well-bedded with muddy limestone or mudstone. Much of the grey limestone is Folk's (1959) micrite and biomicrite. This grey limestone is rich in corals and stromatoporids which form the main allochemical constituent. The Middle member is composed of alternating beds of black mudstone, dark grey muddy limestone and pale green felsic tuff.

Five coral zones are proposed within this formation on the basis of the biostratigraphy of the genus *Favosites* (Kamei, 1955b). The formation trends east and dips steeply north along the Ichinotani Valley. Limestone and muddy limestone samples amounting to some 420 kg from seven horizons (Locs. 1 to 7) along the Ichinotani Valley have been studied here (Text-Fig. 2). This paper describes the tabulate corals from Loc. 1 (N36°13.17′ E137°31.37′, Text-Figs. 2 and 3).



Text-Fig. 2. Route map along the Ichinotani Valley. See Text-Fig. 1 for the locality. ss: sandstone, ms: mudstone, ls: limestone, alt: alternation.



Text-Fig. 3. Photographs showing the field occurrence of Loc. 1. Most samples at this locality were from float stones derived from the immediately neighbouring cliff. (a) Float stones at Loc. 1. (b) The cliff beside Loc. 1. The upper part of the cliff had collapsed to provide the source of the float stones.

The tabulate coral fauna from the Loc. 1, which can be assigned to upper part of the bed 9 (F2b subzone) of Kamei (1955b), comprises the following 17 species:

Favositidae:

Favosites goldfussi d'Orbigny 1850
Favosites flexuosus Kamei, 1955b
Favosites sp. A
Squameopora hidensis (Kamei, 1955b)
Squameopora zhanwaensis fukujiensis subsp. nov.
Squameopora cf. *zhanwaensis* Lin and Huang, 1987
Sapporipora kamitakaraensis sp. nov.
Sapporipora karatanioum sp. nov.

Heliolitidae:

Heliolites wenxianicus Zhang, 1981
Heliolites cf. *gemina* (Tchi, 1976)
Heliolites ichinotaniensis sp. nov.
Heliolites ? sp.
Helioplasma takayamaensis sp. nov.
Pseudoplasmopora okuhidaensis sp. nov.
Pseudoplasmopora cf. *arguta* Bondarenko, 1963

Pachyporidae:

Striatopora sp.
Gertholites ? sp.

SYSTEMATIC DESCRIPTION

Order FAVOSITIDA Wedekind, 1937

Suborder FAVOSITINA Wedekind, 1937

Superfamily FAVOSITOIDE Dana, 1846

Family FAVOSITIDAE Dana, 1846

Definition. Corallum cerioid, hemispherical, nodular, rarely branching or tollinoid, with prismatic corallites; calices perpendicular to distal surface; walls thin, with pores arranged in regular longitudinal rows; septa short, equal, with spines in longitudinal rows or squamulae; tabulae usually complete, perpendicular to inner wall surface, rarely incomplete, concave or convex.

Remarks. This family comprises four subfamilies, Favositinae, Paleofavositinae, Pachyfavositinae and Emmonsinae (Hill, 1981). Young and Elias (1995, p. 77) considered the position and form of mural pores in the Favositidae to be very variable and therefore not a character to be used to distinguish Favositinae from Paleofavositinae.

Subfamily FAVOSITINAE Dana, 1846

Definition. Favositidae with septa represented by septal spines; longitudinally arranged rows of mural pores on wall face.

Genus FAVOSITES Lamarck, 1816

Type species. *Favosites gothlandicus* Milne-Edwards and Haime, 1850, p. 256.

Diagnosis (after Hill, 1981, p. F541). Corallum cerioid, tabular, massive; corallites prismatic, thin-walled; septa represented by longitudinal rows of spines or absent; tabulae complete, subhorizontal; mural pores on corallite faces, in one or several longitudinal rows.

Favosites goldfussi d'Orbigny, 1850 Plate 1, Figs. 1-6

v.1936 *Favosites goldfussi*; Jones, p. 19, Pl. 2, Figs 8-10.

Reg. No.

Samples: NUM-Fz-010811-21 and NUM-Fz-010811-34. Two samples.

Specimens: NUM-Fz-010811-21-1 and NUM-Fz-010811-34-9. Two specimens.

Thin sections: Seven (010811-21-1-1, 010811-21-1-2, 010811-21-1-3, 010811-21-1-4, 010811-21-1-5, 010811-21-1-6 and 010811-21-1-7) and one (010811-34-9-1) thin sections cut from NUM-Fz-010811-21-1 and NUM-Fz-010811-34-9 respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Description

Specimens mostly embedded in limestone matrix. Corallum cerioid, tabular, hemispherical, pyriform, ca. 22mm wide and 23-32mm high; corallites prismatic and polygonal (3- to 8-sided), fanning out from basal portion to lateral surface of corallum at obtuse angles and to top of corallum mostly at right angles. Calice deep, maximum depth 5.2mm. Corallites bimodal in size are randomly distributed in cross section. Immature (3- and 4-sided) width 0.5-1.24mm (0.785mm in average) and mature (5- to 8-sided) width 1.0-3.0mm (1.95mm in average). Walls straight, moderately thick (0.1-0.2mm). Each corallite in contact with thin (generally less than 0.02mm), distinct median suture. Several longitudinal rows of slender or thick septal spines up to 0.67mm long developed especially in the mud-filled part where tabulae distantly spaced. Spines horizontal, pointing upwards or downwards, 4-7 per 3mm. Squamulae absent. Mural pores circular or ellipsoidal, large (0.17-0.38mm in diameter) with very thin pore plate

(less than 0.01mm thick). Pores arranged longitudinally in 1-2 rows on the face, 0.62-1.6mm apart. Tabulae complete, generally planar, rarely concave or wavy, perpendicular to inner surface of corallite wall, thin (less than 0.02mm), 3-8 per 5mm.

Remarks

The specimens here, characterized by large corallites (1.0 to 3.0mm in diameter), distantly spaced, thin tabulae (3-8 per 5mm) and numerous thick or slender septal spines (4-6 per 3mm), are identical to *Favosites goldfussi* (including *F. eifelensis* Nicolson) from Auburg, Gerolstein, Eifel, Germany, British Museum (Natural History) collection Reg. Nos. R26565 and R26568, described by Jones (1936). *F. eifelensis* is considered to be a young form of *F. goldfussi* (Jones, 1936). *F. goldfussi* in the BM (NH) collection has large corallites (the average diameter of ten 5- to 8-sided corallites is 2.0mm), thin tabulae spaced at 6-7 per 5mm, and thick or slender septal spines spaced longitudinally at 4-7 per 3mm. In addition, other characters of these BM (NH) specimens such as moderately thick walls (0.08-0.17mm) with a thin distinct median suture, circular or ellipsoidal mural pores 0.17-0.26mm in diameter arranged in one or two rows on the face, 0.75-1.2mm apart longitudinally, are also identical to those of the present specimens.

Favosites flexuosus Kamei, 1955b Plate 2, Figs. 1-3

1934 *Favosites* cf. *gotlandicus* Lamarck; Ozaki in Shimizu *et al*., p. 69, Pl. XII, Figs. 1-6.

1955b *Favosites flexuosus* Kamei; Kamei, p. 47, Pl. III, Fig. 2.

Reg. No.

Samples: NUM-Fz-010809-c, NUM-Fz-010809-e and NUM-Fz-010811-15. Three samples.

Specimens: NUM-Fz-010809-c-1, NUM-Fz-010809-e-1 and NUM-Fz-010811-15-1. Three specimens.

Thin sections: Four (010809-c-1-1, 010809-c-1-2, 010809-c-1-3 and 010809-c-1-4), four (010809-e-1-1, 010809-e-1-2, 010809-e-1-3 and 010809-e-1-4), and two (010811-15-1-1 and 010811-15-1-2) thin sections cut from NUM-Fz-010809-c-1, NUM-Fz-010809-e-1 and NUM-Fz-010811-15-1, respectively.

Material, horizons and localities

NUM-Fz-010811-15 was from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1). Two specimens, NUM-Fz-010809-c and NUM-Fz-010809-e, were from sub-rounded pebbles at Loc. 1.

Diagnosis (after Kamei, 1955b)

Species of *Favosites* with large corallites, strongly wrinkled wall, distantly spaced thin tabulae, septal spine absent.

Description

Specimens mostly embedded in limestone matrix. Corallum cerioid; massive, hemispherical, more than 23mm wide and 55mm high; corallites prismatic and polygonal (3- to 8-sided), fanning out from basal portion to surface of corallum at obtuse or right angles. Calice shallow or deep (0.05-3.5mm in depth). Corallites bimodal in size are randomly distributed in cross section. Mature (5-8-sided) width generally 2.0-3.0mm (1.5mm in min., 3.5mm in max.) and immature (3- and 4-sided) width 0.5-1.2mm (0.7mm in average). Walls thin or moderately thick (0.06-0.1mm), strongly wrinkled. Each corallite in contact with thin (0.02-0.06mm) median suture. Septal spines generally absent or rarely a row of short spines (up to 0.14mm long). Mural pores large (0.2-0.32mm in diameter), circular with very thin pore plate (less than 0.02mm thick). Pores distantly arranged in one or two longitudinal rows. Tabulae complete, horizontal, mostly planar or slightly concave, very thin (less than 0.02mm), 5-10 per 5mm. Growth wrinkles on corallum surface.

Remarks

The specimens assigned here to *F. flexuosus* are characterized by large corallites, a strongly wrinkled wall, distantly spaced thin tabulae, and the absence of septal spines. The description above coincides completely with that given for *F. flexuosus* by Kamei (1955b). Kamei's description is of a specimen from a slightly higher horizon to the one studied in this paper.

***Favosites* sp. A** Plate 2, Figs. 4-5; Plate 3, Figs. 1-3

Reg. No.

Sample: NUM-Fz-010809-a. One sample.

Specimen: NUM-Fz-010809-a-1. One specimen.

Thin sections: 010809-a-1-1 and 010809-a-1-2.

Material, horizons and localities

This specimen was from a sub-rounded pebble at Loc. 1, the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan.

Description

Specimens embedded in limestone matrix. Corallum massive, cerioid, pyriform, 32mm wide and more than 37mm high. Corallites, prismatic, polygonal (4-, 5- or 6-sided), fanning out from basal portion to lateral surface of corallum at obtuse angle and to top of corallum mostly at right angles. Calice shallow, 0.9-1.5mm in depth. Corallites bimodal in size are randomly distributed in cross section. Immature (4-sided) width from 0.3 to 0.8mm, mature (5- or 6-sided) width 1.0-1.2 mm. Epitheca walls ca. 0.02mm, dark wall 0.03-0.1mm, straight and moderately thin (less than 0.3mm). Thin (less than 0.02mm) median suture present. Peripheral wall thickening absent. Several longitudinal rows of very short (less than 0.1mm) thick, blunt septal spines developed in peripheral part. Spines horizontal or pointing upwards, 6-7 per 3mm. Squamulae absent. Mural pores circular, 0.2-0.25mm in diameter, with very thin (less than 0.01mm) pore plate. Pores arranged longitudinally in 1-3 rows alternating at mid-faces or near edges of corallites, 0.4-0.9 mm apart. Tabulae, 6-10 per 5mm, thin (less than 0.02mm), complete, generally planar but rarely concave, perpendicular to inner surface of corallite wall.

Remarks

This specimen is characterized by 1-3 longitudinal rows of large mural pores, moderately thick walls with a distinct median suture, distantly spaced thin tabulae (6-10 per 5mm) and numerous thick, blunt septal spines.

White and Shengwu (2004, p. 45) summarize the problems in defining species of tabulate corals. Their simple structure and variable morphology has been pointed out by many authors (e. g. Scrutton, 1989, p. 40), and has led to a proliferation of synonymous taxa. Scrutton (1989) advocated that no new species should be described based on unsatisfactory materials. Although the specimen Reg. No. 010809-a-1 might well be a new species of the genus *Favosites*, an open nomenclature is used in this paper, following Scrutton's advice.

Genus SQUAMEOPORA Preobrazhenskiy, 1967

Type species. *Favosites hidensis* Kamei, 1955b

Other species. *S. hidensiformis* (Mironova, 1961); *S. sichanensis* Lin and Huang, 1987; *S. zhanwaensis* Lin and Huang, 1987; *S. ertangensis* Tchi and Wang, 1989.

Diagnosis (after Preobrazhenskiy, 1967, p. 4). Corallum cylindrical with narrow base; corallites prismatic and polygonal, radiating from central part and opening out at surface of corallum at right or acute angle. Walls moderately thick, peripheral wall-thickening present, surrounding visceral cavities of corallites. Mural pores circular, large, displaced towards costae, without pore ridge. Tabulae of conven-

tional type. Septa represented by squamulae or spines in the peripheral part.

Squameopora hidensis (Kamei, 1955b) Plate 3, Figs. 4-5; Plate 4, Figs. 1-5; Plate 5, Figs. 1-2

v.1955b *Favosites hidensis* Kamei; Kamei, p. 53, Pl. III, Figs. 4a-c; Pl. IV, Fig 7.

1959b *Favosites hidensis* Kamei; Hamada, p. 208, Pl. XVI, Figs. 1-12.

1967 *Squameopora hidensis* (Kamei); Preobrazhenskiy, p. 8.

1974 *Striatoporella hidensis* (Kamei); Mironova, p. 49.

1981 ?*Squameopora hidensis* (Kamei); Hill, p. F546, Figs. 359 1a, b.

1987 *Squameopora sichanensis* Lin and Huang; Lin and Huang, p. 212, Pl. 42, Fig. 2.

Reg. No.

Samples: NUM-Fz-010811-3, NUM-Fz-010811-18, NUM-Fz-010811-25 and NUM-Fz-010811-31. Four samples.

Specimens: NUM-Fz-010811-3-2b, NUM-Fz-010811-18-2, NUM-Fz-010811-25-1, NUM-Fz-010811-25-2, NUM-Fz-010811-25-4 and NUM-Fz-010811-31-1. Six specimens.

Thin sections: One (010811-3-2-1b), three (010811-18-2-1, 010811-18-2-2 and 010811-18-2-3), two (010811-25-1-1 and 010811-25-1-2), one (010811-25-2-1b), three (010811-25-4-1, 010811-25-4-2 and 010811-25-4-3), and four (010811-31-1-1, 010811-31-1-2, 010811-31-1-3 and 010811-31-1-4) cut from NUM-Fz-010811-3-2, NUM-Fz-010811-18-2, NUM-Fz-010811-25-1, NUM-Fz-010811-25-2, NUM-Fz-010811-25-4 and NUM-Fz-010811-31-1, respectively.

Material, horizons and localities

All six specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Diagnosis (based on Kamei, 1955b and Hamada, 1959b)

Small corallum, thin walled with peripheral wall thickening, closely spaced, thin tabulae, 1-2 longitudinal rows of mural pores on wall face. Kamei (1955b) reported that septal spines are absent in the type specimen, but Hamada (1959b) described longitudinal rows of septal spines at the calice.

Description

Specimens entirely embedded in limestone matrix. Corallum cerioid, small, 15-35mm wide, more than 10mm high, pyriform or conical, circular or ellipsoidal in cross-section. Corallites prismatic and polygonal (3- to 8-sided), rounded in the peripheral part, fanning out from central or basal portion to corallum surface at obtuse or right angles. Calice generally shallow, 0.5-1.6mm deep. Corallites bimodal in size are randomly distributed in cross section. Immature (3-4-sided) width ranges from 0.28 to 0.75mm (0.5mm in average), mature (5-8-sided) from 0.51 to 1.6mm (1.0mm in average). Walls moderately thick (ca. 0.1mm or more), straight. Peripheral wall thickened with fine fibrous sclerenchymal deposit of calcite (0.08-0.27mm thick) perpendicular to wall, clearly seen in cross section. Each corallite is in contact with thin (generally less than 0.02mm) median suture. Intracalicular offsets increasing peripherally. Several longitudinal rows of slender or thick septal spines (up to 0.4mm in length) developed at peripheral mud-filled part of corallites. Spines pointing upwards, downwards or wavy. Squamulae generally absent but squamula-like very thick wedge-shaped spines may be present. Mural pores circular, medium or large (0.08-0.22mm in diameter) with very thin pore plate (less than 0.02mm thick). Pores arranged in 1 or 2 longitudinal rows on face, ca. 0.35-0.77mm apart. Tabulae complete or rarely incomplete, perpendicular or oblique to inner surface of corallite wall, planar or concave, closely spaced, 8-18 per 5mm, thin or thick (0.04-0.22mm thick).

Remarks

This species is characterized by a small corallum, walls thickening towards the periphery, closely spaced tabulae and septal spines in the peripheral part. The specimens compare very well with *Sqameopora*

hidensis in wall structure and size of corallum. Hamada (1959b) pointed out the "peripheral wall-thickening" as an important character of this species. Although Kamei (1955b) mentioned that the corallum is small in this species (about 1cm in cross section and 3cm in longitudinal section) and generally clavate or pyriform in shape, the holotype (G.I.S.U.L 30119 in Shinshu University, Japan) is more than 7cm in cross section and globular in shape. The present specimens are similar to the paratype (G.I.S.U.L 30120 in Shinshu University, Japan) in corallum size and shape.

Squameopora zhanwaensis fukujiensis subsp. nov. Plate 5, Figs. 3-7

Name

Derived from the hamlet of Fukuji, Takayama City, central Japan.

Reg. No.

Samples: NUM-Fz-010811-1 and NUM-Fz-010811-4. Two samples.

Specimens:

Holotype. NUM-Fz-010811-4-1 (thin sections: 010811-4-1-1 and 010811-4-1-2).

Paratype. NUM-Fz-010811-1-1, NUM-Fz-010811-1-2 and NUM-Fz-010811-1-3.

Thin sections: Two (010811-1-1-1 and 010811-1-1-2), three (010811-1-2-1, 010811-1-2-2 and 010811-1-2-3) and three (010811-1-3-1, 010811-1-3-2 and 010811-1-3-3) thin sections cut from NUM-Fz-010811-1-1, NUM-Fz-010811-1-2 and NUM-Fz-010811-1-3 respectively.

Material, horizons and localities

All four specimens, NUM-Fz-010811-1-1, NUM-Fz-010811-1-2, NUM-Fz-010811-1-3 and NUM-Fz-010811-4-1 were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Diagnosis

Species of *Squameopora* with thin-walled corallites fanning out from basal portion, tabulae distantly spaced, septal spines in rows.

Description

Specimens entirely embedded in limestone matrix. Corallum cerioid, massive; more than 50 mm wide and 33mm high; corallites prismatic, polygonal (3- to 8-sided), fanning out from basal portion to surface of corallum at obtuse or right angles. Calice generally shallow, 0.1-1.3mm in depth. Corallites bimodal in size are randomly distributed in cross section. Immature (3- and 4-sided) width 0.4 to 1.1mm (0.67mm in average), mature (5- to 8-sided) width 0.8 to 2.0mm (1.41mm in average). Walls thin (less than 0.1mm), straight or rarely wrinkled in peripheral part. Each corallite in contact with thin (generally less than 0.02mm) median suture. Sclerenchymal fine fibrous calcite deposit perpendicular to wall is sometimes observed in cross section. Several longitudinal rows of slender or thick septal spines (up to 0.35mm long) pointing upwards are particularly developed in peripheral, mud-filled part of corallites. Wedge-shaped spines are occasionally seen in cross section. Mural pores circular, medium or large (0.1-0.26mm in diameter) with very thin pore plate (less than 0.02mm thick). Pores arranged in 1 or 2 longitudinal rows on face or rarely at wall junction, spaced ca. 0.4-1.25mm apart. Tabulae normally complete, planar and perpendicular to inner surface of corallite wall, rarely incomplete, concave and oblique at peripheral part, normally thin (less than 0.07mm), closely spaced (8-14 per 5mm).

Remarks

The specimens here are clearly different from *S. hidensis* (Kamei, 1955b; Hamada, 1959b), *S. hidensiformis* (Mironova, 1961), *S. sichuanensis* Lin and Huang, 1987 and *S. ertangensis* Tchi and Wang, 1989 in the size and shape of the corallum. In addition, the peripheral wall-thickening which Hamada (1959b) noted as an important character of *S. hidensis* is uncommon in these specimens. The present specimens compare very well with *S. zhanwaensis* described and figured by Lin and Huang

(1987) from the Lower Member of the Yanglugou Formation, Yanglugou, west Qinling Mountains, China, in having a large corallum and corallites which fan out from the basal portion. They are, however, distinguished from that species in having more distantly spaced tabulae. Lin and Huang (1987) described that *S. zhanwaensis* has tabulae of 14-16 in 5mm or sometimes 24-26 in. 5mm.

Squameopora cf. ***zhanwaensis*** Lin and Huang, 1987

Plate 6, Figs. 1-5; Plate 7, Figs. 1-7; Plate 8, Figs. 1-2

cf.1987 *Squameopora zhanwaensis* Lin and Huang; Lin and Huang, p. 212, Pl. 43, Figs. 2-4.

Reg. No.

Samples: NUM-Fz-010811-10, NUM-Fz-010811-15, NUM-Fz-010811-16, NUM-Fz-010811-17, NUM-Fz-010811-24, NUM-Fz-010811-26, NUM-Fz-010811-27, NUM-Fz-010811-33 and NUM-Fz-010811-34. Nine samples.

Specimens: NUM-Fz-010811-10-1, NUM-Fz-010811-15-2, NUM-Fz-010811-16-1, NUM-Fz-010811-17-1, NUM-Fz-010811-17-2, NUM-Fz-010811-17-3, NUM-Fz-010811-17-4, NUM-Fz-010811-24-4, NUM-Fz-010811-26-2, NUM-Fz-010811-27-2, NUM-Fz-010811-33-1, NUM-Fz-010811-34-8 and NUM-Fz-010811-34-13. Thirteen specimens.

Thin sections: Three (010811-10-1-1, 010811-10-1-2 and 010811-10-1-3), one (010811-15-2-1), four (010811-16-1-1, 010811-16-1-2, 010811-16-1-3 and 010811-16-1-4), one (010811-17-1-5b), four (010811-17-2-1, 010811-17-2-2, 010811-17-2-3 and 010811-17-2-4), one (010811-17-3-1), two (010811-17-4-1 and 010811-17-4-2), two (010811-24-4-1 and 010811-24-4-2), three (010811-26-2-1, 010811-26-2-2 and 010811-26-2-3), three (010811-27-2-1, 010811-27-2-2 and 010811-27-2-3), three (010811-33-1-1, 010811-33-1-2 and 010811-33-1-3), two (010811-34-8-1 and 010811-34-8-2), and two (010811-34-13-1 and 010811-34-13-2) thin sections cut from NUM-Fz-010811-10-1, NUM-Fz-010811-15-2, NUM-Fz-010811-16-1, NUM-Fz-010811-17-1, NUM-Fz-010811-17-2, NUM-Fz-010811-17-3, NUM-Fz-010811-17-4, NUM-Fz-010811-24-4, NUM-Fz-010811-26-2, NUM-Fz-010811-27-2, NUM-Fz-010811-33-1, NUM-Fz-010811-34-8 and NUM-Fz-010811-34-13 respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Diagnosis

Corallum comparatively large; corallites fanning out from basal portion; wall usually thin; tabulae planar, closely spaced; septal spines numerous.

Description

Specimens entirely embedded in limestone matrix. Corallum cerioid, massive; conical, pyriform, 18-73mm wide, 20-50mm high; corallites prismatic and polygonal (3- to 8-sided), radiate or fanning out from basal or central portion to lateral surface of corallum at obtuse to acute angle and to top of corallum mostly at right angles. Calice generally shallow, maximum depth 6.5mm. Corallites bimodal in size are randomly distributed in cross section. Immature (3- and 4-sided) width 0.2-1.18mm (0.6mm in average) and mature (5- to 8-sided) width 0.8-2.22mm (1.27mm in average). Walls normally thin (less than 0.1mm), rarely thickened (0.22-0.3mm) by fine fibrous sclerenchymal calcite deposit, straight or rarely wrinkled in peripheral part. Each corallite in contact with thin (normally less than 0.02mm) median suture. Several longitudinal rows of slender or thick septal spines (up to 1.2mm long) developed particularly in mud-filled part where tabulae are distantly spaced. Spines horizontal, upward or downward pointing or wavy, 7-11 per 3mm. Squamulae absent though very thick squamula-like wedge spines occasionally seen in cross section. Mural pores circular or ellipsoidal, medium or large (0.08-0.3mm in diameter) with very thin pore plate (less than 0.01mm thick). Pores arranged longitudinally in 1 or 2 rows alternat-

ing on face or rarely at wall junction, spaced ca. 0.11-1.0mm (usually 0.3-0.5mm) apart. Tabulae complete, generally planar, rarely concave or sagging, perpendicular or oblique to inner surface of corallite wall, thin to thick (0.02-0.2mm), usually 8-16 (rarely up to 20) per 5mm.

Remarks

The specimens assigned here to *S*. cf. *zhanwaensis* compare well with figures of the holotypes in Lin and Huang (1987) from the Lower Member of the Yanglugou Formation, Yanglugou, west Qinling Mountains, China, except that the Japanese specimens have large, distantly spaced mural pores.

