

Late Carboniferous Corals from the Oboradani Formation, Fukui Prefecture

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Abstract The Gzhelian (Late Carboniferous) Oboradani Formation yields a distinctive coral fauna including five species of rugose corals: *Bothrophyllum domheri* forma *a* Fomichev, 1953, *Bothrophyllum* sp. indet., *Pseudotimania*? sp. indet., *Lophocarinophyllum* sp. aff. *L. acanthiseptatum* Grabau, 1922, *Nephe-lophyllum* sp. indet., and a tabulate coral: *Cladochonus hamadai* Igo and Adachi, 1980. *Bothrophyllum domheri* forma *a* is also known from the Podolskian to Kasimovian of the Donetz Basin and from the lower Tahaqi Formation (*Triticites* Zone) of North China. *Cladochonus hamadai* has been known only from the Bashkirian of Fukui, Gifu Prefecture. This report is the first record of corals from the formation, and adds some new data to a poorly known Gzhelian coral fauna in Japan.

Key words: Carboniferous, corals, Oboradani Formation, Fukui.

Introduction

The Oboradani Formation (Yamada *et al.*, 1958) is composed of a gray micritic limestone that crops out in two small separated areas surrounded by the “Otani Conglomerate” in the northern slope of the Kuzuryu Lake at Izumi-mura, Ohno-gun, Fukui Prefecture (Yamada, 1967). Although the Paleozoic rocks of this area including the formation have been regarded as part of an overthrust sheet (Kawai, 1956) or horst (Maeda, 1961), Sohma *et al.* (1983) considered that they are olistoliths and the “Otani Conglomerate” is equivalent to the basal, late Jurassic part of the Tetori Group.

The present corals were collected in 1983 by A. Watanabe and in 1995 and 1996 by S. Niko and T. Kamiya from the type section (locality OB-1 in Niko & Watanabe, 1987) of the Oboradani Formation. The outcrop consists of an approximately 30 m thick limestone, which is divided into the thin-bedded bio-clastic wackestone (represents lowest 3 m part) including the coral fauna described here and upper massive algal boundstone. Previously only foraminifers have been investigated in the Oboradani Formation; Yamada (1967) listed some fusulinids, subsequently Niko and Watanabe (1987) described the fusulinid

fauna. Among the fusulinids, *Carbonoschwagerina morikawai* (Igo) indicates that the limestone is Gzhelian (Late Carboniferous) in age. The six species described here are the first recorded of the coral fauna from the Oboradani Formation and provide new data for elucidating coral biogeography in late Carboniferous age because Gzhelian corals have been poorly known in Japan.

All specimens studied are deposited either in the National Science Museum, Tokyo (NSM), or in the Department of Earth and Planetary Systems Sciences, Faculty of Science, Hiroshima University (IGSH).

Systematic Paleontology

Rugose Corals

(by Nobuo Yamagiwa, Hiroshi Sugimura and Shuji Niko)

Order Stauriida Verrill, 1865

Suborder Caniniina Wang, 1950

Family Bothrophyllidae Fomichev, 1953

Genus *Bothrophyllum* Trautschold, 1879

Bothrophyllum domheri forma *a* Fomichev, 1953

(Figs. 1-1-3, 2-1-4, 3-1-7, 5-1, 2)

Caninophyllum domheri forma *a* Fomichev, 1953, p. 236-242, pl. 12, figs. 2, 3.

Bothrophyllum domheri (Fomichev); Fedorowski, 1975, p. 57.

Caninophyllum domheri forma *b* Fomichev; Wang, 1984, p. 142, pl. 33, fig. 6.

Description: Corallum solitary, but occasionally fasciculate. Corallites sub-cylindrical in form.

In transverse section, corallites subround in outline. Wall thin. In mature stage, corallites (Figs. 1-1, 3, 2-1, 3?, 3-1, 2, 5-1) about 30 to 45 mm in diameter. Dissepimentarium wide. It consists of numerous rows of pseudoherringbone, concentric and anguloconcentric dissepiments. Small lateral dissepiments occasionally observed. Tabularium also wide and relatively clearly differentiated from dissepimentarium by inner wall. Septa of two orders, major and minor in alternation. They straight or slightly sinuous. Septal fine structure fibro-normal to diffuso-trabecular. Major septa 40 to 48 in number. Some of them attain to axial part of corallite and sometimes form loose axial structure with tabulae. Major ones thicker in tabularium than in dissepimentarium, especially in cardinal quadrants. Cardinal septum short and situated within open cardinal fossula. Minor septa occur in dissepimentarium. They more or less variable in length,

Fig. 1. *Bothrophyllum domheri* forma *a* Fomichev, NSM PA14013, $\times 2.1$. 1. Transverse section, at position a in Fig. 2-4; 2. Longitudinal section, at position b in Fig. 2-4; 3. Transverse section, at position c in Fig. 2-4.



Fig. 1.

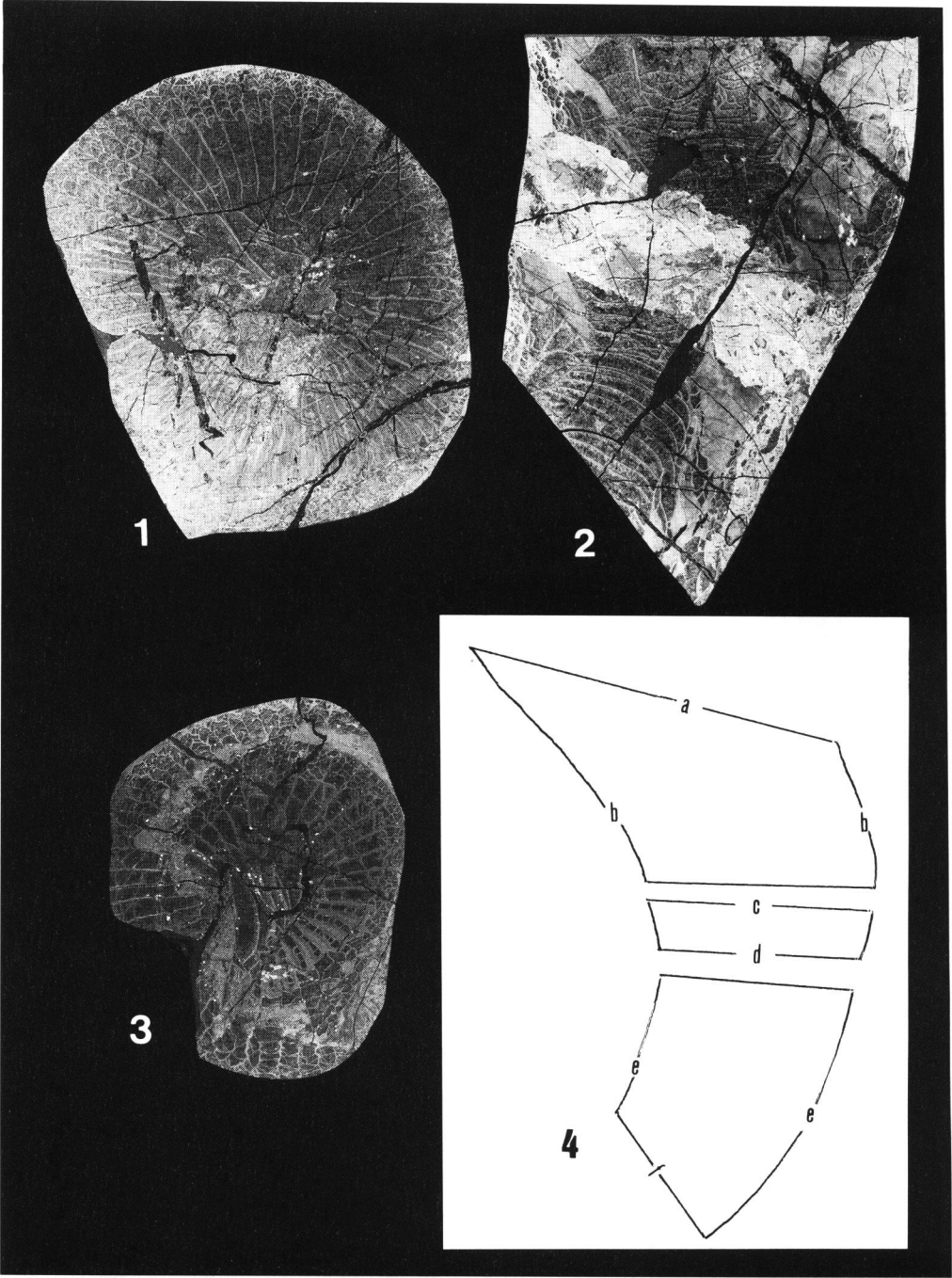


Fig. 2.

ranging commonly from $1/3$ to $1/2$ length of major septa. In immature stage, corallites (Figs. 3–3, 5, 6) look similar to those of mature stage. Formers, however, differ from latters in following characters, 1) smaller corallites, 2) less numerous major septa (30 to 34 in number at 15 to 20 mm in diameter), shorter minor septa (commonly $1/4$ to $2/5$ length of majors). Besides, major septa thickened in all quadrants with in tabularium.

In longitudinal section, dissepimentarium and tabularium wide. Wall thin. In mature stage, dissepiments arranged in 8 to 15 rows (Figs. 1–2, 2–2?, 5–2). Greater series consists of small globose dissepiments. Elongate dissepiments also sometimes arranged; they developed in inner part of dissepimentarium. Tabularium consists of peripheral and axial portions. In peripheral portion, clino tabellae, peripheral