Genus SAPPORIPORA Ozaki, 1934

Type species. *Sapporipora favositoides* Ozaki, 1934 (in Shimizu *et al*., 1934, p. 74)

Other species. *Favosites* (*S.) favositoides* var. *biserialis* Zhizhina and Smirnova, 1957; *Favosites* (*S.) deversor* Yanet; *S. tarbagataica* Barskaja in Bogdanov ed. (1963); *S. baoxingensis* Kim in Xinan geological institute ed. (1978); *S. jingmenensis* Chou in Xian and Chow (1978); *S. qinlingnensis* Zhang, 1981; *S. liuhuiensis*, Zhou, 1986; *S. gannanensis* Tchi, 1987; *S. shaanxiensis* Lin in Xian Institute of Geological and Mineral Resources, Geological and Mineral Resources Section ed. (1982); *S. xinjiangensis* Wang in Wang *et al*. (2001); *S. kamitakaraensis* sp. nov.; *S. karataniorum* sp. nov.

Diagnosis (after Shimizu *et al*., 1934, p. F603). Corallum massive with small corallites. Corallites polygonal, prismatic, united, their walls perforated by single row of very large pores. Walls thick. Tabulae complete, horizontal, spaced at regular intervals. Number of corallites often increased at junction of four walls.

Remarks. Lang *et al*. (1940) suggested that this genus is probably synonymous with the genus *Favosites*. *Sapporipora* can, however, be distinguished from *Favosites* by its small slender corallites and much larger mural pores.

Sapporipora kamitakaraensis sp. nov. Plate 8, Figs. 3-5; Plate 9, Figs. 1-5

Name

After Kamitakara Village, now part of Takayama City, central Japan.

Reg. No.

Samples: NUM-Fz-010811-5, NUM-Fz-010811-12, NUM-Fz-010811-17, NUM-Fz-010811-24, NUM-Fz-010811-25, NUM-Fz-010811-26 and NUM-Fz-010811-31. Seven samples.

Specimens:

Holotype. NUM-Fz-010811-17-1 (thin sections: 010811-17-1-1, 010811-17-1-2, 010811-17-1-3, 010811-17-1-4 and 010811-17-1-5).

Paratype. NUM-Fz-010811-5-1, NUM-Fz-010811-12-1, NUM-Fz-010811-17-2b, NUM-Fz-010811-24-7, NUM-Fz-010811-25-2, NUM-Fz-010811-26-3, NUM-Fz-010811-31-2 and NUM-Fz-010811-31-4.

Thin sections: Two (010811-5-1-1 and 010811-5-1-2), one (010811-12-1-1), one (010811-17-2-4b), three (010811-25-2-1, 010811-25-2-2 and 010811-25-2-3), two (010811-24-7-1 and 010811-24-7-2), two (010811-26-3-1 and 010811-26-3-2), one (010811-31-2-1) and three (010811-31-4-1, 010811-31-4-2 and 010811-31-4-3) thin sections cut from NUM-Fz-010811-5-1, NUM-Fz-010811-12-1, NUM-Fz-010811-17-2b, NUM-Fz-010811-25-2, NUM-Fz-010811-24-7, NUM-Fz-010811-26-3, NUM-Fz-010811-31-2 and NUM-Fz-010811-31-4 respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Diagnosis

A species of *Sapporipora* with small, slender corallites, distinctive median suture, distantly spaced planar tabulae and row of large mural pores.

Description

Specimens entirely embedded in limestone matrix. Corallum massive, cerioid; spherical or hemispherical, circular or ellipsoidal in cross section; small, 17-50mm wide by 14mm to more than 40mm high. Corallites very slender, prismatic and polygonal (3- to 8-sided), sub-matched in size in cross section, radiate from basal or central portion to surface of corallum and opening out at obtuse or right angles. Calice deep, (up to 3.1mm). Immature (3- and 4-sided) width 0.3-0.82mm (0.6mm in average), mature (5- to 8-sided) 0.6-1.33mm (0.9mm in average). Wall straight, thin (ca. 0.1mm), rarely thickened and rounded by fine, sclerenchymal calcite deposit, peripheral wall thickening absent. Each corallite in contact with distinctive median suture (0.01-0.06mm thick). Septal spine absent or rarely present in peripheral part, maximum length 0.26mm. Spines feeble, slender or thick. Squamulae absent. Mural pores circular, 0.15-0.78mm in diameter (usually 0.15-0.45mm) with very thin pore plate (less than 0.01mm). Each wall face with one longitudinal row of large pores 0.5-1.33mm apart. Tabulae complete, generally planar, rarely concave or sagging, perpendicular or oblique to inner surface of corallite wall, very thin (less than 0.02mm), distantly spaced (4-10 per 5mm).

Remarks

The specimens assigned here to *S. kamitakaraensis* are characterized by their small, slender corallites,

Table 1. Main morphological features of genus *Sapporipora* (after Shimizu *et al*., 1934; Zhizhina and Smirnova, 1958; Bogdanov ed., 1963; Xinan Geological Institute ed., 1978; Xian and Chow, 1978; Zhang, 1981; Zhou, 1986; Tchi, 1987; Xian Institute of Geological and Mineral Resources, Geological and Mineral Resources Section ed., 1982; Wang *et al*., 2001)

		S. kamitakarensis	*S. karataniorum*	*S. favositoides* Ozaki	*S. deversor* Yanet	*S. tarbagataica* Barskaja	*S. baoxingensis* Kim
corallites	*size in diam.*	0.6-1.33mm	0.75-1.55mm	small	0.5-1.0mm	0.36-0.47mm	0.4-0.8mm
wall	*thickness*	less than 0.2mm	less than 0.2mm	thick	0.05-0.1mm	0.04-0.11mm	0.02-0.03mm
mural pore	*size in diam.*	0.15-0.45mm	0.15-0.42mm	very large			0.15×0.2-0.2×0.3mm
	space	0.5-1.33mm	0.44-1.15mm	ca. 0.3mm			0.3-0.4mm
	arrangement	1 row, mid faces	1 row, mid faces	1 row, mid faces			1 row, mid faces
tabulae	*shape*	planar or curved	planar or curved	planar or curved			slightly concave
	spacing	4-10 in 5mm	7-10 in 5mm	more 9 in 3mm	3.33-10 in 5mm	8-10 in 3mm	6-12 in 5mm
septal spine		rare or absent	well-developed	absent			absent

		S. jingmenensis Chow	*S. qinlingnensis* Zhang	*S. liuhuiensis* Zhou	*S. gannanensis* Tchi	*S. shaanxiensis* Lin	*S. xinjiangensis* Wang
corallites	*size in diam.*	0.8-1.0mm	generally 0.5-0.6mm	0.4-1.0mm	generally 0.5-0.6mm	generally 0.7-1.05mm	generally 0.7-1.0mm
wall	*thickness*	0.1-0.25mm	0.03-0.04mm (rarely 0.1-0.15mm)	0.04-0.2mm	0.05-0.1mm	0.03-0.1mm	0.1-0.3mm
mural pore	*size in diam.*	0.2x0.3-0.23×0.35mm	0.3×0.15-0.4×0.3	0.2-0.3mm or 0.2×0.3-0.3×0.4mm	0.2-0.3× 0.15-0.2mm	0.15mm	0.2mm
	space	0.6-1.6mm	0.2-0.5mm (commonly 0.3-0.4mm)	0.7-0.8mm	0.2-0.7mm	0.3mm	
	arrangement	1 row, mid faces	generally 1 row, mid or edge of faces	1 row, mid faces or angles	2 row, mid faces or angles	1 row, mid faces	1 row
tabulae	*shape*	planar or curved	planar	planar or curved		planar or curved	sagged
	spacing	5-8 in 5mm (rarely10-12.5 in 5mm)	5 in 5mm	8-10 in 5mm	7.1-25 in 6mm	12-13 in 5mm	13-15 in 5mm
septal spine		absent	absent or rare	absent	rare	absent	well-developed

the distinctive median suture, the distantly spaced tabulae and the very large mural pores. Ten species of the genus *Sapporipora* were compared with the specimens examined in this paper: *S. favositoides* Ozaki (in Shimizu *et al*., 1934, p. 74), *S. deversor* Yanet (in Khodalevich *et al*., 1959, p. 101), *S. tarbagataica* Barskaja (in Bogdanov ed., 1963, p. 132), *S. baoxingensis* Kim (in Xinan Geological Institute ed., 1978, p. 66), *S. jingmenensis* Chow (in Xian and Chow, 1978, p. 182), *S. qinlingnensis* Zhang (in Zhang, 1981, p. 91), *S. liuhuiensis* Zhou (in Zhou, 1986, p. 83), *S. gannanensis* Tchi (in Tchi, 1987, p. 250), *S. shaanxiensis* Lin (in Xian Institute of Geological and Mineral Resources, Geological and Mineral Resources Section ed, 1982, p. 64), *S. xinjiangensis* Wang (in Wang *et al*., 2001, p. 73) (Table 1).

S. kamitakaraensis is clearly distinguished from *S. favositoides* and *S. tarbagataica* by its distantly spaced tabulae, from *S. baoxingensis* by its thicker walls, and from *S. xinjiangensis* in having planar tabulae. In some ways, *S. kamitakaraensis* is similar to *S. shaanxiensis.* It differs, however in having much larger mural pores and distantly spaced tabulae. *S. deversor* has much thicker tabulae than *S. kamitakaraensis*. *S. liuhuiensis* and *S. qinlingnensis* are distinguishable from *S. kamitakaraensis* by the irregular shape of its corallites. *S. jingmenensis* is very similar to *S. kamitakaraensis* but the latter differs in having ellipsoidal mural pores.

Sapporipora karataniorum sp. nov. Plate 9, Fig. 6; Plate 10, Figs. 1-6

Name

The name honours Mr. and Mrs. Karatani who have strongly supported this study.

Reg. No.

Samples: NUM-Fz-010811-25, NUM-Fz-010811-33 and NUM-Fz-010811-34-5. Three samples.

Specimens:

Holotype. NUM-Fz-010811-33-2 (thin sections: 010811-33-2-1 and 010811-33-2-2).

Paratype. NUM-Fz-010811-25-3, NUM-Fz-010811-34-1 and NUM-Fz-010811-34-5a.

Thin sections: One (010811-25-3-1), one (010811-34-1-1), and two (010811-34-5-1a and 010811-34-5-2a) thin sections cut from NUM-Fz-010811-25-3, NUM-Fz-010811-34-1-1 and NUM-Fz-010811-34-5a, respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Diagnosis

Corallites small and slender; wall generally thin, with distinctive median suture, generally straight but wrinkled in the peripheral part; tabulae planar, distantly spaced; mural pores large, in one row on face of corallites; septal spines numerous at calice.

Description

The specimens are mostly embedded in a limestone matrix. The corallum is massive, cerioid, spherical, hemispherical, pyriform or conical, circular or ellipsoidal in cross-section, small (17-25mm wide and 12-25mm high). Corallites slender, prismatic and polygonal (3- to 8-sided), sub-matched in size in cross section, radiate from basal or central portion to surface of corallum and opening out at obtuse or right angles. Calice deep (up to 8mm in depth). Immature corallites (3- and 4-sided) width 0.4 - 0.66mm, mature (5- to 8-sided) width 0.75 - 1.55mm. Walls straight but slightly wavy in peripheral part, generally thin (less than 0.1mm), rarely thick (0.1-0.15mm). Walls rarely thickened and rounded by fine sclerenchymal calcite deposit. Each corallite in contact with distinctive median suture (0.01-0.04mm). Septal spines common in peripheral part (up to 0.42mm long). Spines slender or thick, in longitudinal rows, 0.25-0.53mm apart. Squamulae absent. Mural pores very large (0.15-0.42mm in diameter) with very thin pore plate (less than 0.02mm thick). Each wall face with one longitudinal row of pores 0.44-

1.15mm apart. Tabulae complete, generally planar but rarely concave or sagging, perpendicular or oblique to inner surface of corallite wall, thin (less than 0.1mm thick), distantly spaced 7-10 per 5mm.

Remarks

The small and slender corallites with distantly spaced tabulae and very large mural pores suggest that this species belongs to the genus *Sapporipora*. The specimens are similar to *S. kamitakaraensis* sp. nov., but they differ in having wrinkled walls and numerous septal spines in the peripheral part of the corallum (Table 1). *S. xinjiangensis,* the only previously known species, has long septal spines (Wang *et al*., 2001) and is clearly distinguished from *S. karataniorum* by having deeply sagging tabulae (Table 1).

Order HELIOLITIDA Frech, 1897
Suborder HELIOLITINA Frech, 1897
Superfamily HELIOLITICAE Lindström, 1876
Family HELIOLITIDAE Lindström, 1876

Definition (after Hill, 1981). Corallum massive with cylindrical tabularia surrounded by coenenchyme of prismatic tubules with complete or incomplete diaphragms; tabularia with 12 septal laminae commonly with spinose axial edges, or with 12 longitudinal radial rows of discrete spines, or aseptate; tabulae complete, commonly flat and horizontal, but strongly convex or conical in *Saaremolites*.

Remarks. This family comprises nine genera: *Heliolites*, *Ningqiangolites*, *Saaremolites, Dnestrites*, *Helioplasmolites*, *Helioplasma*, *?Paeckelmannopora*, *Okopites* and *Pachycanalicula* (Hill, 1981). *Heliolites* and the last four genera being reported from the Lower to Middle Devonian (Hill, 1981). Flügel (1956, p. 75) considered the type species of *Pachycanalicula* to be a subspecies of *Heliolites (Heliolites) porosus* (Goldfuss).

Genus HELIOLITES Dana, 1846

Type species. *Astraea porosa* Goldfuss, 1826, p. 64.

Diagnosis (after Hill, 1981, p. F603). Corallum variable in form, massive; tabularia cylindrical, rounded to polygonal or substellate in transverse section; septa developed with 12 axially spinose laminae or spines; tabulae horizontal, coenenchyme of prismatic tubules with transverse diaphragms.

***Heliolites wenxianicus* Zhang, 1981** Plate 11, Figs. 1-5

1981 *Heliolites wenxianicus* Zhang; Zhang, p. 175-176, Pl. 70, Fig. 2.

1987 *Heliolites wenxianicus* Zhang; Tchi, p. 276, Pl. 80, Fig. 6.

Reg. No.

Samples: NUM-Fz-010809-b, NUM-Fz-010811-3, NUM-Fz-010811-4, NUM-Fz-010811-13, NUM-Fz-010811-25, NUM-Fz-010811-28 and NUM-Fz-010811-30. Seven samples.

Specimens: NUM-Fz-010809-b-1, NUM-Fz-010811-3-1, NUM-Fz-010811-4-1b, NUM-Fz-010811-13-3, NUM-Fz-010811-13-4, NUM-Fz-010811-25-4b, NUM-Fz-010811-28-7, NUM-Fz-010811-28-10 and NUM-Fz-010811-30-5. Nine specimens.

Thin sections: Eight (010809-b-1-1, 010809-b-1-2, 010809-b-1-3, 010809-b-1-4, 010809-b-1-5, 010809-b-1-6, 010809-b-1-7 and 010809-b-1-8), one (010811-3-1-1), one (010811-4-1-1b), one (010811-13-3-1), one (010811-13-4-1), two (010811-25-4-1b and 010811-25-4-2b), one (010811-28-7-2b), three (010811-28-10-1, 010811-28-10-2 and 010811-28-10-3), and two (010811-30-5-1 and 010811-30-5-2) thin sections cut from NUM-Fz-010809-b-1, NUM-Fz-010811-3-1, NUM-Fz-010811-4-1, NUM-Fz-010811-13-3, NUM-Fz-010811-13-4, NUM-Fz-010811-25-4, NUM-Fz-010811-28-7, NUM-Fz-010811-28-10, and NUM-Fz-010811-30-5, respectively.

Material, horizons and localities

All specimens except for NUM-Fz-010809-b-1 were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1). NUM-Fz-010809-b-1 was from a sub-rounded pebble at Loc.1.

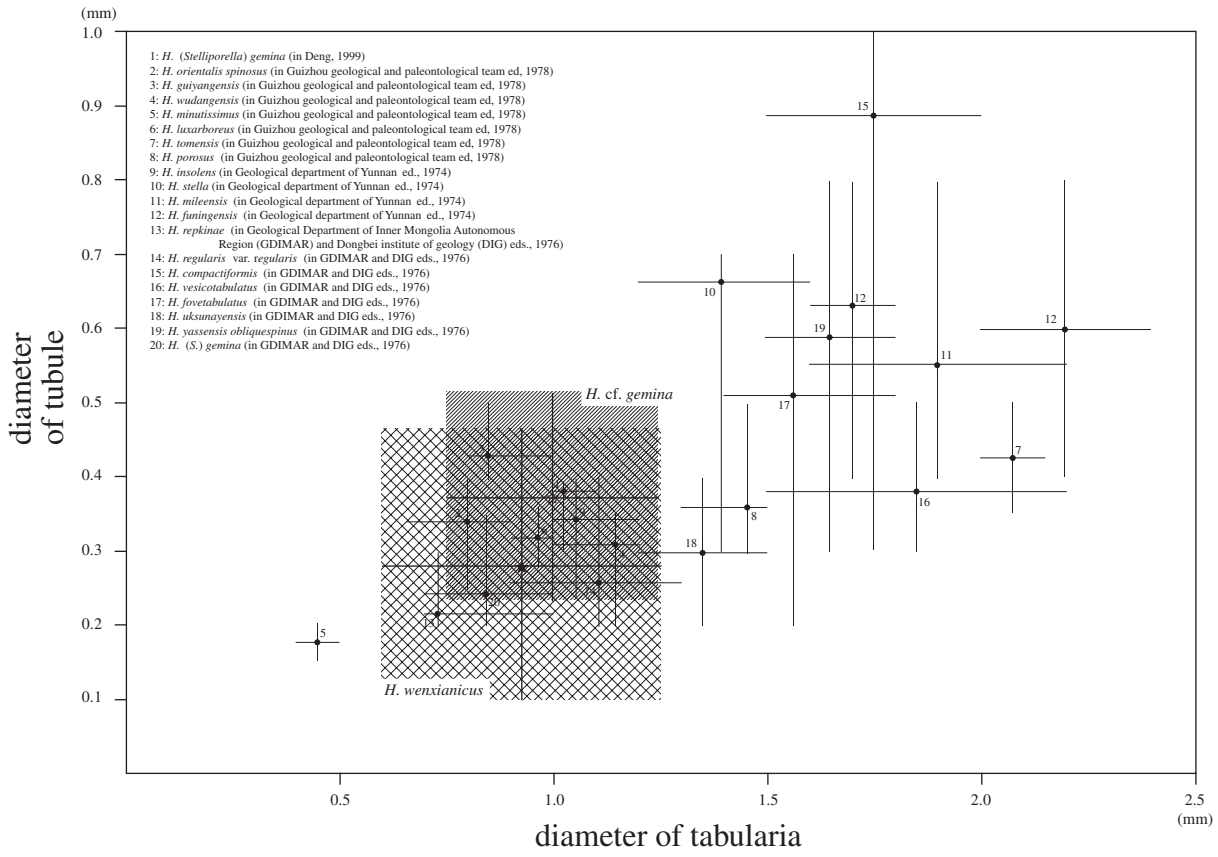
Description

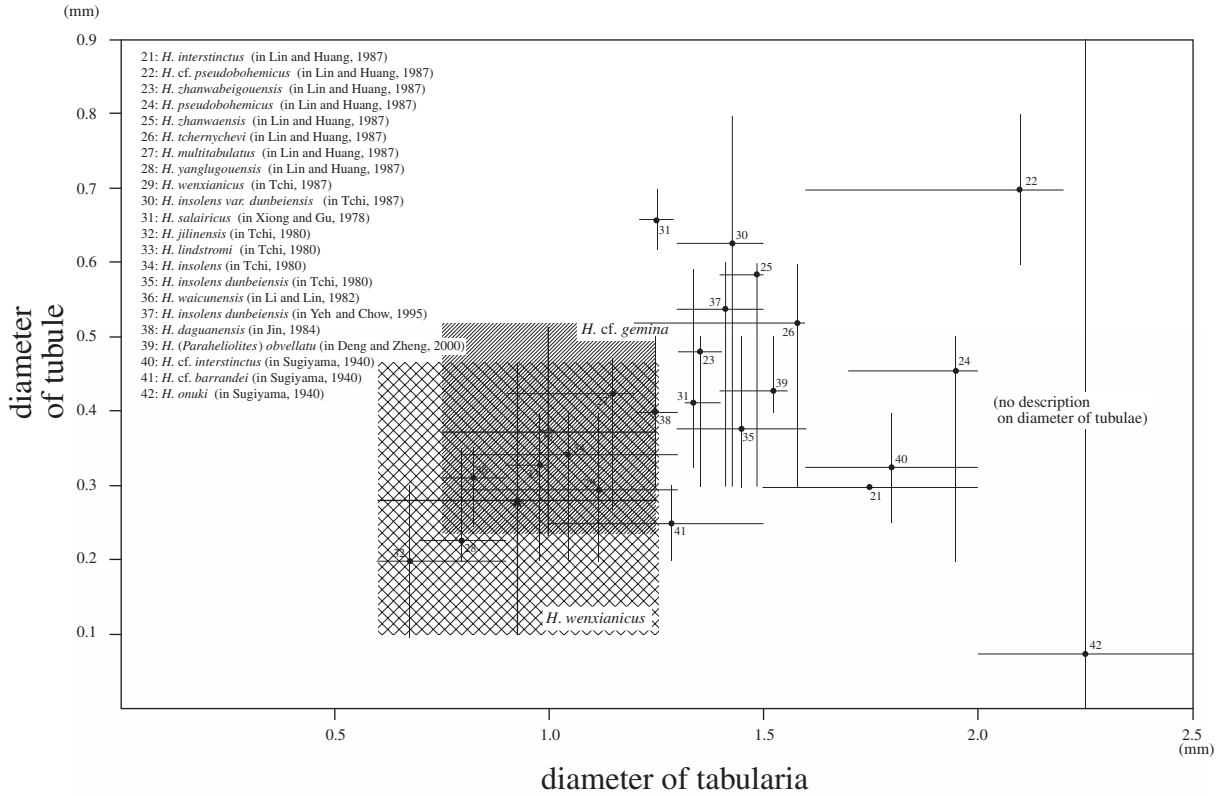
Corallum of variable form, heliolitoid. Tabularia circular or subpolygonal in transverse section, cylindrical, straight, diameter 0.6-1.25mm; walls 0.025-0.12 thick; septal spines commonly well-developed in 12 longitudinal rows, slender, horizontal or curved upwards; tabulae complete, horizontal or oblique, flat, convex or concave, generally very thin (less than 0.04mm), 10-15 per 5mm. Tabularia separated by 0.2-1.42mm of coenenchymal tubules. Coenenchymal tubules 4- to 6-sided in transverse section, 0.1-0.47mm in diameter; coenenchymal walls 0.025-0.12mm thick (usually 0.025-0.075mm thick); diaphragms generally flat, 20-32 per 5mm.