tabellae and periaxial tabellae are seen. In axial portion, tabulae incomplete or complete. They subhorizontal and wave. 8 to 11 tabulae counted in vertical distance of 5 mm. Dome-like tabellae and edges of major septa sometimes observed in axial portion. In immature stage, corallite (Fig. 3–4) resembles those of mature stage in many respects, but differs from latters in having dissepiments arranged in less numerous rows.

Remarks: The present specimens are characterized by their large corallite size, large septal number, relatively long minor septa and dilated major septa in the tabularium (especially in the cardinal quadrants). Besides, they have pseudo-herringbone, concentric and anguloconcentric dissepiments. The features mentioned above well agree with those of *Bothrophyllum domheri* forma *a* from the Podolskian to Kasimovian in the Donetz Basin. The present form much resembles the specimen described as *Caninophyllum domheri* forma *b* by Wang (1984) from the lower Tahaqi Formation (*Triticites* Zone) in Xinjiang, North China in many important characters. Therefore, the writers suggest that the latter belongs to the present forma *a*.

The present form is also related to *Bothrophyllum domheri* forma *b* (Fomichev, 1953, p. 236–242, pl. 11, figs. 1, 2, pl. 12, fig. 1) from the Podolskian to Kasimovian in the Donetz Basin, *B. domheri* (Fontaine, 1961, p. 149, 150, pl. 13, fig. 2, pl. 14, fig. 3) from the Moscovian in Viet Nam, *B. domheri* (Fontaine in Fontaine *et al.*, 1991, p. 42–43, pl. 21, figs. 4, 5, pl. 23, fig. 4, pl. 24, figs. 1–5) from the Moscovian in Thailand, and *B. sp. indet.* in this paper, but differs from the latter four in having longer minor septa.

Material: Eight specimens, NSM PA14013-14016; IGSH-SN 10049-10052.

Fig. 2. *Bothrophyllum domheri* forma *a* Fomichev, NSM PA14013, 1–3 = $\times 2.1$, 4 = $\times 1.0$.
 1. Transverse section, at position d in Fig. 2–4; 2. Longitudinal section, at position e in Fig. 2–4; 3. Transverse section, at position f in Fig. 2–4; 4. Sketch showing the positions of illustrated sections.