Remarks

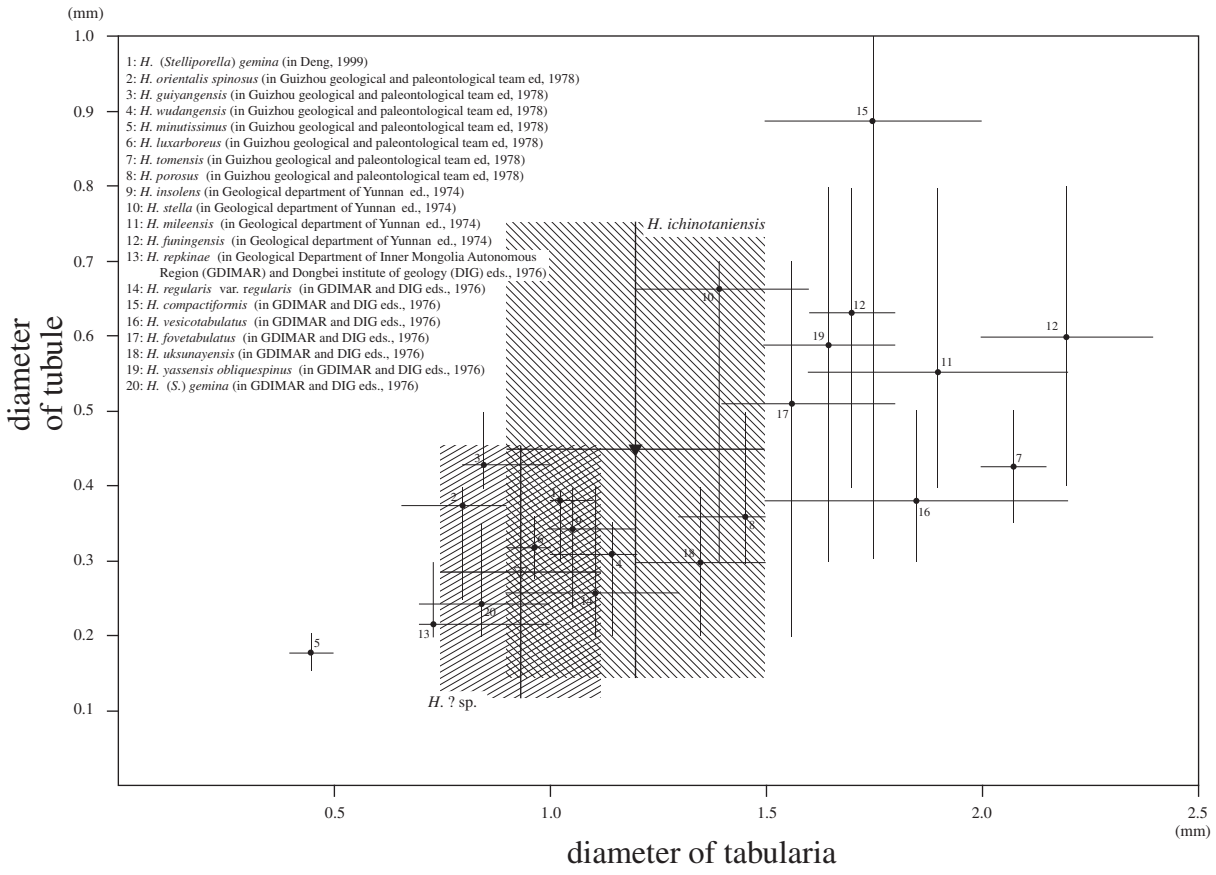
These specimens are identified as belonging to the genus *Heliolites*. 61 species of the genus *Heliolites* from East Asia were compared with the specimens examined in this paper: *H. anfuiensis* Yu and Deng; *H. arboreus* Sugiyama; *H. assuetus* Bondarenko; *H. baichengensis* Wang; *H.* (*Pachycanalicura*) cf. *barrandei* (Hoernes); *H. bohemicus* Wentzel; *H.* (*Paraheliolites*) *bulongensis* (Lin et Huang); *H. compactiformis* Tchi; *H. daguanensis* Kim; *H. decipiens* (McCoy); *H. densitabulatus* Wang; *H. decipiens* var. *minimus* Rukhin; *H. fenggangensis* Yang; *H. fovetabulatus* Tchi; *H. funingensis* King; *H.* (*Stelliporella*) *gemina* (Tchi); *H. guiyangensis* Chow; *H. guizhouensis* Yang; *H. huanghuachongensis* Chow; *H. insolens* Tchernychev; *H. insolens dunbeiensis* Dubatolov; *H. interstinctus* (Linne); *H. interstinctus-intermedis* Wentzel; *H.* (*Paraheliolites*) *jilinensis* Tchi; *H. lindstromi* Kovalevsky; *H. luorepingensis* Wu; *H. luxarboreus* Yang; *H. magnus* Yu; *H. mileensis* King; *H. minutissimus* Chow; *H. multitabulatus* Bondarenko; *H. obliquus* Yu; *H. onukii* Sugiyama; *H. orientalis* Yu; *H.* (*Paraheliolites*) *obvellatus* Deng and Cheng; *H. orientalis spinosus* Yang; *H. paradoxicus* Lin and Wang; *H. paravulgaris* Kim; *H. porosus* (Goldfuss); *H. pseudobohemicus* Bondarenko; *H. regularis* var. *kuznetskiensis* Tchernychev; *H. repkinae* Kovalevsky; *H.* (*Paraheliolites*) *salairicus* Tchernychev; *H. sinkiangensis* Yu; *H. stella* King; *H. tashanensis* Lin and Chow; *H. tchernychevi* Bondarenko; *H. tomensis* Tchernychev; *H. uksunayensis* Mironova; *H. vesicotabulatus* Tchi; *H. volutus* Yu and Deng; *H. vulgaris irregularis* Tchernychev; *H. waicunensis* Lin and Chow; *H. wenxianicus* Zhang; *H. wudangensis* Chow; *H. yanbianensis* Kim; *H. yanglugouensis* Lin and Fuan; *H. yassensis obliquespinus* Chu; *H. zhanwabeigouensis* Lin and Fuan; *H. zhanwaensis* Lin and Fuan; *H. zoigeensis* Lin and Fuan (Xian Institute of Geological and Mineral Resources, Geological and Mineral Resources Section ed, 1982; Xinjiang Geological Department, Xinjiang Geological Institute and Xinjiang Petroleum Department eds., 1981; Nanjing Institute of Geology and Mineralogy, Geology and Mineralogy Section ed., 1983; Tchi, 1980; Xiong and Gu, 1978; Wang *et al*., 2001; Tchi, 1987; Xinan Geological Institute ed., 1978; Lin and Huang, 1987; Lin and Wang, 1987; Geological Department of Inner Mongolia Autonomous Region (GDIMAR) and Dongbei Institute of Geology (DIG) eds., 1976; Fubei Institute of Geology, Geological Department of Hubei, Geological Department of Guandong, Geological Department of Henan, Geological Department of Hunan and Geological Department of Guangxi Autonomous Region eds., 1977; Geological Department of Yunnan ed., 1974; Regional Geological Surveying Team of Hubei ed., 1994; Guizhou Geological and Paleontological Team ed, 1978; Deng, 1999; Yeh and Chow, 1995; Jin, 1984; Deng and Zheng, 2000; Sugiyama, 1940; Yu, 1962; Lin and Chow, 1977; Lin and Huang, 1986; Kamei, 1955b; Zhang, 1981).

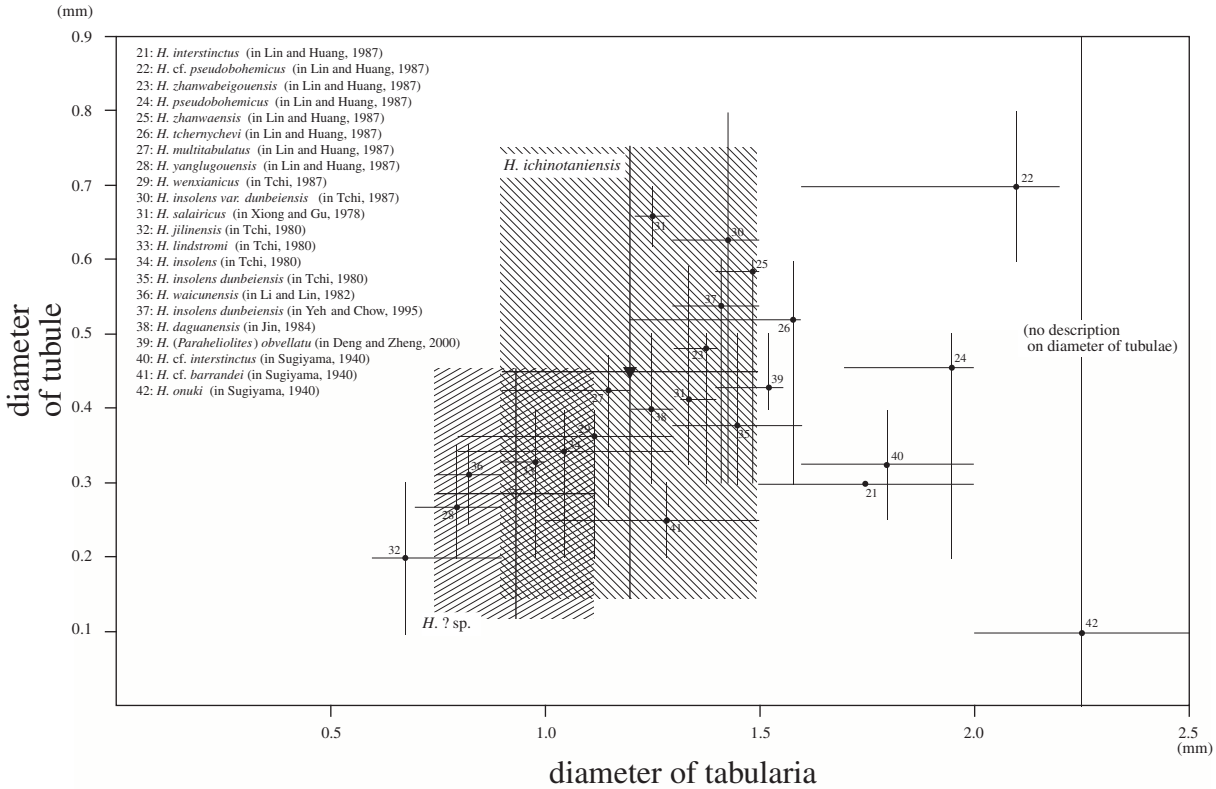
Those assigned here to *H. wenxianicus* are characterized by closely spaced diaphragms. They are similar to *H. orientalis spinosus* (in Guizhou Geological and Paleontological Team ed, 1978; p. 237), *H. guiyangensis* (in Guizhou Geological and Paleontological Team ed, 1978; p. 237), *H. repkinae* (in GDIMAR and DIG eds., 1976; p. 123), *H. regularis* var. *kuznetskiensis* (in GDIMAR and DIG eds.,

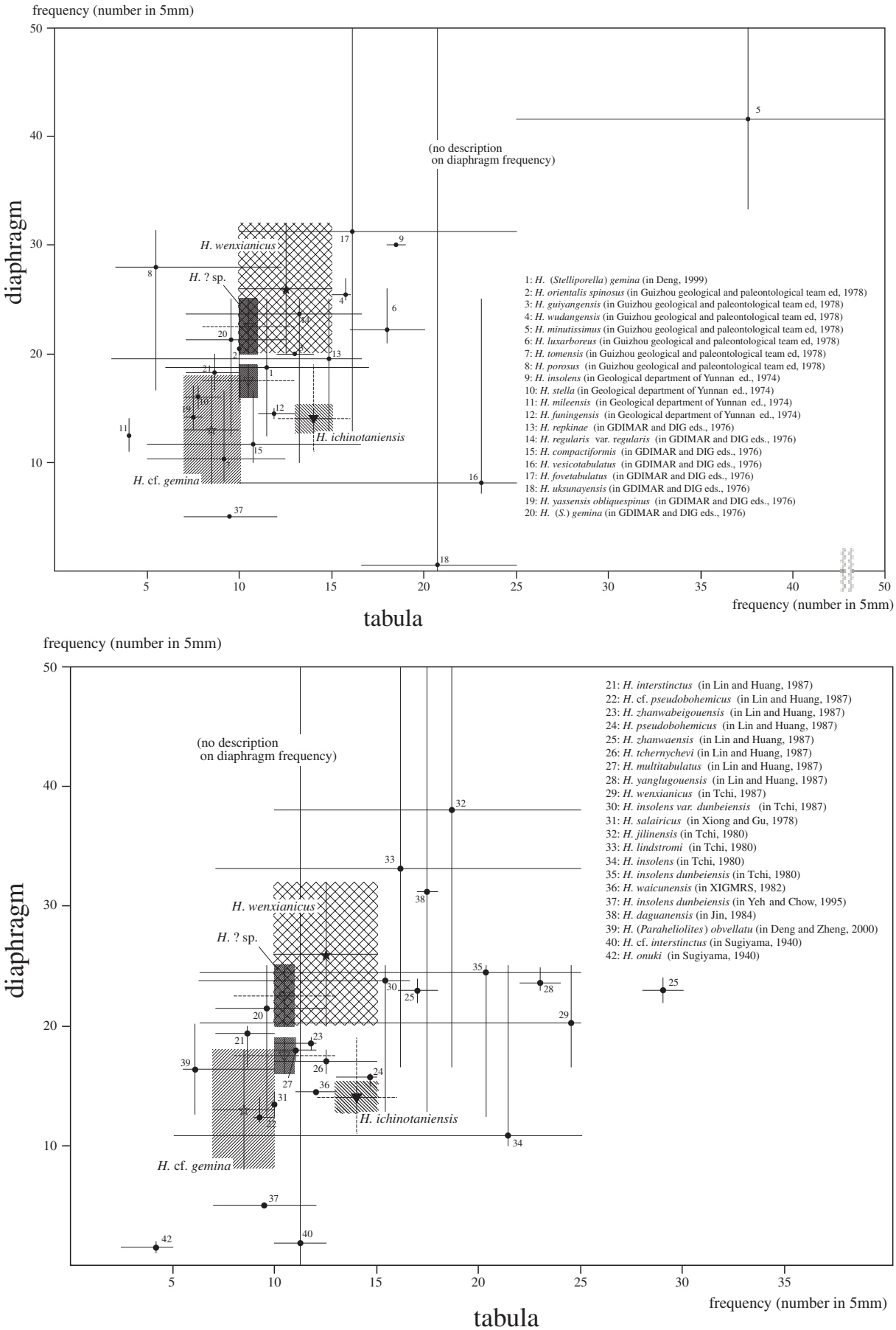




Text-Fig. 4. Diameters of tabularia (x-axis) and tubules (y-axis) of *Heliolites* from Asia (having septal structure only). GDIMAR: Geological Department of Inner Mongolia Autonomous Region, DIG: Dongbei Institute of Geology, XIGMRS; Xian Institute of Geological and Mineral Resources Section. (continue to next page)


(mm)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
diameter of tubule
1: H. (Stelliporella) gemina (in Deng, 1999)
2: H. orientalis spinosus (in Guizhou geological and paleontological team ed, 1978)
3: H. guiyangensis (in Guizhou geological and paleontological team ed, 1978)
4: H. wudangensis (in Guizhou geological and paleontological team ed, 1978)
5: H. minutissimus (in Guizhou geological and paleontological team ed, 1978)
6: H. luxarboreus (in Guizhou geological and paleontological team ed, 1978)
7: H. tomensis (in Guizhou geological and paleontological team ed, 1978)
8: H. porosus (in Guizhou geological and paleontological team ed, 1978)
9: H. insolens (in Geological department of Yunnan ed., 1974)
10: H. stella (in Geological department of Yunnan ed., 1974)
11: H. mileensis (in Geological department of Yunnan ed., 1974)
12: H. funingensis (in Geological department of Yunnan ed., 1974)
13: H. repkinae (in Geological Department of Inner Mongolia Autonomous Region (GDIMAR) and Dongbei institute of geology (DIG) eds., 1976)
14: H. regularis var. regularis (in GDIMAR and DIG eds., 1976)
15: H. compactiformis (in GDIMAR and DIG eds., 1976)
16: H. vesicotabulatus (in GDIMAR and DIG eds., 1976)
17: H. fovetabulatus (in GDIMAR and DIG eds., 1976)
18: H. uksunayensis (in GDIMAR and DIG eds., 1976)
19: H. yassensis obliquespinus (in GDIMAR and DIG eds., 1976)
20: H. (S.) gemina (in GDIMAR and DIG eds., 1976)
H. ichinotaniensis
H. ? sp.
0.5
1.0
1.5
2.0
2.5
(mm)
diameter of tabularia


(mm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
diameter of tubule
21: H. interstinctus (in Lin and Huang, 1987)
22: H. cf. pseudobohemicus (in Lin and Huang, 1987)
23: H. zhanwabeigouensis (in Lin and Huang, 1987)
24: H. pseudobohemicus (in Lin and Huang, 1987)
25: H. zhanwaensis (in Lin and Huang, 1987)
26: H. tchernychevi (in Lin and Huang, 1987)
27: H. multitabulatus (in Lin and Huang, 1987)
28: H. yanglugouensis (in Lin and Huang, 1987)
29: H. wenxianicus (in Tchi, 1987)
30: H. insolens var. dunbeiensis (in Tchi, 1987)
31: H. salairicus (in Xiong and Gu, 1978)
32: H. jilinensis (in Tchi, 1980)
33: H. lindstromi (in Tchi, 1980)
34: H. insolens (in Tchi, 1980)
35: H. insolens dunbeiensis (in Tchi, 1980)
36: H. waicunensis (in Li and Lin, 1982)
37: H. insolens dunbeiensis (in Yeh and Chow, 1995)
38: H. daguanensis (in Jin, 1984)
39: H. (Paraheliolites) obvellatu (in Deng and Zheng, 2000)
40: H. cf. interstinctus (in Sugiyama, 1940)
41: H. cf. barrandei (in Sugiyama, 1940)
42: H. onuki (in Sugiyama, 1940)
H. ichinotaniensis
H. ? sp.
(no description on diameter of tubulae)
0.5
1.0
1.5
2.0
2.5
(mm)
diameter of tabularia



Text-Fig. 5. Tabular (x-axis) and diaphragm (y-axis) frequencies of *Heliolites* from Asia (having septal structure only).

1976; p. 123), *H. wenxianicus* (in Tchi, 1987; p. 276), *H. lindstromi* (in Tchi, 1980; p. 185) and *H. insolens* (in Tchi, 1980; p. 185) in their septal structure, the size of the tabularia, the size of the coenenchymal tubules, the tabular frequency and the diaphragm frequency (Text-Figs. 4 and 5). However, the coenenchymal wall of the specimens examined here is generally thicker than that of *H. repkinae*, *H. regularis* var. *kuznetskiensis* or *H. lindstromi*. *H. orientalis* var. *spinosus* differs in having substellate tabularia. Although GDIMAR and DIG eds. (1976) described spines pointing upwards from the coenenchymal wall in *H. guiyangensis*, such spines were not observed in the specimens examined here which compare very well with *H. wenxianicus* as described and figured by Zhang (1981) from the upper part of the Middle Devonian Xiaputonggou Formation, Putonggou, south Qinling Mountains, China, and by Tchi (1987) from the upper part of the Lower Devonian Xiaputonggou Formation, Putonggou, west Qinling Mountains, China.

***Heliolites* cf. *gemina* (Tchi, 1976)** Plate 12, Figs. 1-3

1976 *Stelliporella gemina* Tchi; GDIMAR and DIG eds., p. 125, Pl. 50, Fig. 3.

1999 *Heliolites gemina* (Tchi); Deng, p. 229, Pl. 40, Fig. 1.

Reg. No.

Samples: NUM-Fz-010809-f, NUM-Fz-010811-15, NUM-Fz-010811-30 and NUM-Fz-010811-34. Four samples.

Specimens: NUM-Fz-010809-f-1a, NUM-Fz-010811-15-3, NUM-Fz-010811-30-4 and NUM-Fz-010811-34-2a. Four specimens.

Thin sections: Three (010809-f-1-1, 010809-f-1-2 and 010809-f-1-3), two (010811-15-3-1 and 010811-15-3-2), one (010811-30-4-1), and one (010811-34-2-1a) thin sections cut from NUM-Fz-010809-f-1, NUM-Fz-010811-15-3, NUM-Fz-010811-30-4, and NUM-Fz-010811-34-2a, respectively.

Material, horizons and localities

All specimens except for NUM-Fz-010809-f-1 were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1). NUM-Fz-010809-f-1 was from a sub-rounded pebble at Loc.1.

Description

Corallum of variable form, heliolitoid. Tabularia circular, oval or subpolygonal in transverse section, cylindrical, straight, diameter 0.75-1.25mm; walls 0.04-0.2mm thick; septa commonly represented by 12 slender spines with thick bases, rarely by septal laminae with axially spinose edges, horizontal or curved upwards; tabulae complete, horizontal or oblique, flat, convex or concave, generally very thin (less than 0.05mm), 7-10 per 5mm. Tabularia separated by 0.3-1.67mm of coenenchymal tubules. Coenenchymal tubules 3- to 8-sided in transverse section, 0.23-0.51mm in diameter; coenenchymal walls 0.025-0.12mm thick; diaphragms generally flat, 8-18 per 5mm.

Remarks

These specimens are identified as belonging to the genus *Heliolites* by their circular tabularia and coenenchymal tubules with transverse diaphragms. 61 species of the genus *Heliolites* from East Asia were compared with the specimens examined in this paper: *H. anfuiensis* Yu and Deng; *H. arboreus* Sugiyama; *H. assuetus* Bondarenko; *H. baichengensis* Wang; *H.* (*Pachycanalicura*) cf. *barrandei* (Hoernes); *H. bohemicus* Wentzel; *H.* (*Paraheliolites*) *bulongensis* (Lin et Huang); *H. compactiformis* Tchi; *H. daguanensis* Kim; *H. decipiens* (McCoy); *H. densitabulatus* Wang; *H. decipiens* var. *minimus* Rukhin; *H. fenggangensis* Yang; *H. fovetabulatus* Tchi; *H. funingensis* King; *H.* (*Stelliporella*) *gemina* (Tchi); *H. guiyangensis* Chow; *H. guizhouensis* Yang; *H. huanghuachongensis* Chow; *H. insolens* Tchernychev; *H. insolens dunbeiensis* Dubatolov; *H. interstinctus* (Linne); *H. interstinctus-intermedis* Wentzel; *H.* (*Paraheliolites*) *jilinensis* Tchi; *H. lindstromi* Kovalevsky; *H. luorepingensis* Wu; *H.*

luxarboreus Yang; *H. magnus* Yu; *H. mileensis* King; *H. minutissimus* Chow; *H. multitabulatus* Bondarenko; *H. obliquus* Yu; *H. onukii* Sugiyama; *H. orientalis* Yu; *H.* (*Paraheliolites*) *obvellatus* Deng and Cheng; *H. orientalis spinosus* Yang; *H. paradoxicus* Lin and Wang; *H. paravulgaris* Kim; *H. porosus* (Goldfuss); *H. pseudobohemicus* Bondarenko; *H. regularis* var. *kuznetskiensis* Tchernychev; *H. repkinae* Kovalevsky; *H.* (*Paraheliolites*) *salairicus* Tchernychev; *H. sinkiangensis* Yu; *H. stella* King; *H. tashanensis* Lin and Chow; *H. tchernychevi* Bondarenko; *H. tomensis* Tchernychev; *H. uksunayensis* Mironova; *H. vesicotabulatus* Tchi; *H. volutus* Yu and Deng; *H. vulgaris irregularis* Tchernychev; *H. waicunensis* Lin and Chow; *H. wenxianicus* Zhang; *H. wudangensis* Chow; *H. yanbianensis* Kim; *H. yanglugouensis* Lin and Fuan; *H. yassensis obliquespinus* Chu; *H. zhanwabeigouensis* Lin and Fuan; *H. zhanwaensis* Lin and Fuan; *H. zoigeensis* Lin and Fuan (Xian Institute of Geological and Mineral Resources, Geological and Mineral Resources Section ed, 1982; Xinjiang Geological Department, Xinjiang Geological Institute and Xinjiang Petroleum Department eds., 1981; Nanjing Institute of Geology and Mineralogy, Geology and Mineralogy Section ed., 1983; Tchi, 1980; Xiong and Gu, 1978; Wang *et al*., 2001; Tchi, 1987; Xinan Geological Institute ed., 1978; Lin and Huang, 1987; Lin and Wang, 1987; Geological Department of Inner Mongolia Autonomous Region (GDIMAR) and Dongbei Institute of Geology (DIG) eds., 1976; Fubei Institute of Geology, Geological Department of Hubei, Geological Department of Guandong, Geological Department of Henan, Geological Department of Hunan and Geological Department of Guangxi Autonomous Region eds., 1977; Geological Department of Yunnan ed., 1974; Regional Geological Surveying Team of Hubei ed., 1994; Guizhou Geological and Paleontological Team ed, 1978; Deng, 1999; Yeh and Chow, 1995; Jin, 1984; Deng and Zheng, 2000; Sugiyama, 1940; Yu, 1962; Lin and Chow, 1977; Lin and Huang, 1986; Kamei, 1955b; Zhang, 1981).

In respect of the size of their tabularia, the size of the coenenchymal tubules, tabular frequency and diaphragm frequency, the specimens examined here are similar to *H. (Stelliporella*) *gemina* (in GDIMAR and DIG eds, 1976; p. 125 and Deng, 1999; p. 229), *H. orientalis spinosus* (in Guizhou Geological and Paleontological Team ed, 1978; p. 237), *H. stella* (in Geological department of Yunnan ed., 1974; p. 247), *H. repkinae* (in GDIMAR and DIG eds., 1976; p. 123), *H. regularis* var. *kuznetskiensis* (in GDIMAR and DIG eds., 1976; p. 123) and *H. insolens* (in Tchi, 1980; p. 185) (Text-Figs. 4 and 5).

H. (*S.*) *gemina* described and figured in GDIMAR and DIG eds (1976) from the Upper Silurian Xibiehe Formation, Inner Mongolia, China, is similar to the specimens examined here in having axially spinose septal laminae and septal spines. However, the Japanese specimens have more closely spaced tabulae and diaphragms than the Chinese specimens. In *H. gemina*, described by Deng (1999) from the Middle Silurian Shaebuer Formation, Inner Mongolia, China, the septa are only represented by septal laminae.

***Heliolites ichinotaniensis* sp. nov.** Plate 12, Figs. 4-7

Name

The name is derived from the Ichinotani Valley, Fukuji, central Japan.

Reg. No.

Samples: NUM-Fz-010811-14, NUM-Fz-010811-18, NUM-Fz-010811-20, NUM-Fz-010811-21, NUM-Fz-010811-29 and NUM-Fz-010811-32. Six samples.

Specimens:

Holotype. NUM-Fz-010811-18-1 (thin sections: 010811-18-1-1, 010811-18-1-2 and 010811-18-1-3).

Paratype. NUM-Fz-010811-14-1, NUM-Fz-010811-20-1, NUM-Fz-010811-21-2, NUM-Fz-010811-29-1 and NUM-Fz-010811-32-1.

Thin sections: One (010811-14-1-1), two (010811-20-1-1 and 010811-20-1-2), six (010811-21-2-1, 010811-21-2-2, 010811-21-2-3, 010811-21-2-4, 010811-21-2-5 and 010811-21-2-6), two (010811-29-1-1 and 010811-29-1-2), and nine (010811-32-1-4, 010811-32-1-5, 010811-32-1-7, 010811-32-1-8,

010811-32-1-9a, 010811-32-1-10, 010811-32-1-11a, 010811-32-1-12a and 010811-32-1-13a) thin sections cut from NUM-Fz-010811-14-1, NUM-Fz-010811-20-1, NUM-Fz-010811-21-2, NUM-Fz-010811-29-1 and NUM-Fz-010811-32-1 respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Description

Corallum of variable form, heliolitoid. Tabularia generally polygonal or substellate rarely circular in transverse section, cylindrical, straight, diameter 0.9-1.5mm; walls 0.025-0.1 thick; septal spines well developed in 12 longitudinal rows, slender, long, horizontal to sharply curved upwards; tabulae complete, horizontal or oblique, flat, convex or concave, rarely sagging, generally very thin (less than 0.05mm), usually 8-11 per 5mm, rarely 12-16 per 5mm. Tabularia separated by 0.5-2.5mm of coenenchymal tubules. Coenenchymal tubules 4- to 8-sided in transverse section, 0.15-0.75mm in diameter (mostly 0.4-0.5mm); coenenchymal walls 0.02-0.66mm thick with distinct median suture; diaphragms generally flat, but rarely convex or concave, 11-19 per 5mm (usually 13-15 per 5mm),

Remarks

This species is characterized by thin-walled polygonal or substellate tabularia, distantly spaced diaphragms and long slender septal spines. In the size of the tabularia, the size of the coenenchymal tubules, tabula frequency and diaphragm frequency, the specimens studied here are similar to *H.* (*S.*) *gemina* (in GDIMAR and DIG eds., 1976; p. 125 and Deng, 1999; p. 229), *H. regularis* var. *kuznetskiensis* (in GDIMAR and DIG eds., 1976; p. 123), *H. fovetabulatus* (in GDIMAR and DIG eds., 1976; p. 124), *H. tchernychevi* (in Lin and Huang, 1987; p. 229), *H. insolens dunbeiensis* (in Tchi, 1980; p. 185 and Tchi, 1987; p. 276) and *H. insolens* (in Tchi, 1980; p. 185) (Text-Figs. 4 and 5). Although *H. regularis* var. *kuznetskiensis* and *H. fovetabulatus* are similar to this new species in having long slender spines, they differ in having circular tabularia. *H. tchernychevi* has stellate to substellate tabularia, and in *H. ichinotaniensis* the diaphragms are much more closely spaced.

***Heliolites* ? sp.** Plate 13, Figs. 1-4

Reg. No.

Samples: NUM-Fz-010811-7, NUM-Fz-010811-13, NUM-Fz-010811-25, NUM-Fz-010811-28, NUM-Fz-010811-33 and NUM-Fz-010811-34. Six samples.

Specimens: NUM-Fz-010811-7-1, NUM-Fz-010811-13-1, NUM-Fz-010811-25-4, NUM-Fz-010811-28-1, NUM-Fz-010811-33-2b, NUM-Fz-010811-34-2b and NUM-Fz-010811-34-12. Seven specimens.

Thin sections: Two (010811-7-1-1 and 010811-7-1-2), two (010811-13-1-1 and 010811-13-1-2), two (010811-25-4-1b and 010811-25-4-2b), two (010811-28-1-1 and 010811-28-1-2), one (010811-33-2-2b), one (010811-34-2-1b), and five (010811-34-12-1, 010811-34-12-2, 010811-34-12-3, 010811-34-12-4 and 010811-34-12-5) thin sections cut from NUM-Fz-010811-7-1, NUM-Fz-010811-13-1, NUM-Fz-010811-25-4, NUM-Fz-010811-28-1, NUM-Fz-010811-33-2, NUM-Fz-010811-34-2 and NUM-Fz-010811-34-12 respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Description

Corallum of variable form, heliolitoid. Tabularia circular in transverse section, cylindrical, straight, diameter 0.75-1.12mm; walls 0.025-0.2 thick; septal spines well developed in 12 longitudinal rows, slender or rarely very thick, horizontal or curved upwards; tabulae complete, horizontal or oblique, flat,

convex or concave, generally very thin (less than 0.02mm), 10-11 per 5mm. Each tabularium is separated by 0.25-1.35mm of coenenchymal tubules. Coenenchymal tubules 4- to 6-sided in transverse section, 0.125-0.46mm in diameter; coenenchymal walls 0.02-0.15mm thick, often with lenticular thickening; diaphragms generally flat, but rarely slightly convex or concave, 20-25 per 5mm where closely spaced and 16-19 per 5mm where distantly spaced.

Remarks

The specimens assigned here to *Heliolites* ? sp. A are similar to those referred to *H. wenxianicus* in this paper in having closely spaced tabulae and diaphragms (Text-Figs. 4 and 5), but they can be distinguished from *H. wenxianicus* by the lenticular thickening of the coenenchymal walls and likely to be assigned to genus *Helioplasma* as they occasionally have incomplete and overlapping convex diaphragms.

Genus HELIOPLASMA Kettnerová, 1933

Type species. *Helioplasma kolihai* Kettnerová, 1933, p. 181.

Other species. *H. domestica* Bondarenko, 1966; *H.* (?) *indotata* Bondarenko, 1966; *H. propinguus* (Bondarenko, 1966); *H. aliena* Galle, 1973; *H. dnestriensis* (Bondarenko, 1981); *H. urjupica* Bondarenko; *H.* (?) *squameoformis* Bondarenko; *H. delicatum* Yanet and Lobanov, 1992 (in Lobanov, 1992).

Bondarenko (1966) was uncertain whether *H. domestica* was a member of the genus *Helioplasma,* while Galle (1969) included it in that genus. In addition, Galle (1969) included *Bogimbailites propinguus* Bondarenko, 1966 in the genus *Helioplasma.*

Diagnosis (after Hill, 1981, p. F603). Corallum heliolitoid; tabularial walls slightly thickened; septa represented by long septal spines; tabulae complete, not evenly horizontal; coenenchymal tubules normally prismatic with horizontal diaphragms, or occasionally elongate in transverse section with incomplete overlapping convex diaphragms as well as horizontal, complete diaphragms.

***Helioplasma takayamaensis* sp. nov.** Plate 13, Figs. 5-8

Name

The name is derived from Takayama City, Gifu Prefecture, central Japan.

Reg. No.

Samples: NUM-Fz-010811-26-1 and NUM-Fz-010811-28-2. Two specimens.

Specimens:

Holotype. NUM-Fz-010811-26-1 (thin sections: 010811-26-1-1 and 010811-26-1-2).

Paratype. NUM-Fz-010811-28-2.

Thin sections: Two (010811-28-2-1 and 010811-28-2-2) thin sections cut from NUM-Fz-010811-28-2.

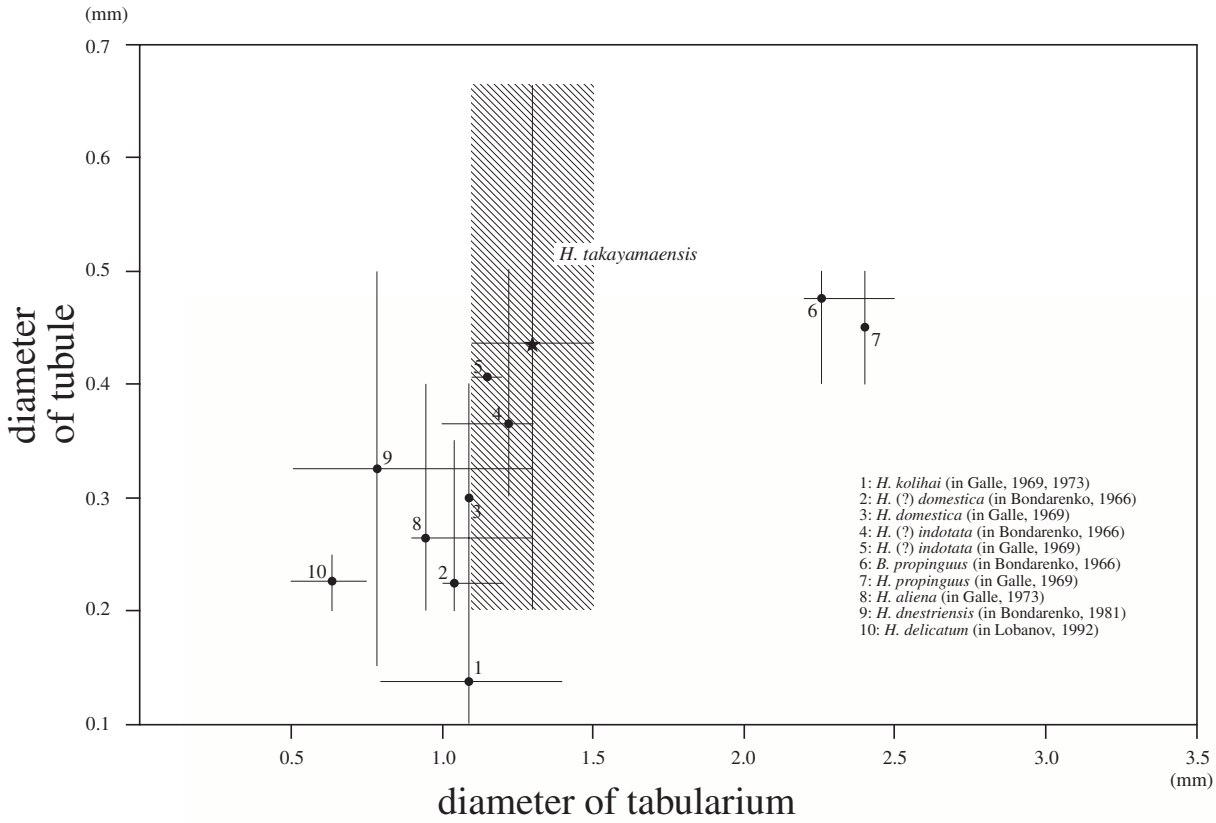
Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

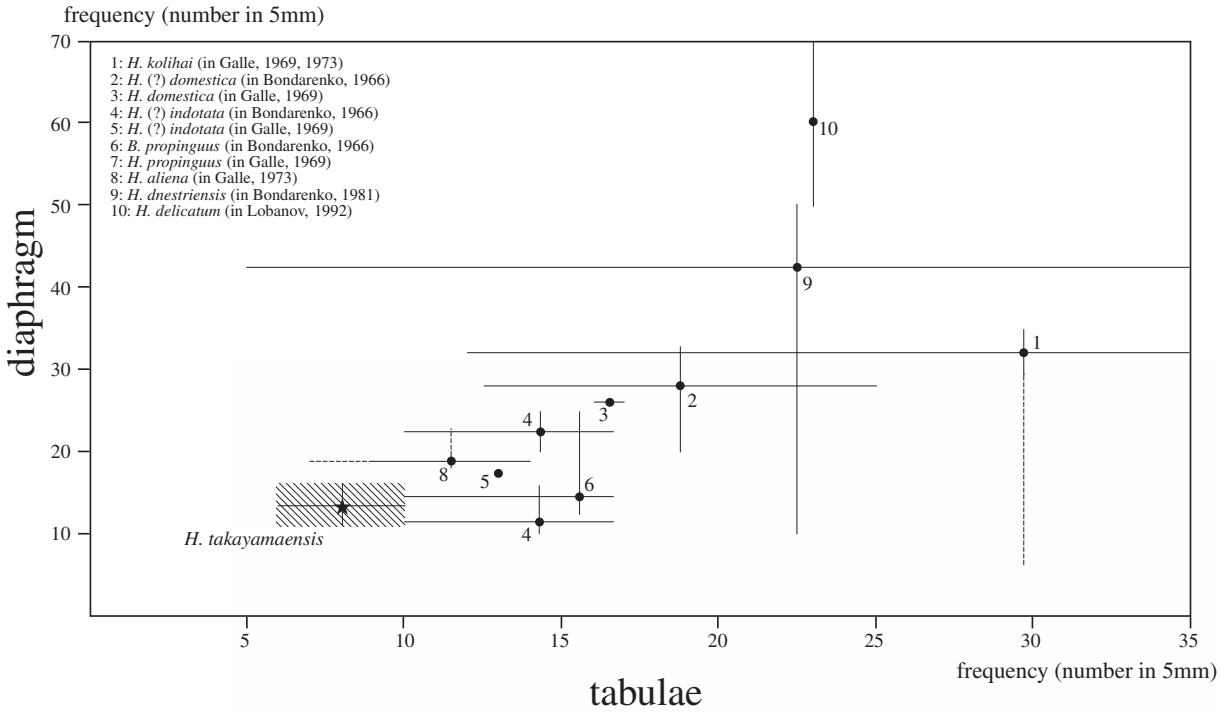
Description

Corallum massive, heliolitoid. Tabularia circular or polygonal in transverse section, cylindrical, straight, diameter 1.1-1.5mm; walls 0.025-0.125 thick; septal spines well developed in 12 longitudinal rows, slender, long, curved upwards; tabulae complete, concave or sagging, rarely flat or convex, generally very thin (less than 0.04mm), 6-10 per 5mm. Tabularia separated by 0.25-1.35mm of coenenchymal tubules. Coenenchymal tubules 4- to 8-sided in transverse section, 0.2-0.67mm in diameter; coenenchymal walls 0.03-0.1mm thick; diaphragms sometimes deeply sagging sometimes conical, incomplete and convex, also some horizontal complete diaphragms, 11-16 per 5mm.

Remarks



Text-Fig. 6. Diameters of tabularia (x-axis) and tubules (y-axis) of *Helioplasma*.



Text-Fig. 7. Tabular (x-axis) and diaphragm (y-axis) frequencies of *Helioplasma*.

These specimens are characterized by thick-walled tabularia, and deeply sagging or overlapping convex diaphragms. These features place them clearly within the genus *Helioplasma*. The specimens studied here are clearly distinguished from *H. kolihai* (in Galle, 1969; p. 170 and 1971; p. 34), *H. domestica* (in Bondarenko, 1966; p. 194), *H.* (?) *indotata* (in Bondarenko, 1966; p. 193), *H. aliena* (in Galle, 1973; p. 35), and *H. delicatum* (in Lobanov, 1992; p. 9) in having widely spaced tabulae and diaphragms (Text-Figs. 6 and 7). *H. propinguus* (in Bondarenko, 1966; p. 192) has much larger tabularia than the present specimens (Text-Fig. 6). The tabula of *H. dnestriensis* (in Bondarenko, 1981; p. 16) are not concave or sagging, and are thus different from those of the present specimens.

Family PSEUDOPLASMOPORIDAE Bondarenko, 1963

Definition (Hill, 1981). Corallum variable in form; walls of tabularia smooth (with no trace of facets) or longitudinally folded; septa either laminae or longitudinal rows of spines, or absent; tabulae complete, horizontal; an aureola of 12 tubules surrounding each tabularium, variable in radius; remaining coenenchyme also of tubules with complete, horizontal diaphragms or rarely with oblique and incomplete diaphragms.

Remarks. This family is composed of four genera, *Pseudoplasmopora*, *Amphilites*, *Pachyhelioplasma* and *Visbylites* (Hill, 1981). The former three genera were reported from the Lower to ?Middle Devonian (Hill, 1981).

Genus PSEUDOPLASMOPORA Bondarenko, 1963

Type species. *Pseudoplasmopora conspecta* Bondarenko, 1963, p. 47.

Other species. *P. follis* (Milne-Edwards and Haime, 1851); *P. gippslandica* (Chapman, 1914); *P. aseptata* (Regnell, 1941); *P. cargoensis* (Hill, 1957); *P. arguta arguta* Bondarenko, 1963; *P. plasmopolides* Lin, 1963; *P. septosa* Bondarenko, 1966; *P. subdecipiens* (Kovalevsky, 1956); *P. bella* (Kovalevsky, 1956); *P. arguta festivus* Bondarenko, 1966; *P. isenica* Bondarenko, 1966; *P. regularis* (Dun, 1927); *P. lojopingensis* Xiong in Xiong and Gu (1978); *P. sanxiaensis* Xiong in Xiong and Gu (1978); *P. yichangensis* Xiong in Xiong and Gu (1978); *P. hubeiensis* Xiong in Xiong and Gu (1978); *P. microsa* Wang in Xinjiang Geological Department *et al*. eds. (1981); *P. longisepta* Klaamann, 1984; *P. yaokengensis* Deng and Zheng, 2000.

Although Bondarenko (1963) included *Plasmopora follis* Milne-Edwards and Haime, 1851 in his new genus *Pseudoplasmopora,* whether or not this decision was correct is debatable. Bondarenko (1966) considered *P. follis* described by Shimizu *et al*. (1934) from the Ken-niho conglomerate, North Korea to be a synonym of *P. septosa*.

Diagnosis (after Hill, 1981, p. F603). Pseudoplasmoporidae with septa consisting of septal spines or absent, walls of tabularia and tubules unthickened, diaphragms of tubules rarely oblique and incomplete.

***Pseudoplasmopora okuhidaensis* sp. nov.** Plate 14, Figs. 1-7

Name

The name is derived from Okuhida-onsen-go (Okuhida Spa), Takayama City, Gifu Prefecture, central Japan.

Reg. No.

Samples: NUM-Fz-010811-28-4, NUM-Fz-010811-33-4 and NUM-Fz-010811-34. Three samples.

Specimens:

Holotype. NUM-Fz-010811-28-4 (thin sections: 010811-28-4-1, 010811-28-4-2, 010811-28-4-3 and 010811-28-4-4).

Paratype. NUM-Fz-010811-33-4 and NUM-Fz-010811-34-5b.

Thin sections: One (010811-33-4-1), and two (010811-34-5-1b and 010811-34-5-2b) thin sections cut from NUM-Fz-010811-33-4, and NUM-Fz-010811-34-5b respectively.

Material, horizons and localities

All specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Description

Corallum massive, heliolitoid. Tabularia circular with an aureola of 12 elongated coenenchymal tubules in transverse section, cylindrical, straight, diameter 1.125-2.0mm; walls 0.025-0.15mm thick (commonly 0.075-0.15mm); septa well developed, represented by 12 laminae with axially spinose edges or longitudinal rows of slender, long septal spines. Spinose edges and spines generally curved upwards. Tabulae complete, mostly concave or sagging, generally very thin (less than 0.05mm), 6-8 per 5mm. Tabularia separated by 0.425-1.5mm of coenenchymal tubules. Coenenchymal tubules 4- to 6-sided in transverse section, 0.1-1.15mm in diameter; coenenchymal walls 0.025-0.125mm thick; diaphragms generally flat, complete or rarely incomplete, 7-13 per 5mm.

Remarks

These specimens are referable to the genus *Pseudoplasmopora* by having an aureola of 12 tubules around each tabularium and tubules normally with flat diaphragms. *Pseudoplasmopora okuhidaensis* is characterized by large corallites, distantly spaced tabulae and the presence of diaphragms (Text-Figs. 8 and 9). Tabulae are generally concave or rarely deeply sagging.

The specimens are clearly distinguished from any other species of the genus by having distantly spaced tabulae and diaphragms (Text-Fig. 9). They are similar to *P. subdecipiens* (in Bondarenko, 1966; p. 160) and *P. cargoensis* (in Bondarenko and Minjin, 1981; p. 116) in tabular frequency, but are quite different from those species in having much smaller tabularia (Text-Figs. 8 and 9).

***Pseudoplasmopora* cf. *arguta* Bondarenko, 1963** Plate 15, Figs. 1-6

cf.1963 *Pseudoplasmopora arguta* Bondarenko: Bondarenko, p. 48, Pl. IV, Fig. 2.

cf.1966 *Pseudoplasmopora arguta* Bondarenko: Bondarenko, p. 162, Pl. XX, Fig. 4.

Reg. No.

Samples: NUM-Fz-010811-33 and NUM-Fz-010811-34. Two samples.

Specimens: NUM-Fz-010811-33-3, NUM-Fz-010811-34-2b and NUM-Fz-010811-34-3. Three specimens.

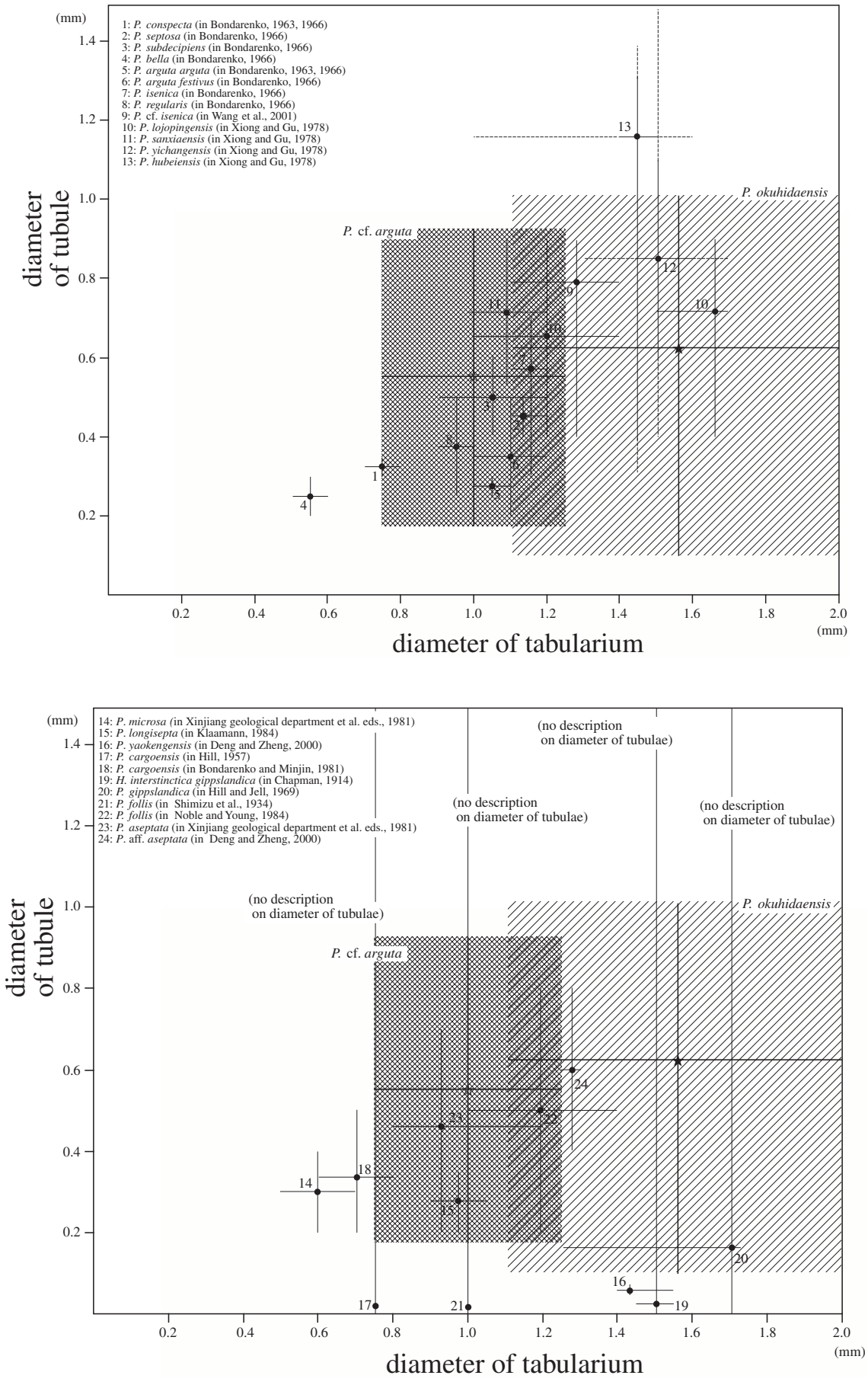
Thin sections: Three (010811-33-3-2, 010811-33-3-1 and 010811-33-3-3), one (010811-34-2-1b), and five (010811-34-3-3, 010811-34-3-4, 010811-34-3-5a, 010811-34-3-6a and 010811-34-3-7a) thin sections cut from NUM-Fz-010811-33-3, NUM-Fz-010811-34-2b and NUM-Fz-010811-34-3 respectively.