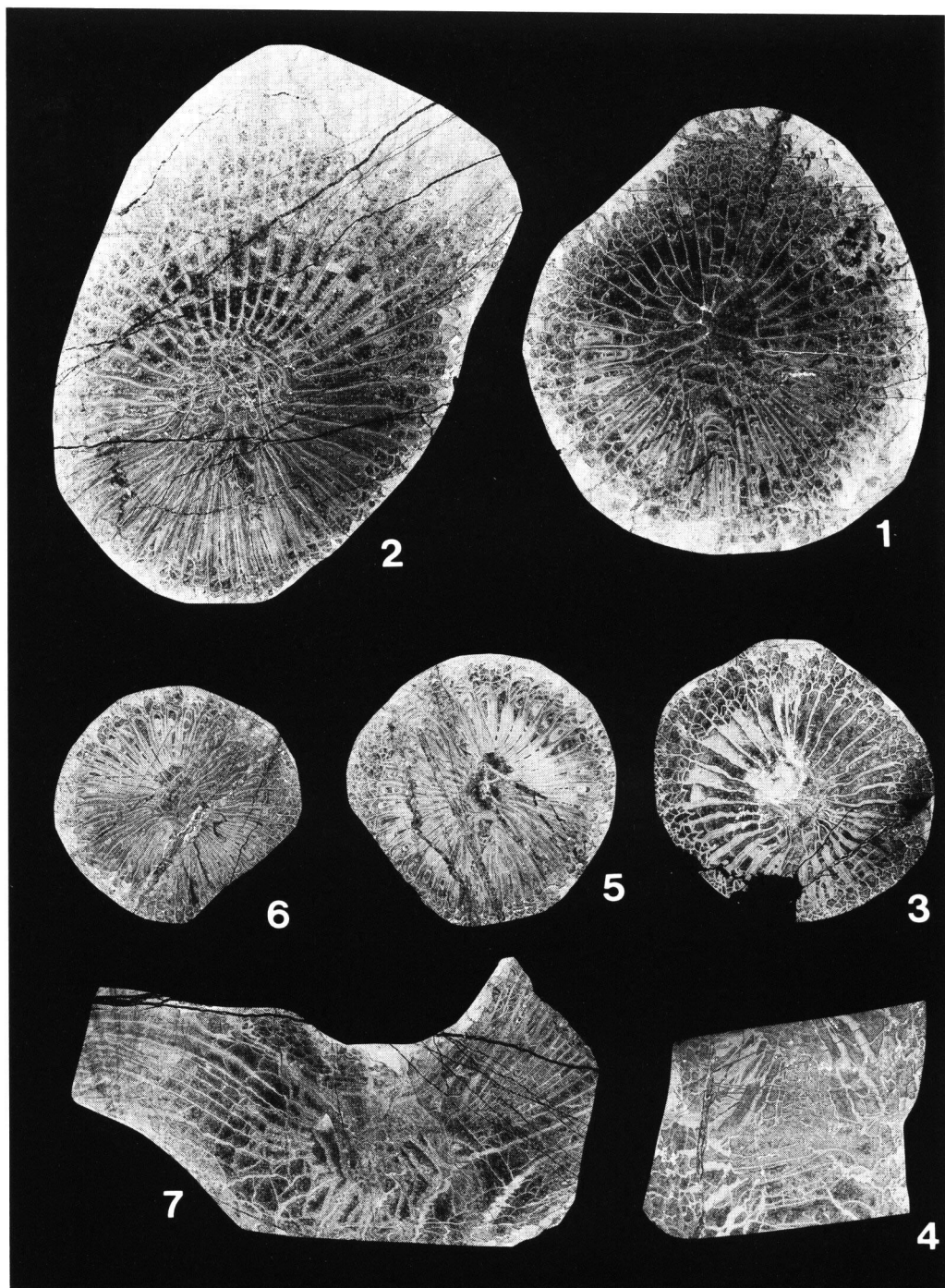


Fig. 3.

Bothrophyllum sp. indet.

(Figs. 4-1, 2)

Description: Corallum solitary. Corallite may be subcylindrical.

In transverse section, corallite broken. However, it may have been originally subellipsoidal in outline with longest diameter of $48+ \text{ mm}$ in mature stage (Fig. 4-1). Wall missing. Dissepimentarium wide. Dissepiments commonly arranged in herringbone and concentric patterns. Tabularium also wide. Boundary between dissepimentarium and tabularium rather clear. Long major septa about 70 in number, straight or slightly sinuous. They show fine structure of diffuso-trabecular or fibro-normal types. They thick in tabularium, especially in cardinal quadrants. Some of them reach axial part. Cardinal septum short. Minor septa almost lacking.

In longitudinal section, dissepimentarium wide. Dissepiments arranged in 15 to 20 rows in mature stage (Fig. 4-2). They commonly composed of small globose dissepiments. Tabularium also wide. It consists of peripheral and axial portions. In peripheral portion, clino tabellae, peripheral tabellae and periaxial tabellae present. In axial portion, incomplete or complete? tabulae are seen. They subhorizontal and wave.

Remarks: The present form is related to *Bothrophyllum domheri* forma *b* by Fomichev (1953) from the Podolskian to Kasimovian in the Donetz Basin. However, the former differs from the latter in having more numerous major septa. Besides, the minor septa of the former form are almost absent.

Material: Eight specimens, IGSH-SN 10053, 10056-10062.

Genus *Pseudotimania* Dobrolyubova and Kabakovich, 1948

Pseudotimania ? sp. indet.

(Fig. 5-3)

Description: Corallum solitary.

In transverse section, corallite subellipsoidal in outline. It $20+ \text{ mm}$ in shortest diameter. Wall and dissepimentarium missing. Major septa 47 in number in tabularium. Major ones pinnate toward cardinal and counter septa. They dilated, especially in cardinal quadrants and weakly or strongly sinuous. Cardinal septum short. Counter septum longer and thinner than neighboring major ones.

Fig. 3. *Bothrophyllum domheri* forma *a* Fomichev, $\times 2.1$. 1. Transverse section, NSM PA14014; 2. Transverse section (somewhat oblique), IGSH-SN 10049; 3. Transverse section, NSM PA14016; 4. Longitudinal section (somewhat oblique), NSM PA14016; 5. Transverse section, IGSH-SN 10051; 6. Transverse section, IGSH-SN 10050; 7. Longitudinal section, IGSH-SN 10052.