Material, horizons and localities

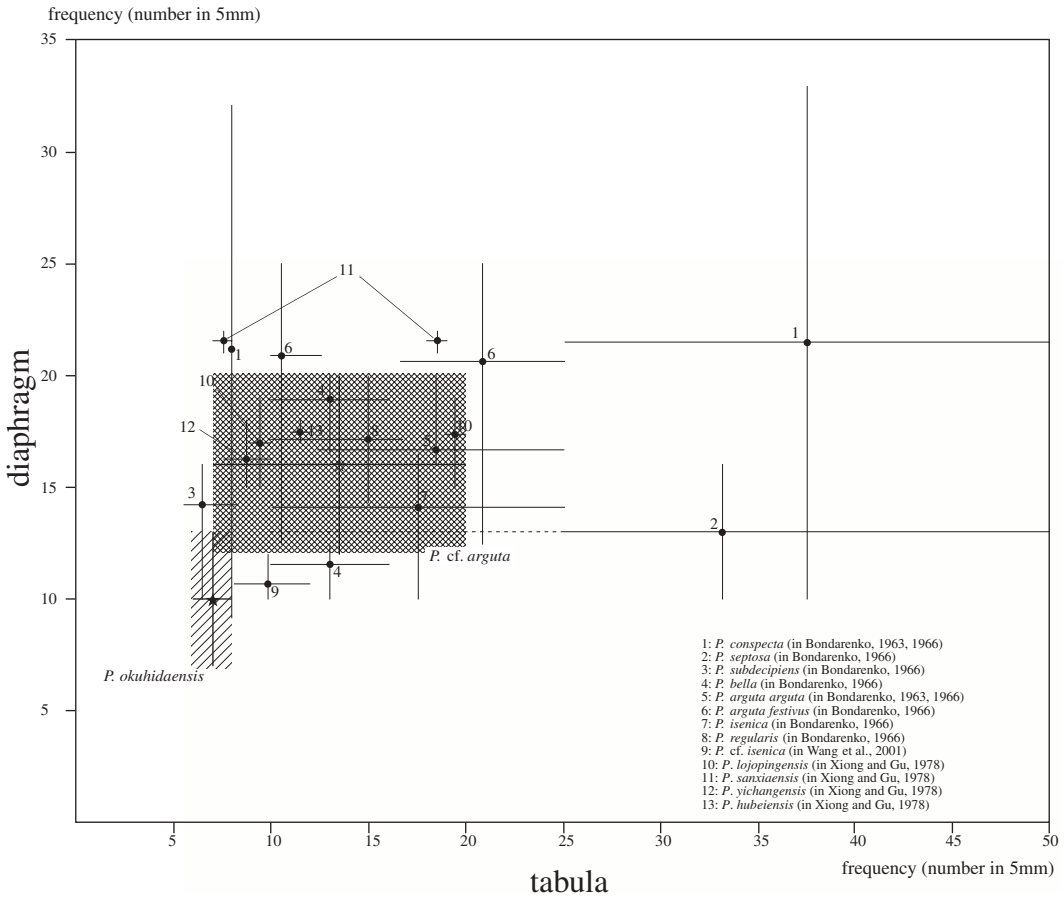
All specimens were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

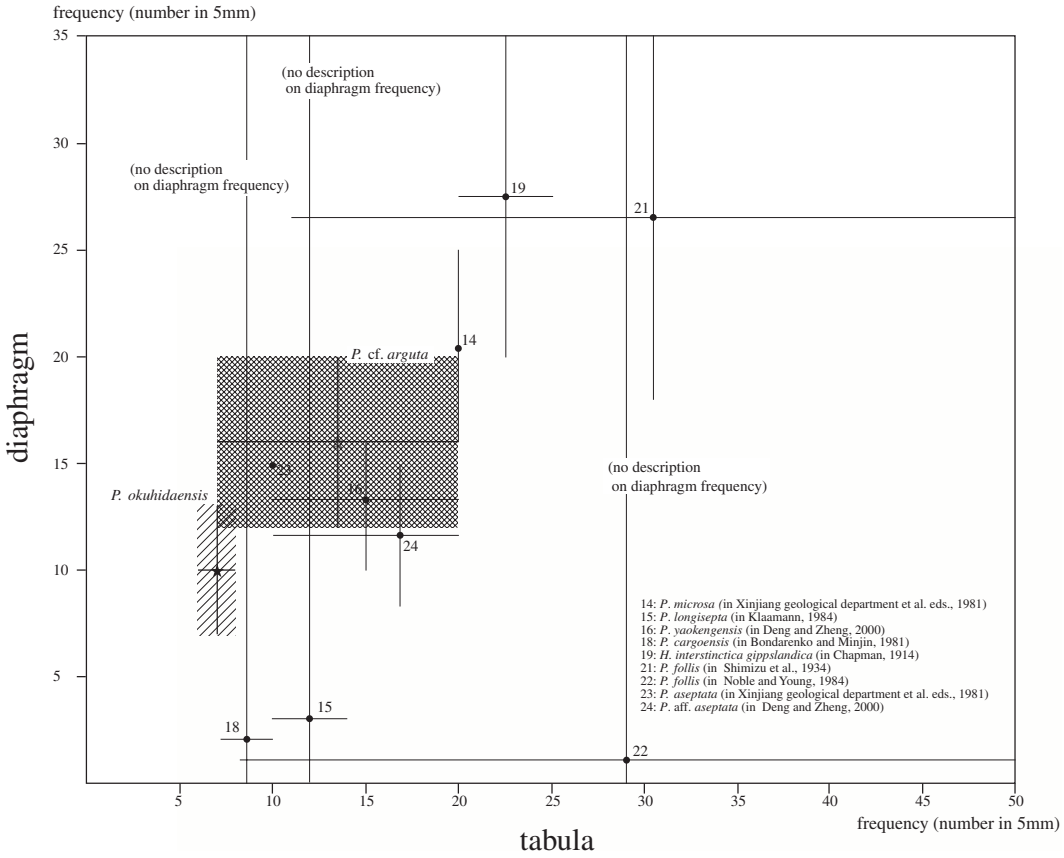
Description

Corallum massive, heliolitoid. Tabularia circular with an aureola of 12 elongated coenenchymal tubules in transverse section, cylindrical, straight, diameter 0.75-1.25mm; walls 0.025-0.125mm thick; septa well-developed, represented by 12 longitudinal rows of long, slender septal spines, curved upwards. Tabulae complete, horizontal, flat or concave or rarely wavy, moderately thick (less than 0.1mm), 7-20 per 5mm. Tabularia separated by 0.65-1.175mm of coenenchymal tubules. Coenenchymal tubules 4- to 5-sided in transverse section, 0.175-0.925mm in diameter; coenenchymal walls 0.025-0.075mm thick; diaphragms flat or rarely concave or convex, 12-20 per 5mm.



Text-Fig. 8. Diameters of tabularia (x-axis) and tubules (y-axis) of *Pseudoplasmopora*.





Text-Fig. 9. Tabular (x-axis) and diaphragm (y-axis) frequencies of *Pseudoplasmopora*.

Remarks

These specimens are referable to the genus *Pseudoplasmopora* by having an aureola of 12 tubules around each tabularium and tubules usually with flat diaphragms. The specimens here are clearly different from *Pseudoplasmopora okuhidaensis* in having much smaller tabularia and coenenchymal tubules, closely spaced diaphragms and lenticular coenenchymal wall-thickening.

The present specimens are clearly distinguished from *P. follis* (in Shimizu, 1934; p. 66 and Noble and Young, 1984; p. 874), *P. gippslandica* (in Chapman, 1914; p. 311 and Hill and Jell, 1969; p. 23), *P. aseptata* (in Xinjiang Geological Department *et al*. eds., 1981; p. 66 and Deng and Zheng, 2000; p. 221), *P. lojopingensis* (in Xiong and Gu, 1978; p. 257), *P. sanxiaensis* (in Xiong and Gu, 1978; p. 258), *P. yichangensis* (in Xiong and Gu, 1978; p. 258), *P. hubeiensis* (in Xiong and Gu, 1978; p. 258), *P. microsa* (in Xinjiang Geological Department *et al*. eds., 1981; p. 66) and *P. yaokengensis* (in Deng and Zheng, 2000; p. 221) in having numerous long septal spines. In addition, they can be distinguished from *P. subdecipiens* (in Bondarenko, 1966; p. 160), *P. yichangensis*, *P. hubeiensis*, *P. aseptata*, *P. yaokengensis* and *P. cargoensis* (in Hill, 1957; p. 104, and Bondarenko and Minjin, 1981; p. 116) by the size of the tabularium and the size of the coenenchymal tubules (Text-Fig. 8). The specimens are quite different from *P. conspecta* (in Bondarenko, 1963; p. 47, and 1966; p. 161) in the spacing of the tabulae and diaphragms (Text-Fig. 9.). *P. isenica* (in Bondarenko, 1966; p. 164, and Wang *et al*., 2001; p. 82) differs in having a larger distance between each tabularium. *P. regularis* (figured in Bondarenko, 1966; p. 165) usually seems to have oblique, incomplete diaphragms. *Pseudoplasmopora* cf. *arguta* here is similar to *P. arguta* described by Bondarenko (1963; p. 48, and 1966; p. 162), but his description of the type specimen did not mention the lenticular coenenchymal wall-thickening.

Superfamily PACHYPORICAE Gerth, 1921

Family PACHYPORIDAE Gerth, 1921

Definition (after Hill, 1981, p. F575). Corallum cerioid and branching; corallites polygonal or rounded-polygonal in cross section and diverging from axis of branch to open usually normal to surface of branch, but toward apex of branch at an acute angle; corallite walls thin and favositoid in axial zones, more or less markedly developed in peripheral zone of branch; original microstructure, when retained, with stereozone consisting of radial fibers deposited in concentric growth laminae; septal spines or rarely squamulae may project from stereozone into tabularium; mural pores and tabulae present.

Genus STRIATOPORA Hall, 1851

Type species. *Striatpora flexuosa* Hall, 1851, p. 97.

Diagnosis (after Hill, 1981, p. F582). Corallum, ramose with cylindrical or slightly compressed branches; corallites curving gently away from axial longitudinal direction and opening obliquely to surface on small branches; calices may show septal ridges. Walls thin in axial zone, thickening to become wide stereozones distally, with distinct growth lamellation; corallites polygonal in section but tabularium cylindrical distally because of wall thickening; mural pores common; septal spines may project into lumen; tabulae complete; new corallites originate in one of two position, either near axis of branch or near boundary between inner thin-walled and outer thick-walled zones; the latter do not produce new corallites.

***Striatopora* sp.** Plate 16, Figs. 1-11; Plate 17, Figs. 1-8

Reg. No.

Samples: NUM-Fz-010809-e, NUM-Fz0o10809-h, NUM-Fz-010811-24, NUM-Fz-010811-28, NUM-Fz-010811-29, NUM-Fz-010811-30, NUM-Fz-010811-31, NUM-Fz-010811-32, NUM-Fz-010811-33

and NUM-Fz-010811-34. Ten samples.

Specimens: NUM-Fz-010809-e-1, NUM-Fz-010809-e-2, NUM-Fz-010809-h-1, NUM-Fz-010811-24-1, NUM-Fz-010811-24-2, NUM-Fz-010811-24-3, NUM-Fz-010811-24-6, NUM-Fz-010811-28-3, NUM-Fz-010811-28-5, NUM-Fz-010811-28-6, NUM-Fz-010811-28-7, NUM-Fz-010811-29-1, NUM-Fz-010811-30-1, NUM-Fz-010811-31-5, NUM-Fz-010811-31-7, NUM-Fz-010811-32-1, NUM-Fz-010811-32-2, NUM-Fz-010811-33-5, NUM-Fz-010811-34-2, NUM-Fz-010811-34-6, NUM-Fz-010811-34-7, NUM-Fz-010811-34-8, NUM-Fz-010811-34-11 and NUM-Fz-010811-34-16. Twenty-four specimens.

Thin sections: Three (010809-e-1-1, 010809-e-1-2 and 010809-e-1-3), three (010809-e-2-1, 010809-e-2-2 and 010809-e-2-3), three (010809-h-1-1, 010809-h-1-2 and 010809-h-1-3), one (010811-24-1-1), one (010811-24-2-1), one (010811-24-1-3-1), two (010811-24-1-6-1 and 010811-24-1-6-3), one (010811-28-3-1), two (010811-28-5-1 and 010811-28-5-2), two (010811-28-6-1 and 010811-28-6-2), one (010811-28-7-1), one (010811-29-1-1b), one 010811-30-1-1), one (010811-31-5-1), one (010811-31-7-1), six (010811-32-1-1, 010811-32-1-2, 01081-32-1-6, 010811-32-1-11b, 010811-32-1-12b, 010811-32-1-13band), two (010811-32-2-1 and 010811-32-2-2), two (010811-33-5-1 and 010811-33-5-2), one (010811-34-2-1), one (010811-34-6-1), two (010811-34-7-1 and 010811-34-7-2), one (010811-34-8-1b), one (010811-34-11-1) and two (010811-34-16-1 and 010811-34-16-2) thin sections cut from NUM-Fz-010809-e-1, NUM-Fz-010809-e-2, NUM-Fz-010809-h-1, NUM-Fz-010811-24-1, NUM-Fz-010811-24-2, NUM-Fz-010811-24-3, NUM-Fz-010811-24-6, NUM-Fz-010811-28-3, NUM-Fz-010811-28-5, NUM-Fz-010811-28-6, NUM-Fz-010811-28-7, NUM-Fz-010811-29-1, NUM-Fz-010811-30-1, NUM-Fz-010811-31-5, NUM-Fz-010811-31-7, NUM-Fz-010811-32-1, NUM-Fz-010811-32-2, NUM-Fz-010811-33-5, NUM-Fz-010811-34-2, NUM-Fz-010811-34-6, NUM-Fz-010811-34-7, NUM-Fz-010811-34-8, NUM-Fz-010811-34-11 and NUM-Fz-010811-34-16 respectively.

Material, horizons and localities

All specimens except for NUM-Fz-010809-e and NUM-Fz-010809-h were from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1). NUM-Fz-010809-e and NUM-Fz-010809-h were from sub-rounded pebbles at Loc.1.

Description

Specimens mostly embedded in limestone matrix. Corallum cerioid, branching, cylindrical, ramose; branches 3-8mm in diameter; corallites rounded or rounded-polygonal in cross section. Corallites diverging from axis to open generally at acute angles to surface but at obtuse angles to surface in a specimen NUM-Fz-010809-e-1, width 0.2-0.9mm. Walls thin and favositoid in axial part (0.025-0.1mm thick) but slightly thickened to form stereozones in peripheral part (0.05-0.2mm thick). Concentric growth laminae in stereozones. Each corallite in contact with thin distinct median suture. Thick, short septal spines present especially at calice. Spines pointing slightly upwards. Squamulae absent. Mural pores numerous, circular or ellipsoidal, large (0.125-0.25mm in diameter). Pores arranged longitudinally on face, ca. 0.6-1.2mm apart. Tabulae absent or very rare.

Genus GERTHOLITES Sokolov, 1955

Type species. *Pachypora curvata* Waagen and Wentzel, 1886 of Gerth, 1921, p. 107.

Other species. *G. xizangensis* Lin, 1984; *G.*? *tebaga* Frugel, 1997.

Diagnosis (after Hill, 1981, p. F582). Corallum branching; branches of radially diverging corallites increasing notably in diameter during growth and opening normal to surface of branch: edge of tabularium raised in calice, variable in size and distant; septal spines visible in calices; skeletal thickening great; mural tunnels vermiform, anastomosing; tabulae rare to absent.

***Gertholites* ? sp.** Plate 17, Figs. 9-10

Reg. No.

Sample: NUM-Fz-010811-34. One sample.

Specimen: NUM-Fz-010811-34-15.

Thin section: One NUM-Fz-010811-34-15-1.

Material, horizons and localities

The specimen was from the Upper Member of the Fukuji Formation, along the Ichinotani Valley, Takayama City, Gifu Prefecture, central Japan (Loc.1).

Description

Corallum branching, cylindrical; branch 2.5mm in diameter, 11.6mm in height; corallites diverging from axis to open at acute angle to surface, width 0.175-0.3mm. Walls in axial part 0.05-0.075mm thick, with peripheral stereozones 0.05-0.275mm thick. Each corallite in contact with thin, distinct median suture. Septal spines, squamulae and tabulae absent. Mural tunnels anastomosing; skeletal thickening heavy.

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飛騨外縁帯デボン系福地層の床板サンゴ化石について　―その1―

東田　和弘（TSUKADA Kazuhiro）名古屋大学博物館

飛騨外縁帯福地地域のデボン系福地層は保存良好なサンゴ化石を多産し，日本の古生界研究の上で重要な地層の一つである．筆者は現在，本層の床板サンゴ化石群集について検討を進めているが，その一部が明らかになったのでここに報告する．

本研究では，岐阜県高山市福地の一ノ谷沿いで福地層の 7 地点（(Locs. 1 to 7）より，合計420kgの含サンゴ化石試料を採取した．そのうち 1 地点（Loc. 1）の約 63kg の試料について検討した結果，以下の床板サンゴ化石が同定された．*Favosites goldfussi, F. flexuosus, F.* sp. A, *Squameopora hidensis, S. zhanwaensis fukujiensis* subsp. nov., *S.* cf. *zhanwaensis, Sapporipora kamitakaraensis* sp. nov., *Sa. karatanioum* sp. nov., *Heliolites wenxianicus, H.* cf. *gemina, H. ichinotaniensis* sp. nov., *H.* ? sp., *Helioplasma takayamaensis* sp. nov., *Pseudoplasmopora okuhidaensis* sp. nov., *P.* cf. *arguta, Striatopora* sp., *Gertholites* ? sp.

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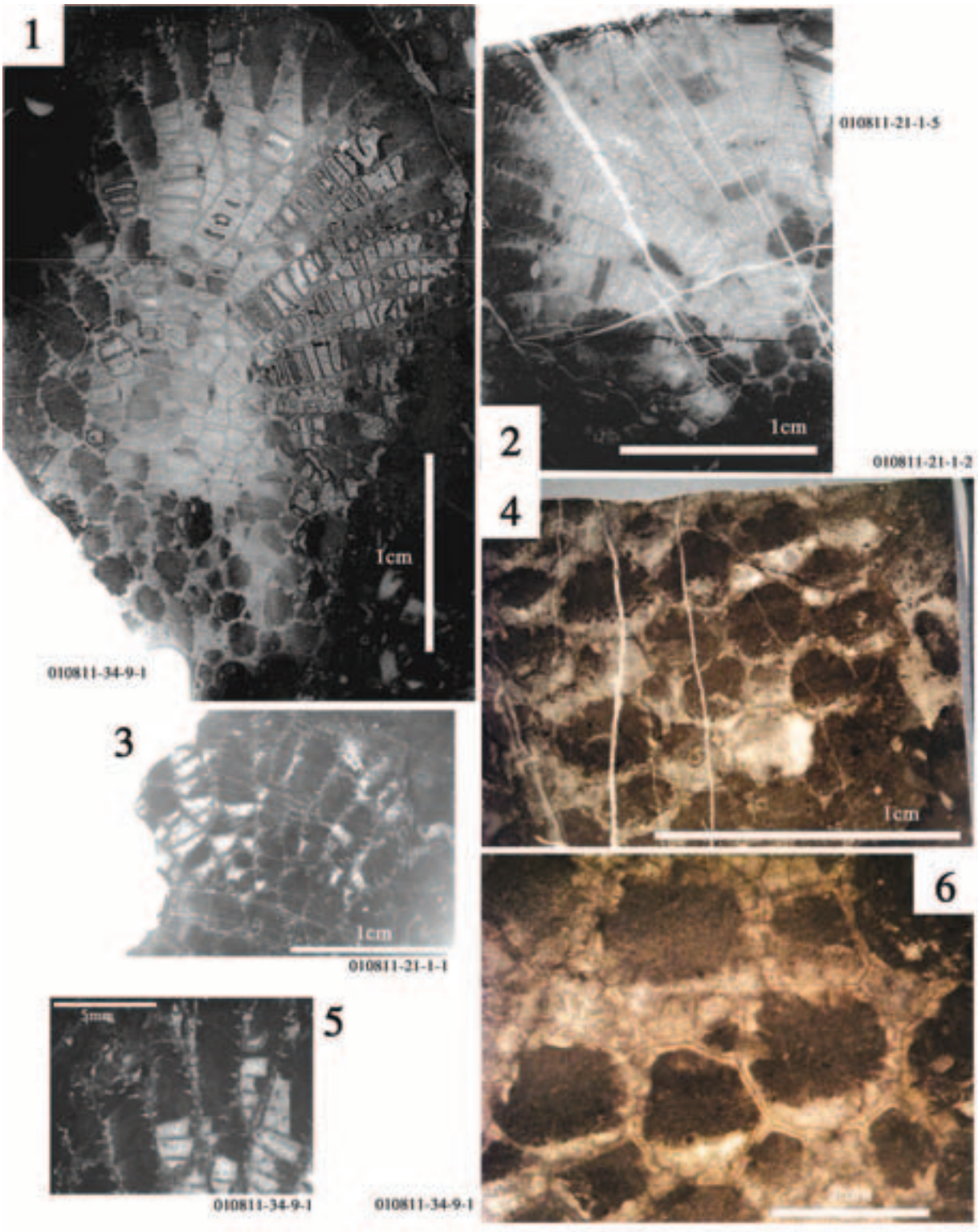
PLATE

Plate 1

***Favosites goldfussi* d'Orbigny, 1850**

Figs. 1 and 2 Transverse and longitudinal thin section. Fig. 3 Longitudinal thin section. Fig. 4 Transverse thin section. Fig. 5 Longitudinal thin section. Fig. 6 Transverse thin section.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010811-34-9-1
6
010811-34-9-1

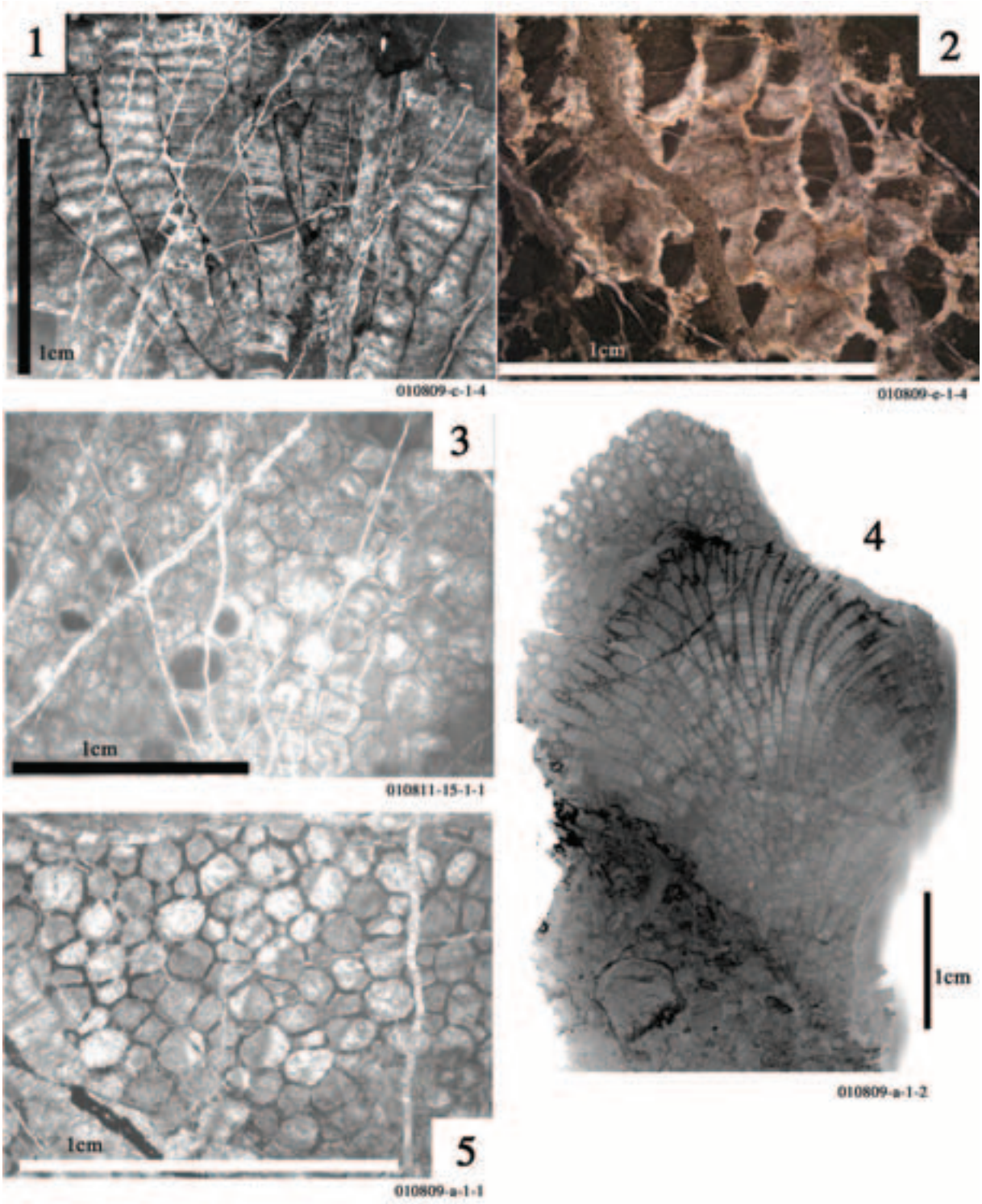
Plate 2

***Favosites flexuosus* Kamei, 1955**

Fig. 1 Longitudinal thin section. Figs. 2-3 Transverse thin section.

***Favosites* sp. A**

Fig. 4 Longitudinal thin section. Fig. 5 Transverse thin section.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1cm
010809-a-1-1

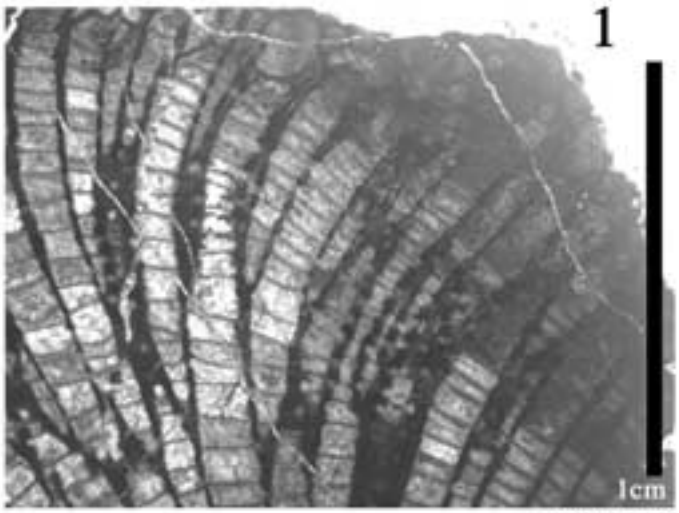
Plate 3

***Favosites* sp. A**

Fig. 1 Longitudinal thin section. Fig. 2 Close up view of Fig. 1. Fig. 3 Transverse thin section.

***Squameopora hidensis* (Kamei, 1955)**

Fig. 4 Close up view of Fig. 5. Fig. 5 Transverse and longitudinal thin section.



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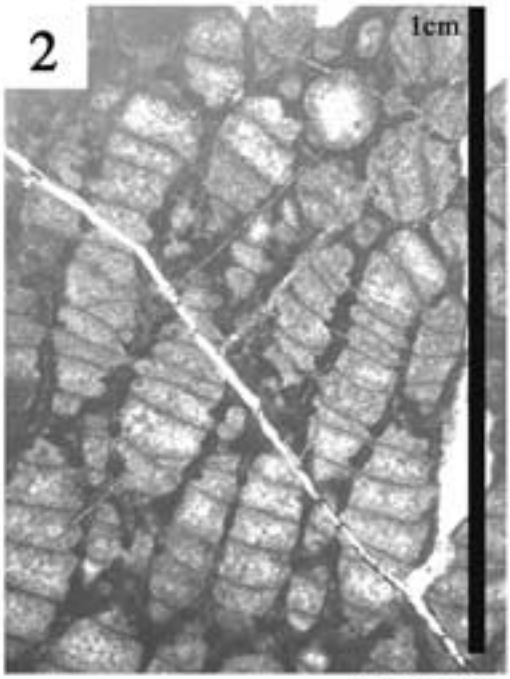

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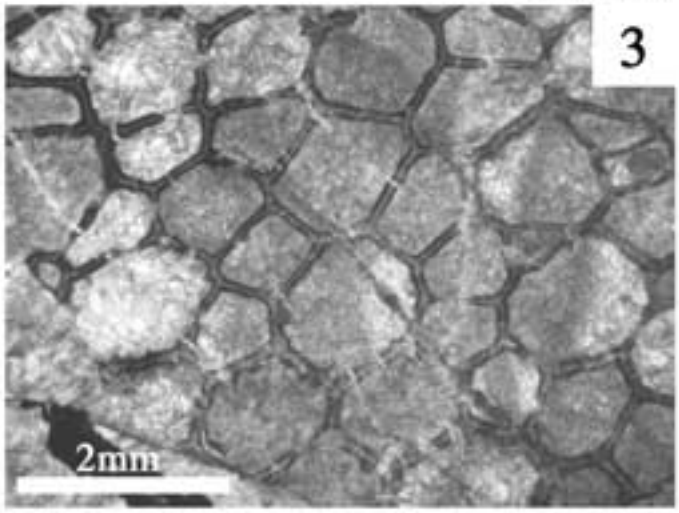

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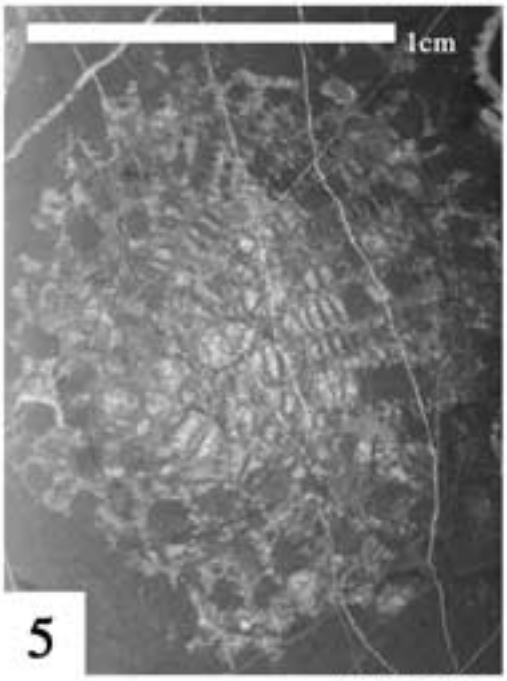

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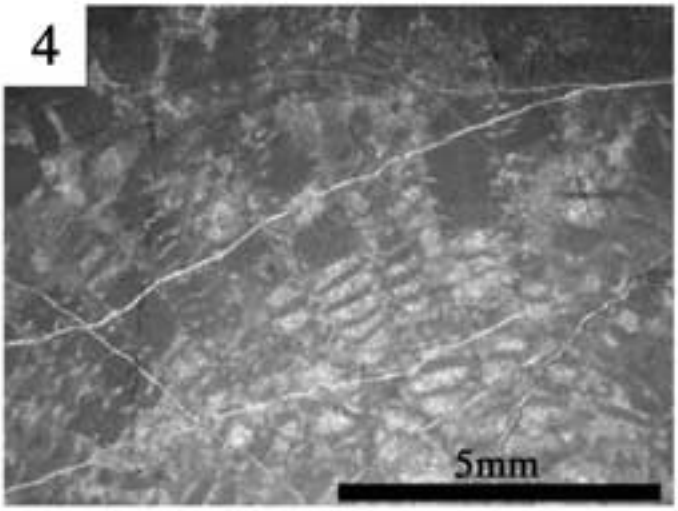

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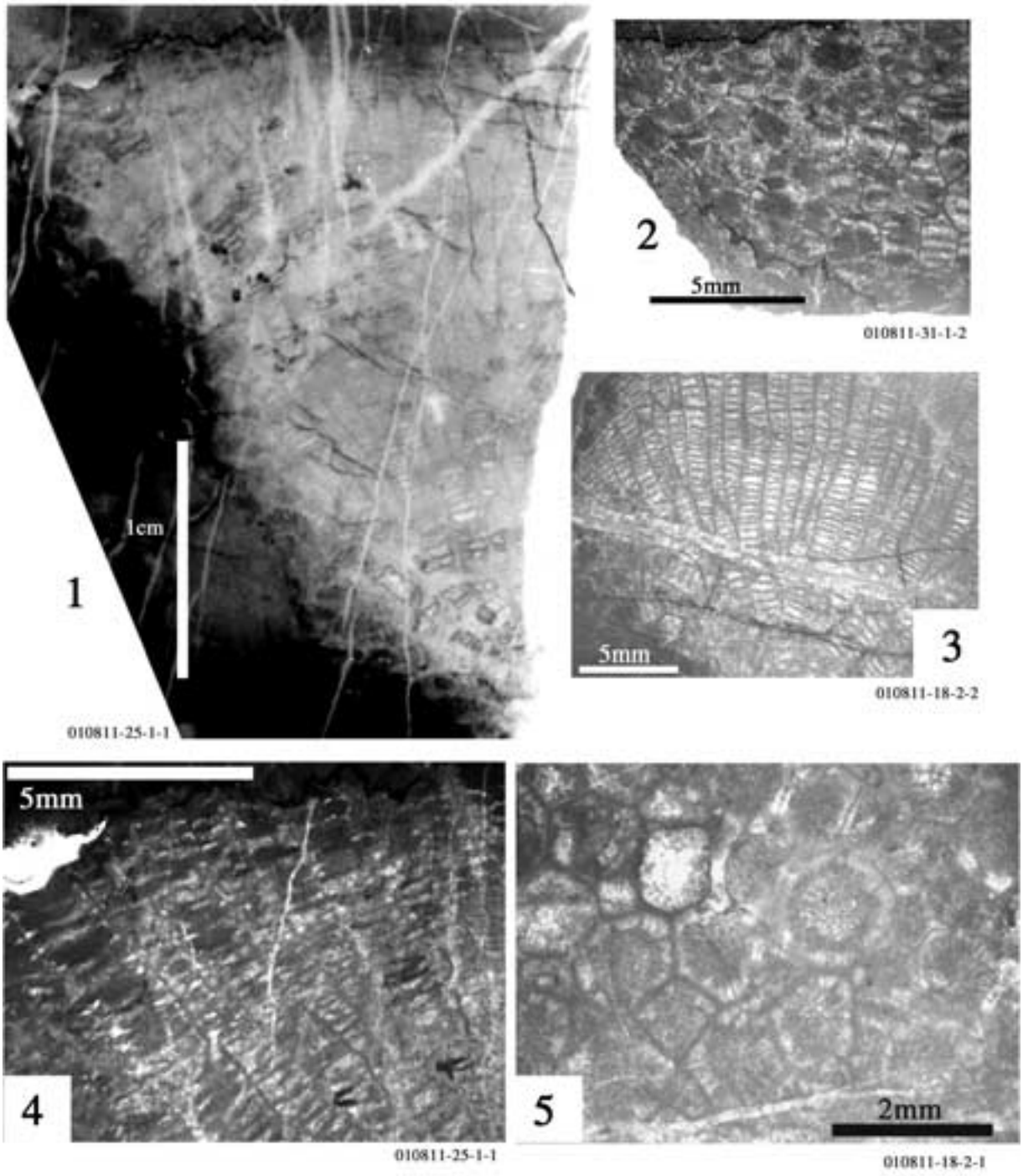
Plate 4

***Squameopora hidensis* (Kamei, 1955)**

Figs. 1-4 Longitudinal thin section. Fig. 5 Transverse thin section.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010811-18-2-1

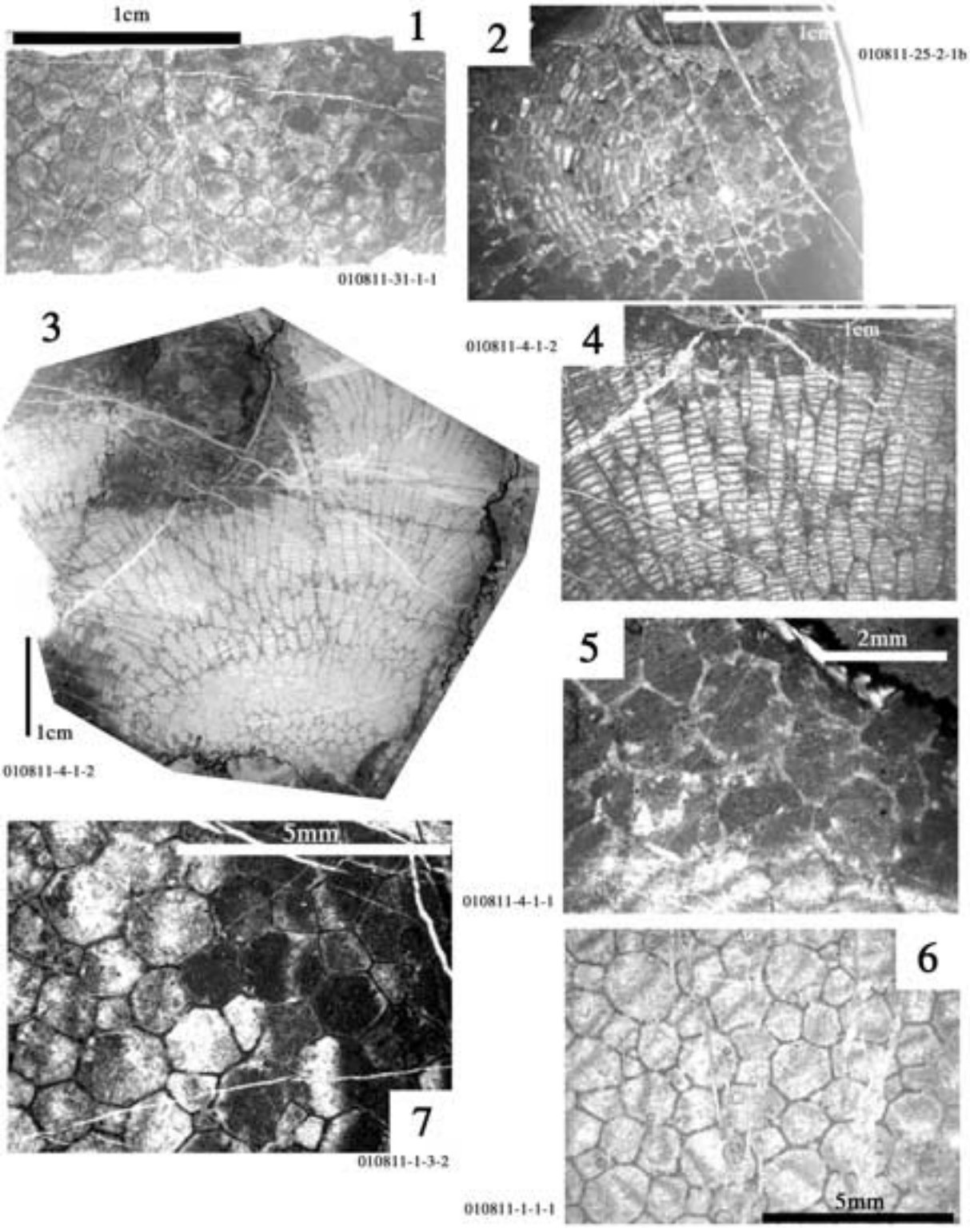
Plate 5

***Squameopora hidensis* (Kamei, 1955)**

Fig. 1 Transverse thin section. Fig. 2 Transverse and longitudinal thin section.

***Squameopora zhanwaensis fukujiensis* subsp. nov.**

Figs. 3-4 Longitudinal thin section. Figs. 5-7 Transverse thin section.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010811-4-1-1
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7
010811-1-3-2
6
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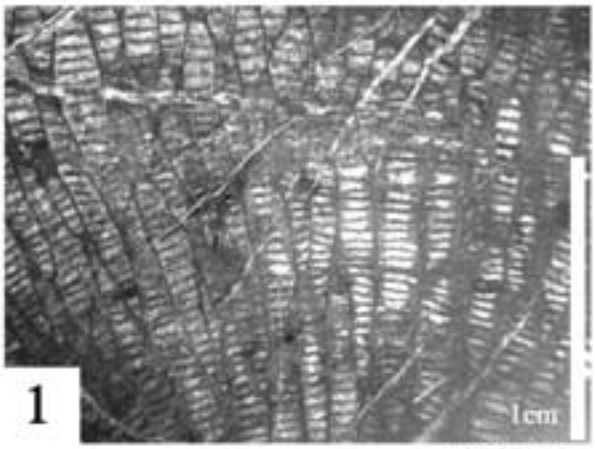
Plate 6

***Squameopora* cf. *zhanwaensis* Lin and Huang, 1987**

Figs. 1, 3 and 5 Longitudinal thin section. Figs. 2 and 4 Transverse thin section. The arrow in Fig. 2 shows squamula.



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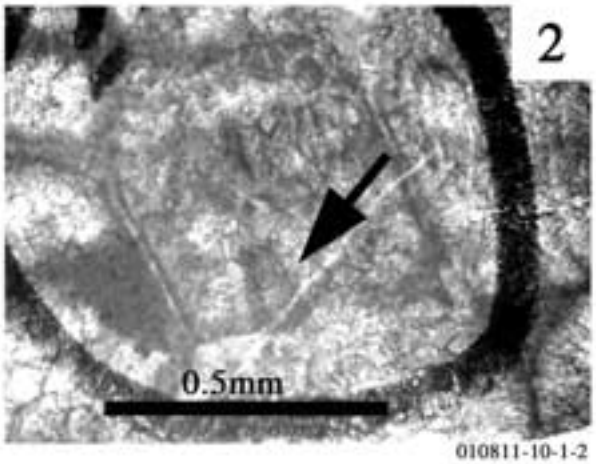

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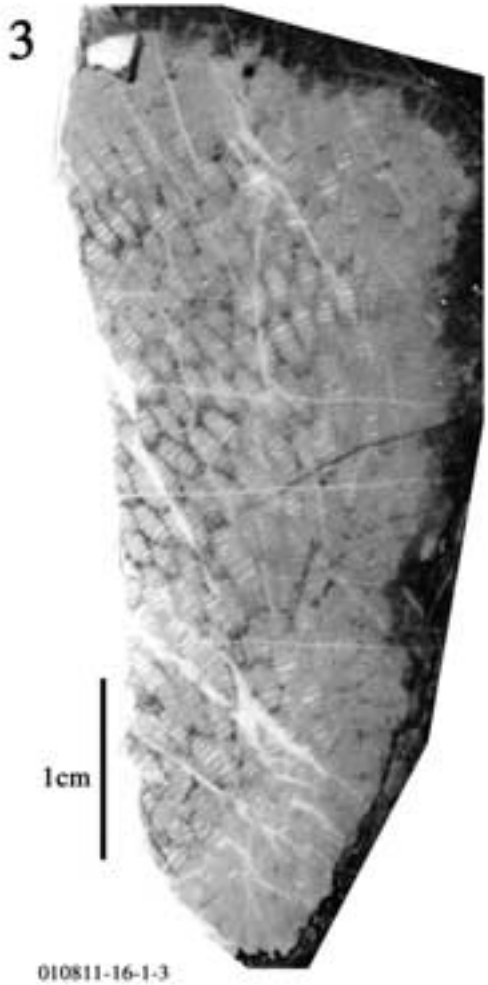

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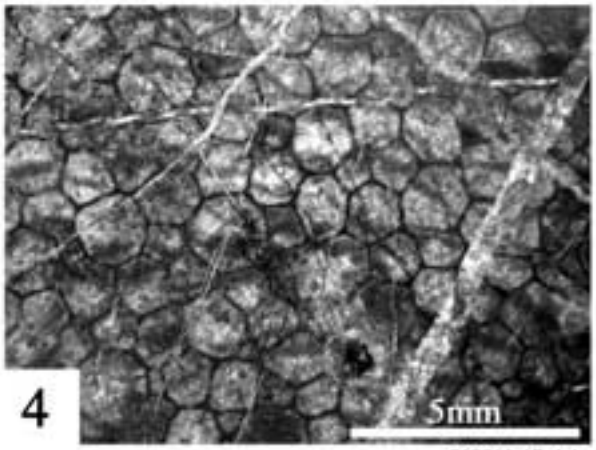

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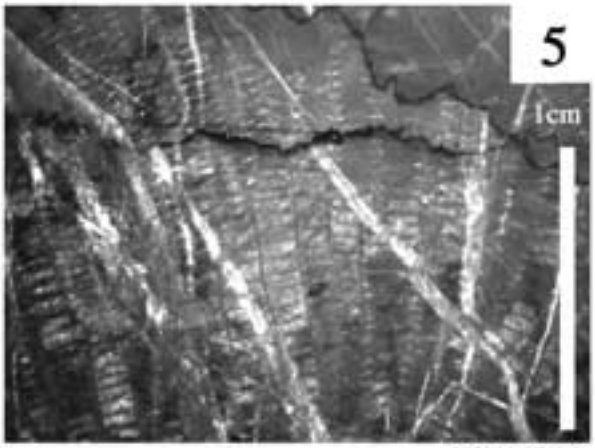

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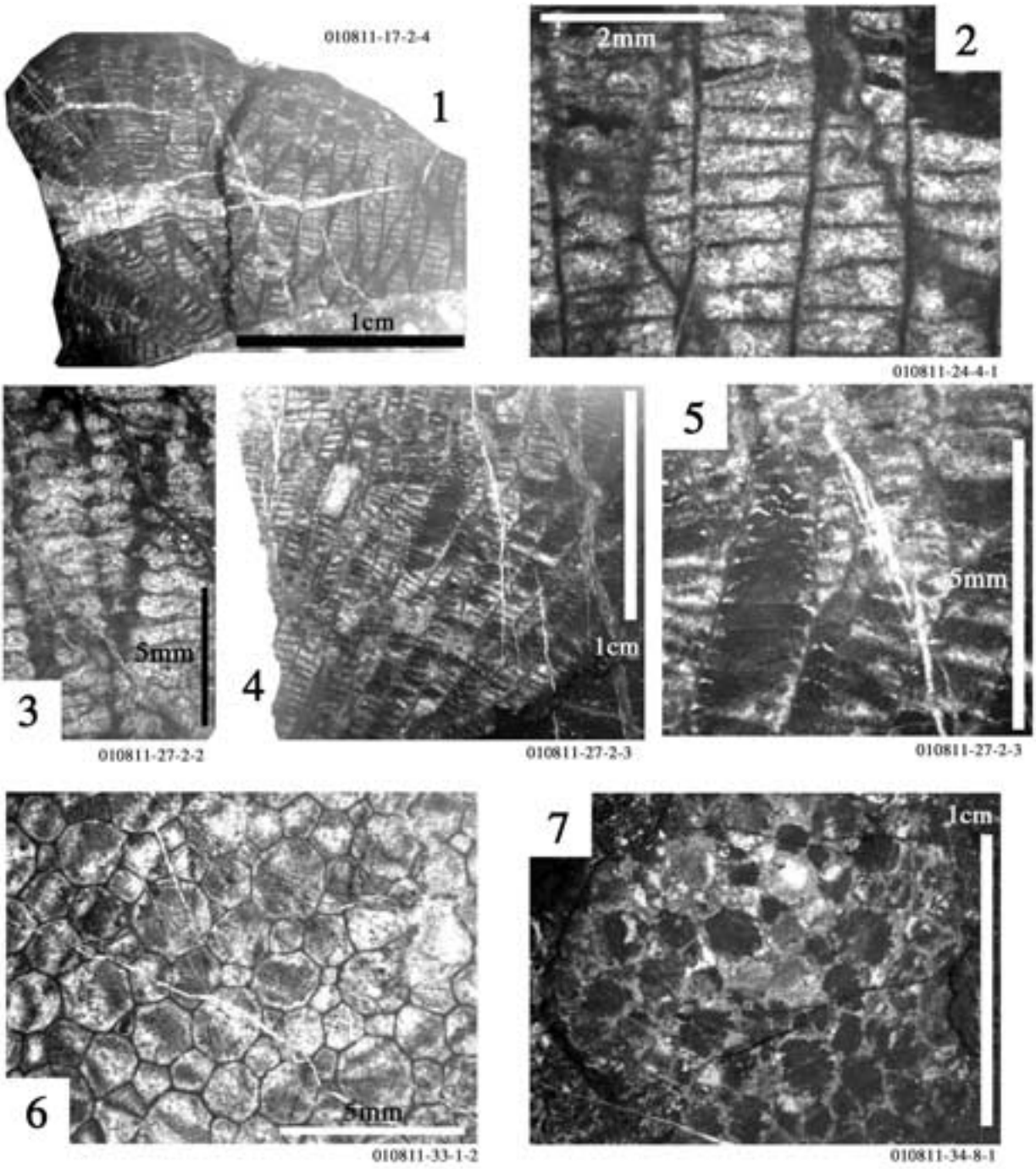
Plate 7

***Squameopora* cf. *zhanwaensis* Lin and Huang, 1987**

Figs. 1-5 Longitudinal thin section. Figs. 6-7 Transverse thin section.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010811-33-1-2
7
1cm
010811-34-8-1

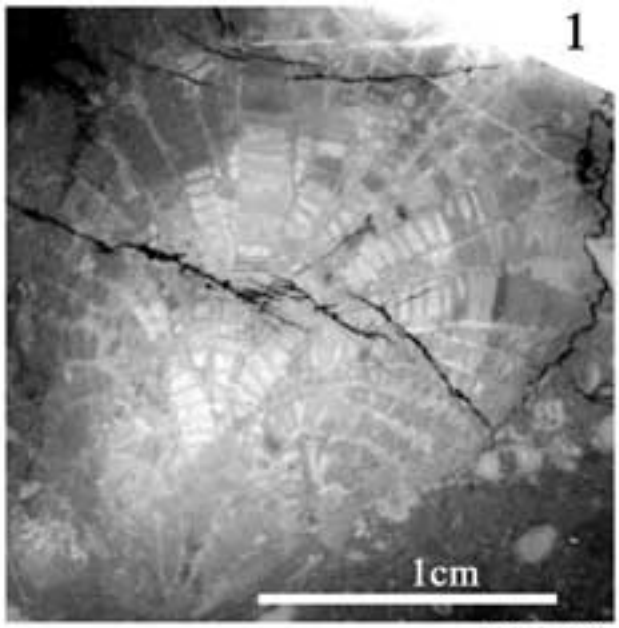
Plate 8

***Squameopora* cf. *zhanwaensis* Lin and Huang, 1987**

Figs. 1-2 Longitudinal thin section.

***Sapporipora kamitakaraensis* sp. nov.**

Figs. 3-4 Longitudinal thin section. Fig. 5 Transverse thin section.



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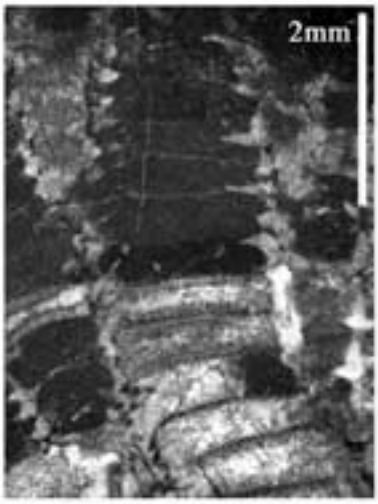

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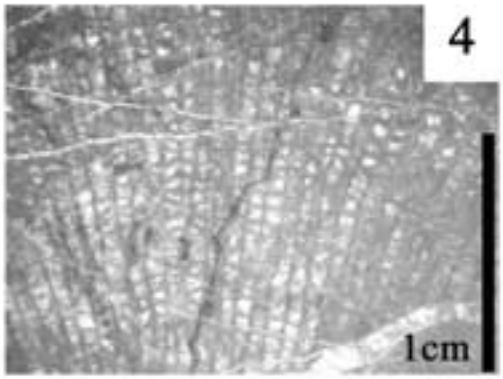

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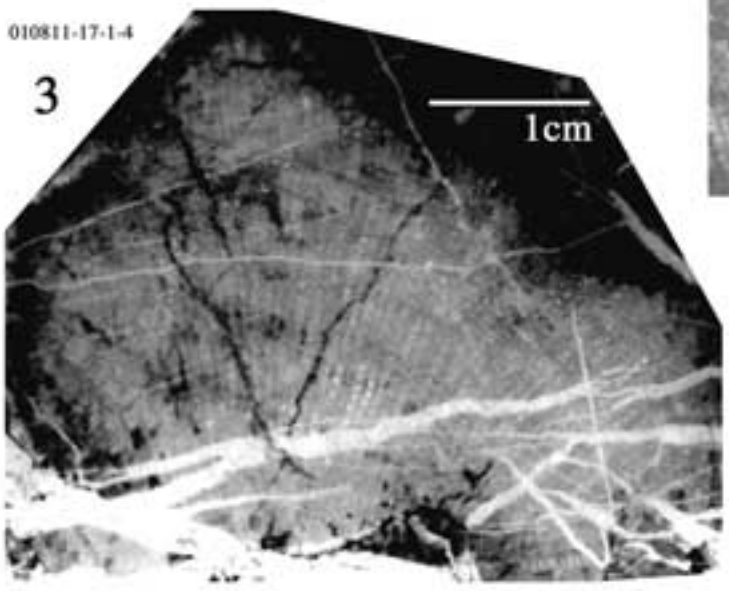
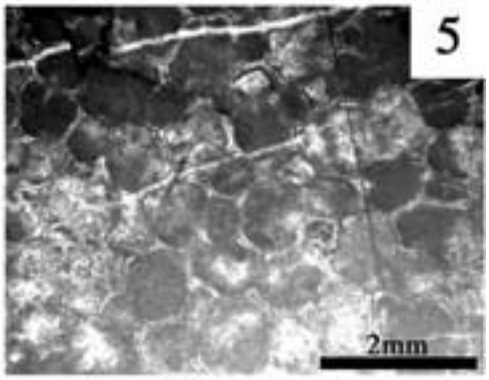




010811-17-1-1

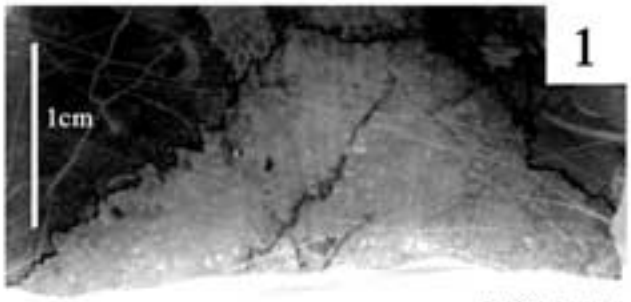
Plate 9

***Sapporipora kamitakaraensis* sp. nov.**

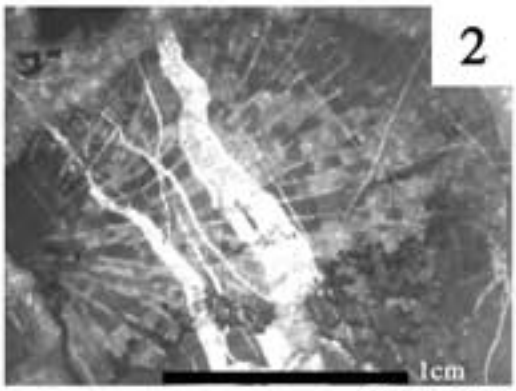
Figs. 1-2 and 5 Longitudinal thin section. Fig. 3 Transverse thin section. Fig. 4 Close up view of Fig. 3.

***Sapporipora karatanioum* sp. nov.**

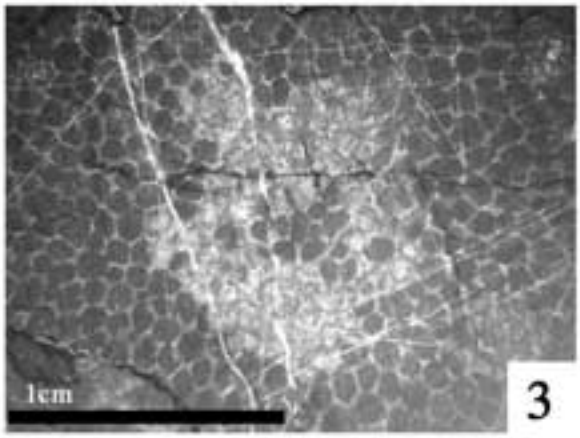
Fig. 6 Transverse and longitudinal thin section.



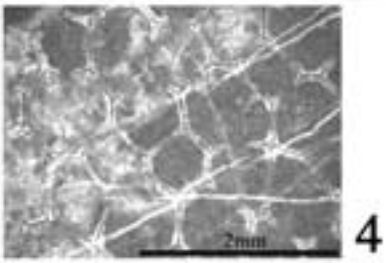
010811-17-1-2



010811-17-2-4b



010811-5-1-2



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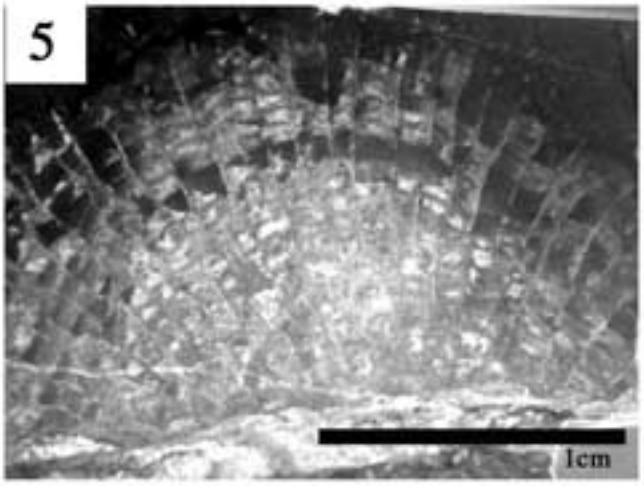
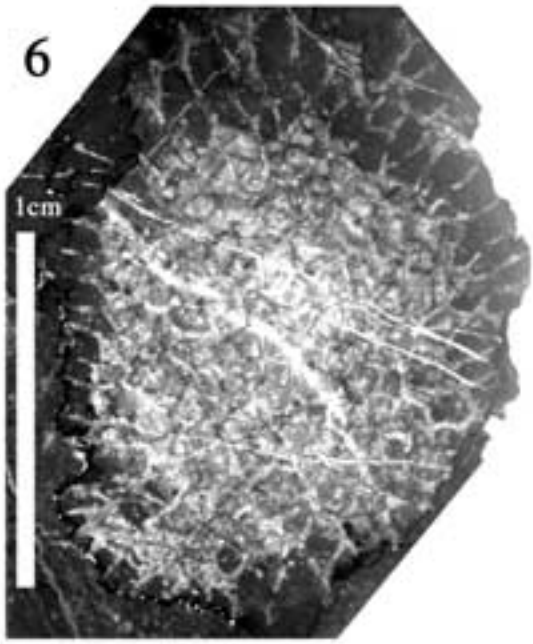


010811-24-7-2

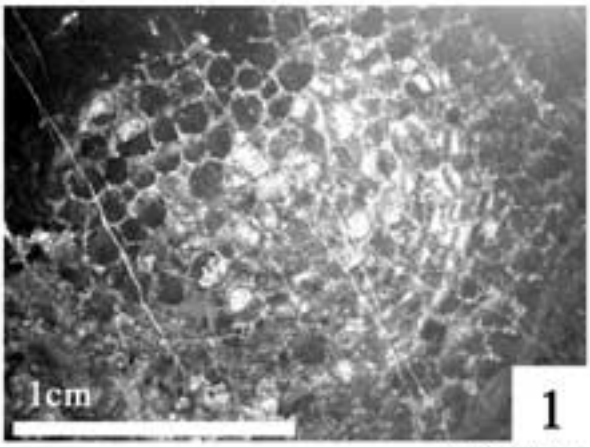


010811-33-2-2

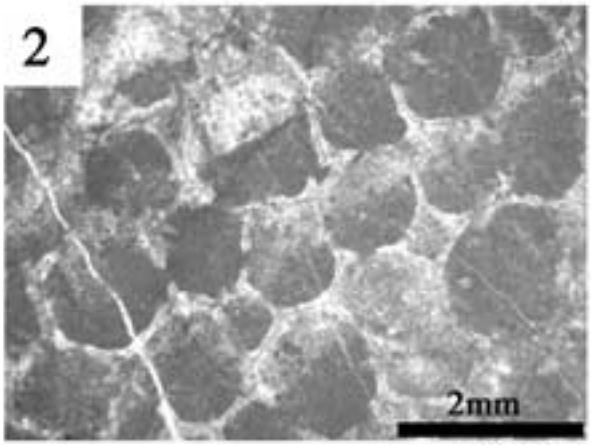
Plate 10

***Sapporipora karataniorum* sp. nov.**

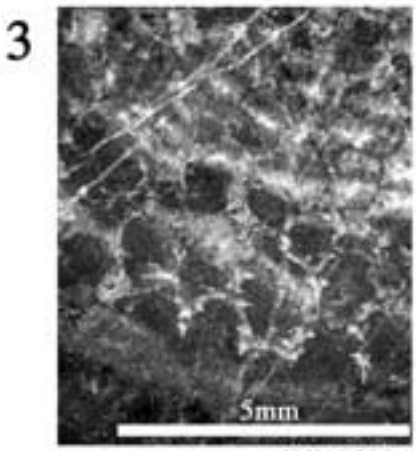
Fig. 1 Transverse thin section. Figs. 2-3 Close up view of Fig. 1. Fig. 4 Transverse and longitudinal thin section. Fig. 5 Close up view of Fig. 4. Fig. 6 Longitudinal thin section.



010811-25-3-1



010811-25-3-1



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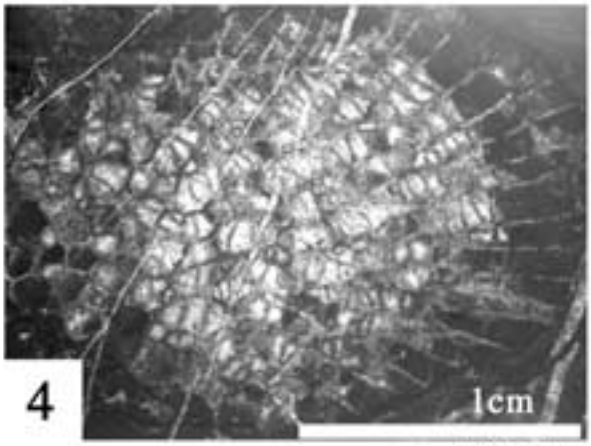

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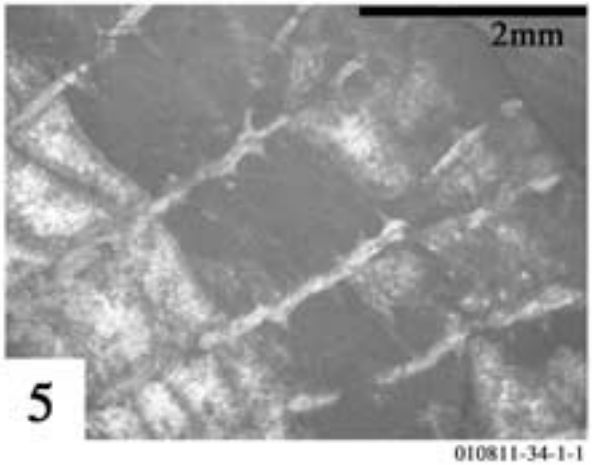

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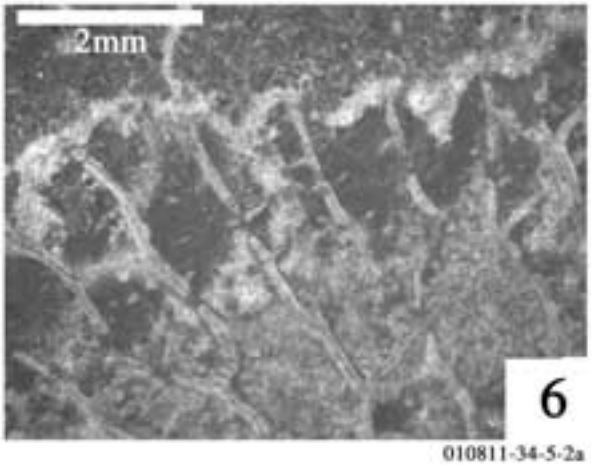


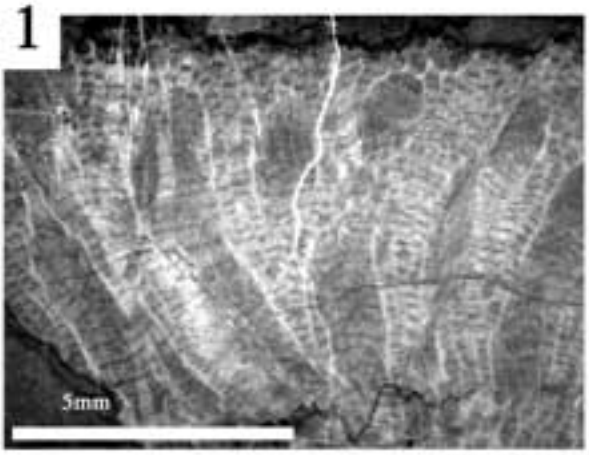
010811-34-5-2a

Plate 11

***Heliolites wenxianicus* Zhang, 1981**

Figs. 1 and 5 Longitudinal thin section. Figs. 2-4 Transverse thin section.

1



010811-b-1-7

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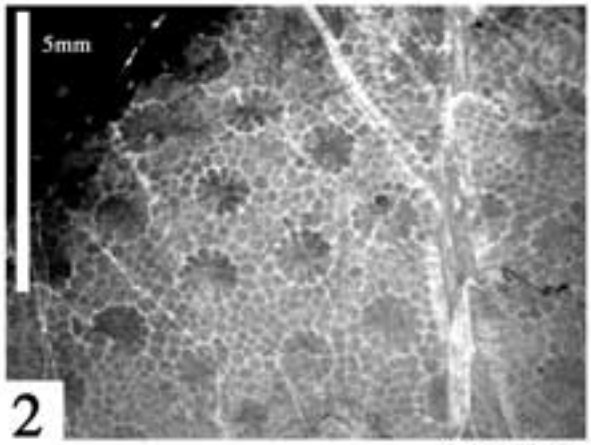

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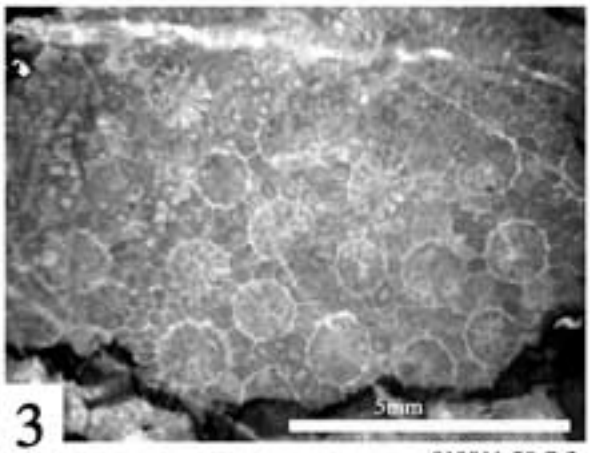
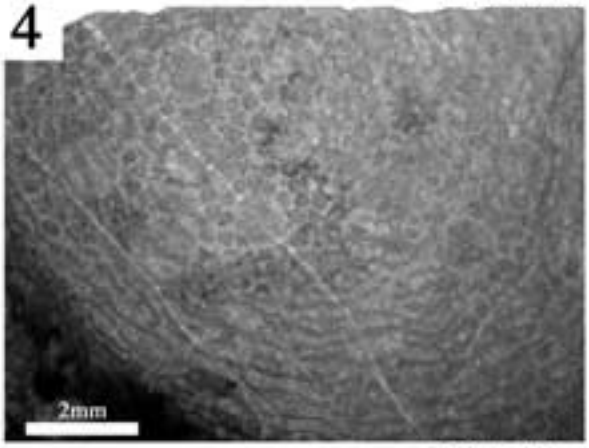


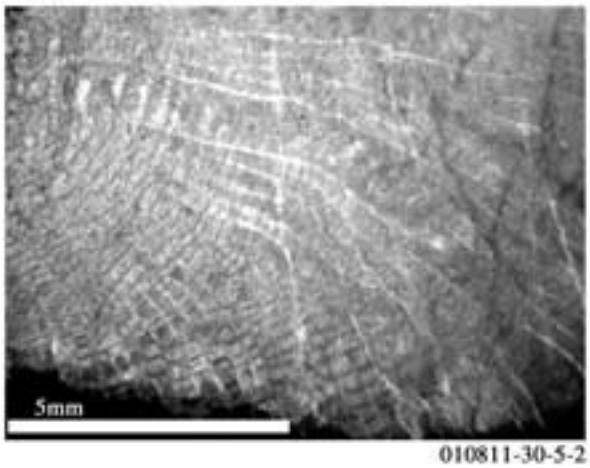
010811-28-7-2

4



010811-30-5-1

5



010811-30-5-2

Plate 12

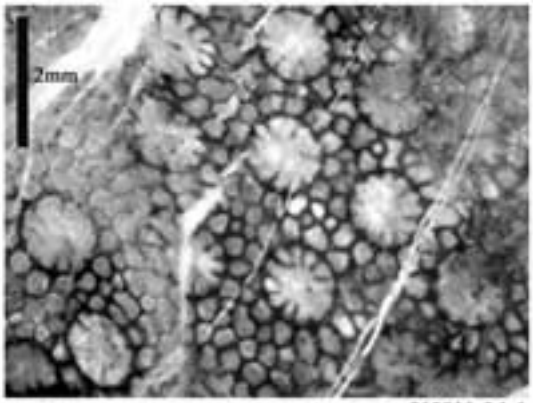
***Heliolites* cf. *gemina* (Tchi, 1976)**

Fig. 1 Transverse thin section. Figs. 2-3 Longitudinal thin section.

***Heliolites ichinotaniensis* sp. nov.**

Fig. 4 Transverse thin section. Fig. 5 Close up view of Fig. 4. Figs. 6-7 Longitudinal thin section.

1



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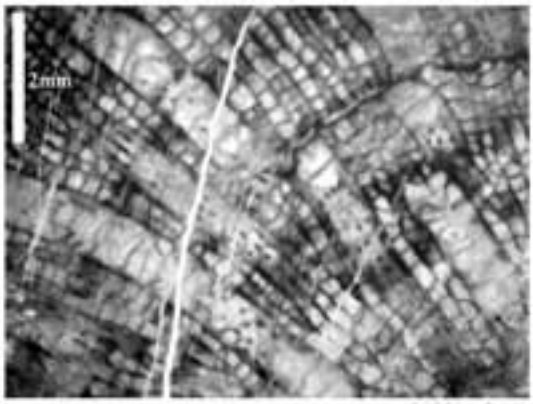

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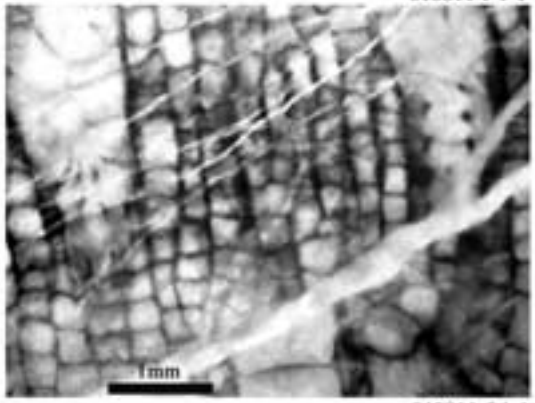

010811-f-1-1

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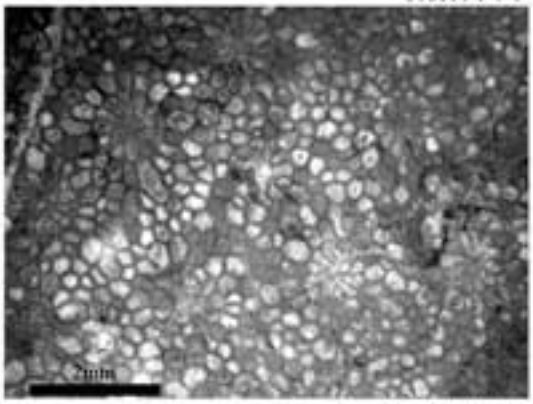

010811-18-1-1

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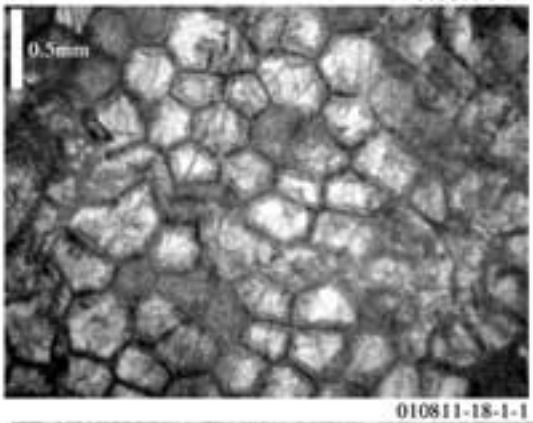

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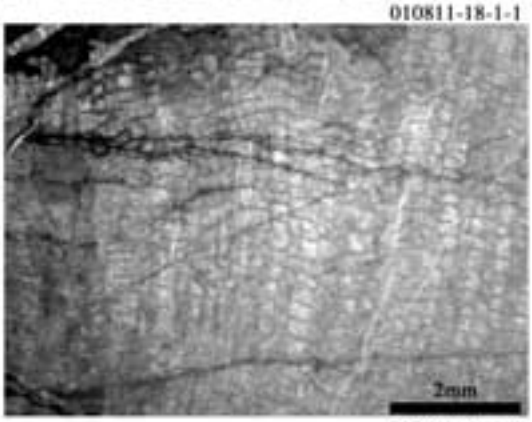
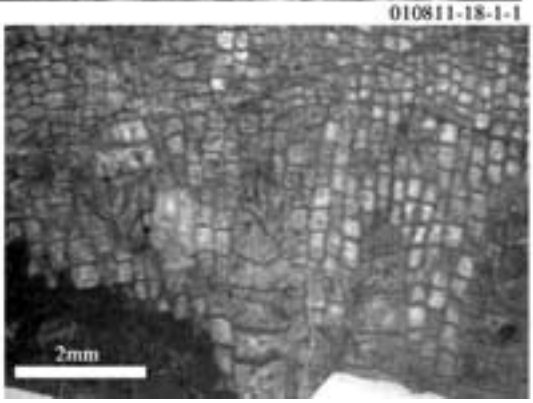


010811-18-1-3

7



010811-18-1-3

Plate 13

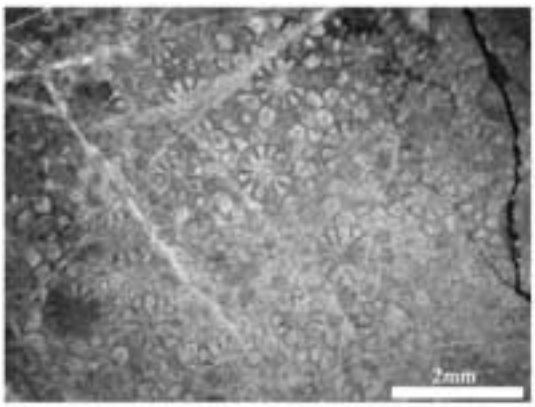
***Heliolites* ? sp.**

Fig. 1 Transverse thin section. Figs. 2-4 Longitudinal thin section.

***Helioplasma* sp. A**

Fig. 5 Transverse thin section. Figs. 6-8 Longitudinal thin section.

1



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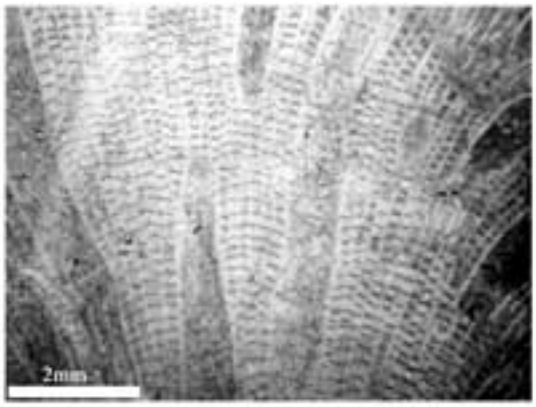

010811-34-12-3

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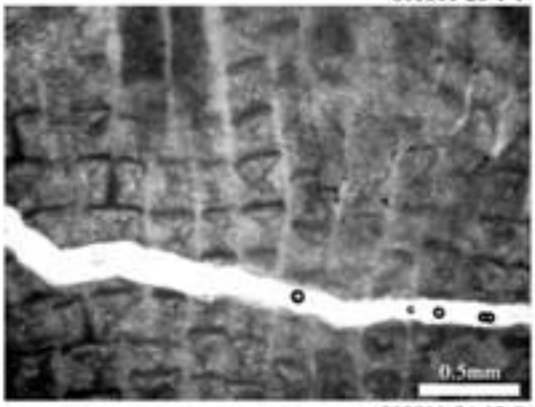

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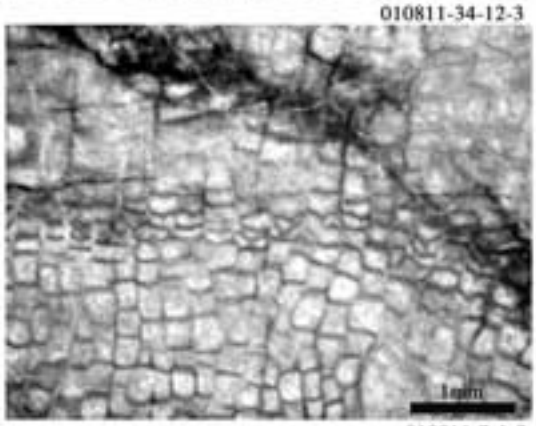

010811-7-1-2

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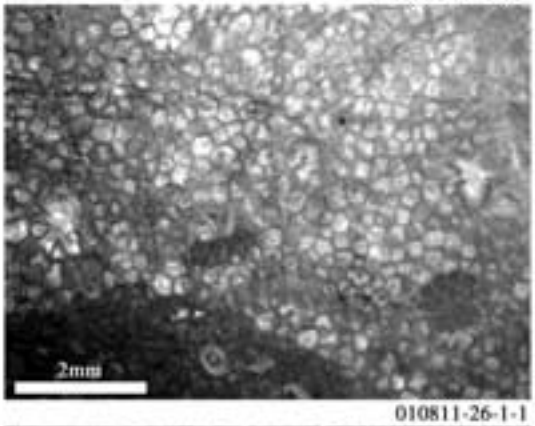

010811-26-1-1

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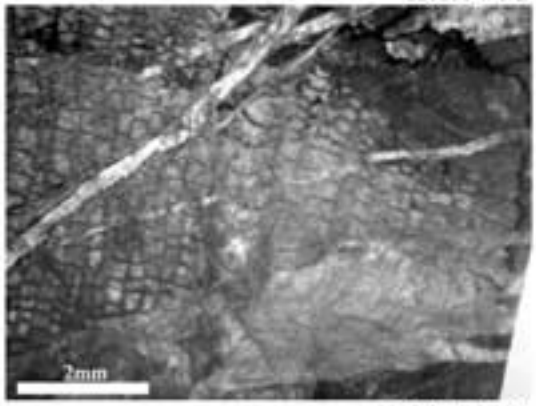

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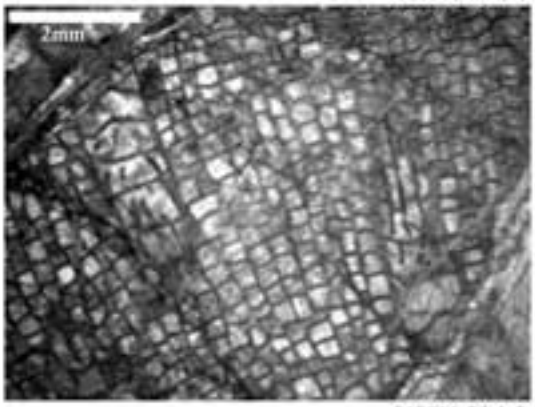

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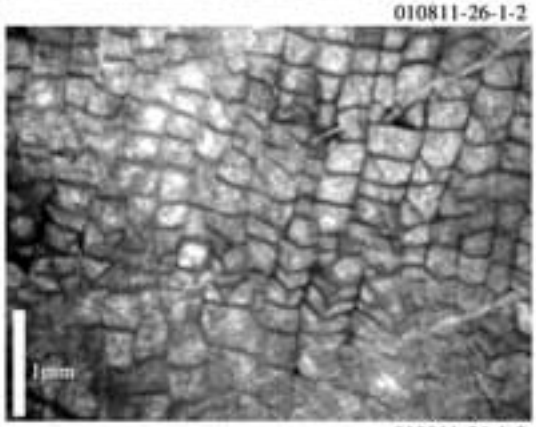
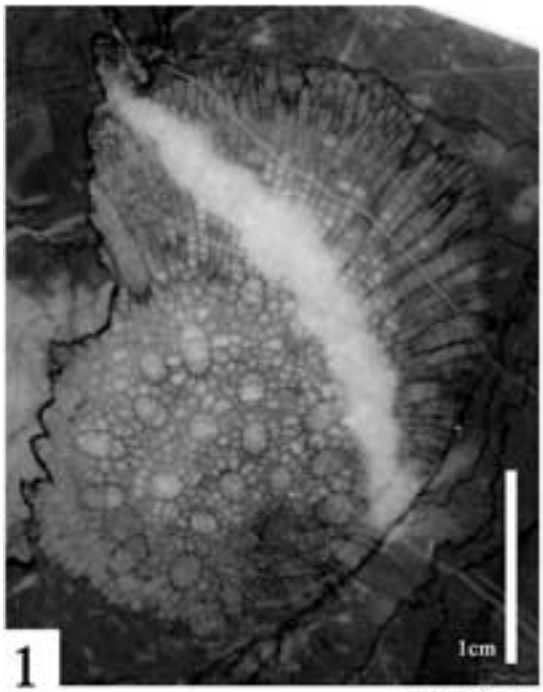


010811-26-1-2

Plate 14

***Pseudoplasmopora okuhidaensis* sp. nov.**

Fig. 1-2 Transverse and longitudinal thin section. Figs. 3 and 7 Transverse thin section. Figs. 4-6 Longitudinal thin section.



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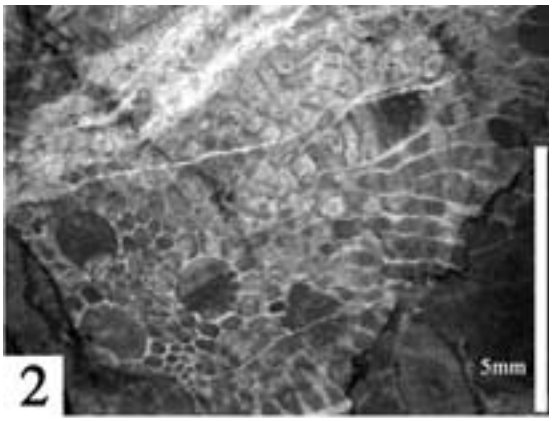
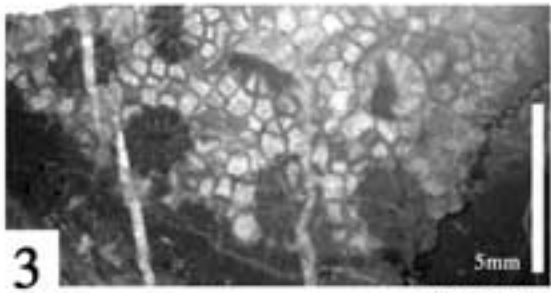
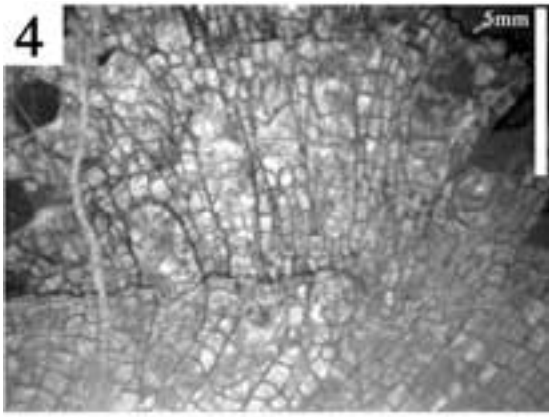


010811-34-5-2b



010811-28-4-4



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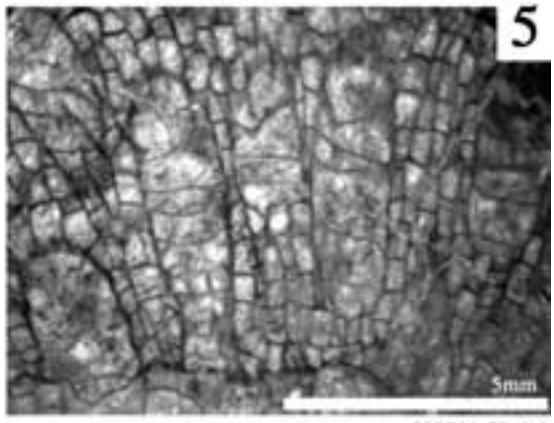

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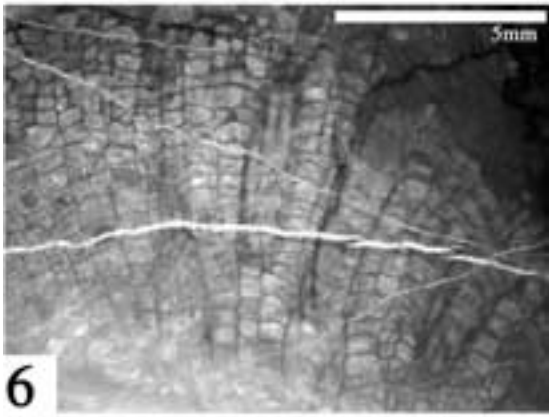

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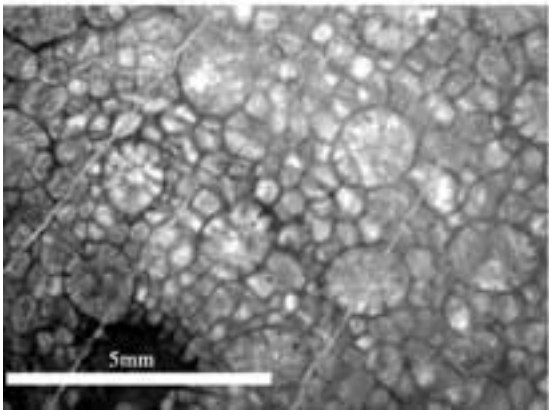


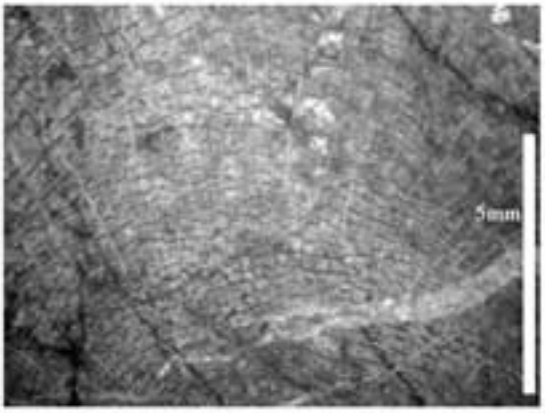
010811-33-4-1

Plate 15

***Pseudoplasmopora* cf. *arguta* Bondarenko, 1963**

Figs. 1-2 and 5 Longitudinal thin section. Figs. 3-4 Transverse and longitudinal thin section. Fig. 6 Transverse thin section.

1



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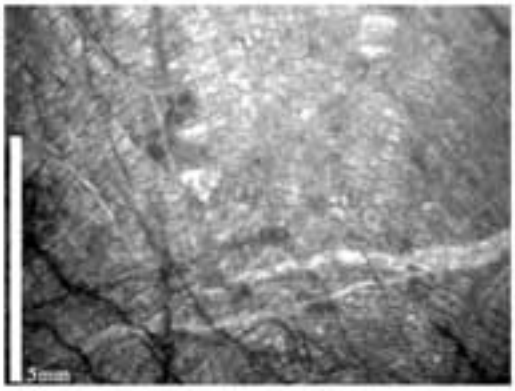

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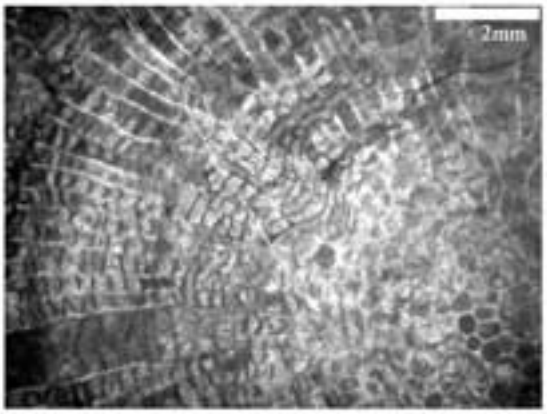
3



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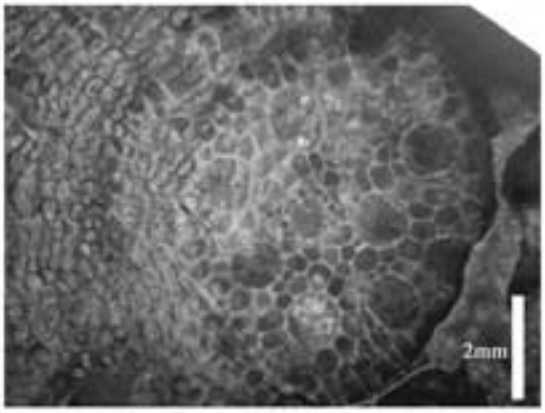

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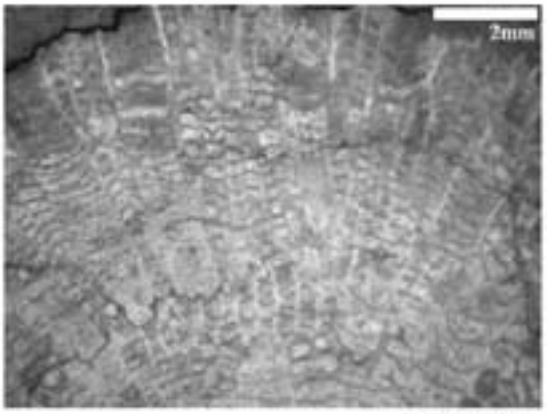
5



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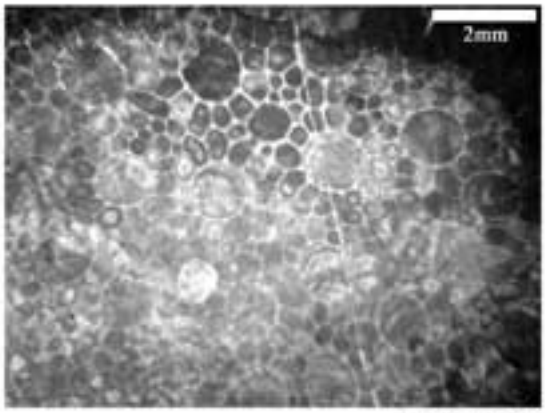
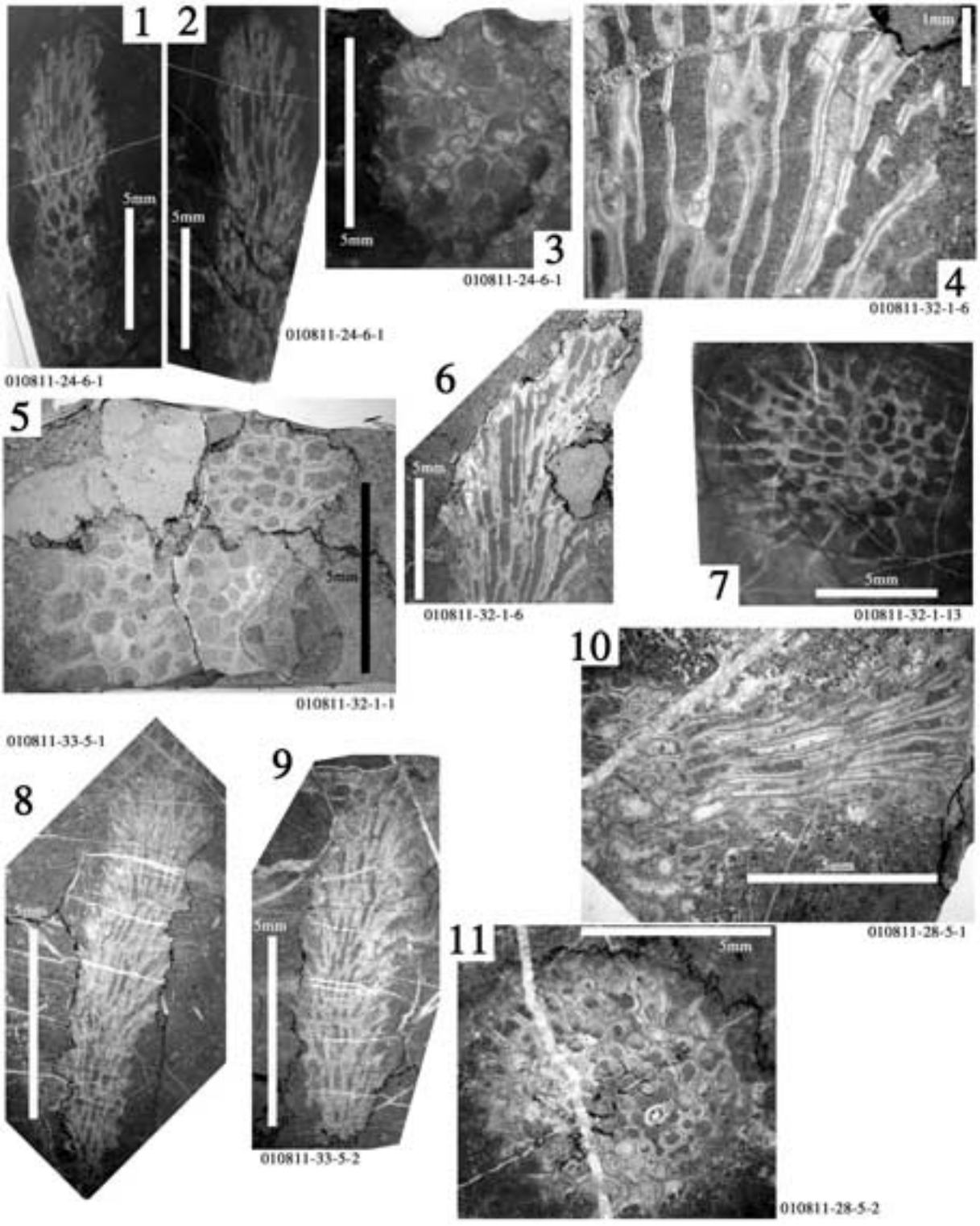


010811-34-3-6

Plate 16

***Striatopora* sp.**

Figs. 1, 2, 6, 8 and 9 Longitudinal thin section. Fig. 4 Close up view of Fig. 6. Figs. 3 and 5 Transverse thin section. Figs. 7, 10 and 11 Tangential section.


1
2
5mm
5mm
010811-24-6-1
010811-24-6-1
3
5mm
010811-24-6-1
4
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5
5mm
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6
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010811-32-1-6
7
5mm
010811-32-1-13
010811-33-5-1
8
5mm
9
5mm
010811-33-5-2
10
5mm
010811-28-5-1
11
5mm
010811-28-5-2

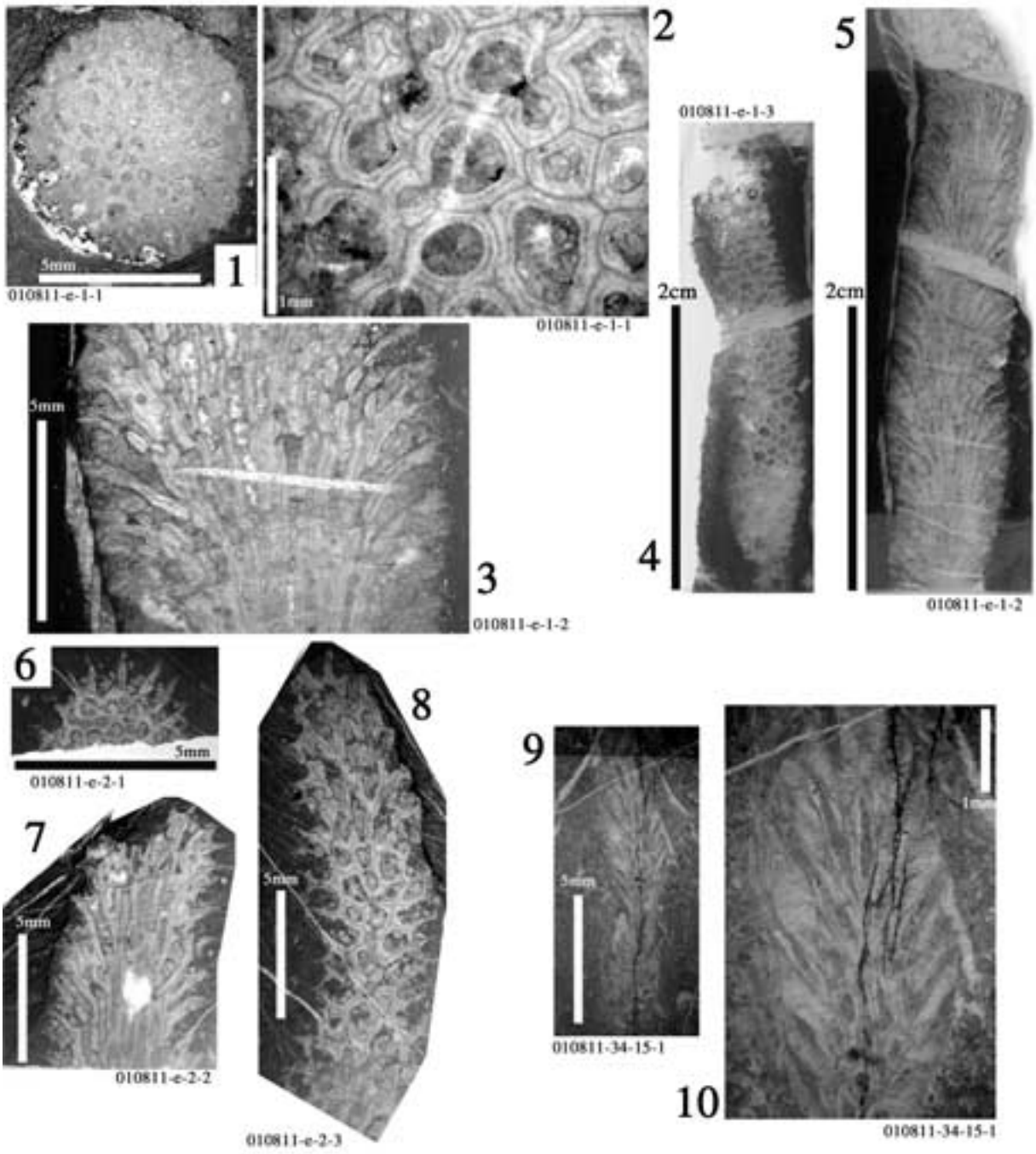
Plate 17

***Striatopora* sp.**

Figs. 1 and 6 Transverse thin section. Fig. 2 Close up view of Fig. 1. Fig. 3 Close up view of Fig. 5. Figs. 4-5 and Figs. 7-8 Longitudinal thin section.

***Gertholites* ? sp.**

Fig. 9 Longitudinal thin section. Fig. 10 Close up view of Fig. 9.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5mm
010811-e-1-1
2
1mm
010811-e-1-1
010811-e-1-3
2cm
4
5
2cm
010811-e-1-2
5mm
3
010811-e-1-2
6
5mm
010811-e-2-1
7
5mm
010811-e-2-2
8
5mm
010811-e-2-3
9
5mm
010811-34-15-1
1mm
10
010811-34-15-1