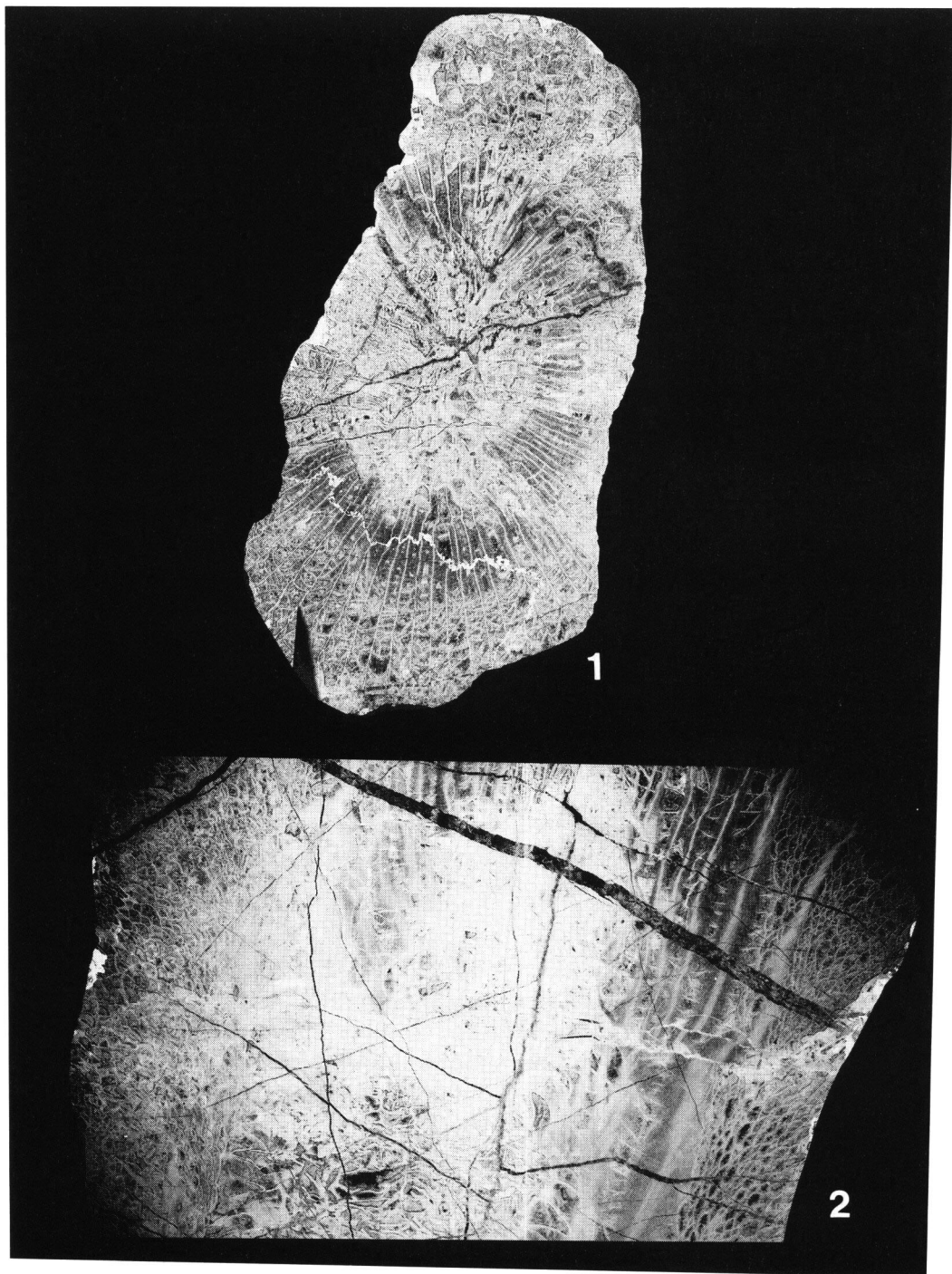


Fig. 4.

Closed cardinal and alar fossulae observed. Septa fibro-normal type in fine structure. Minor septa missing. Axial structure absent.

No longitudinal section is seen.

Remarks: Although the wall and dissepimentarium are missing, the present form may belong to the genus *Pseudotimania* (indicating Late Carboniferous in age) in its major septa of the cardinal and counter quadrants placed pinnately, dilated major septa in the tabularium (especially in the cardinal quadrants), no axial structure and distinct cardinal and alar fossulae.

Material: A single specimen, IGSH-SN 10054.

Suborder Plerophyllina Sokolov, 1960

Family Lophophyllidae Grabau, 1928

Genus *Lophocarinophyllum* Grabau, 1922

Lophocarinophyllum sp. aff. *L. acanthiseptatum* Grabau, 1922

(Figs. 5-4, 5)

Compare:

Lophophyllum (*Lophocarinophyllum*) *acanthiseptatum* Grabau, 1922, p. 51-59, pl. 1, figs. 6a, c, 7a, c, 8a, c, e, 9a, c, e, f, 10c, 11c, 18-21.

non *Lophocarinophyllum acanthiseptatum* Grabau: Heritsch, 1936, p. 114-115, pl. 17, figs. 19-20, text-fig. 13; Fontaine, 1961, p. 85, 86, pl. 1, figs. 6, 7, pl. 3, fig. 8, pl. 6, figs. 1a-c, pl. 7, fig. 5.

Description: Corallum solitary. Corallites subcylindrical in form.

In transverse section, corallite subround in outline and 12 mm in diameter in mature stage. Wall relatively thick, attaining about 1.0 mm in thickness. Septa of two orders, major and minor in alternation, both being nearly straight or slightly sinuous. Septal fine structure fibro-normal. Major septa moderately thick, about 23 in number in mature stage. They long and reach near axial structure except counter septum. Several axial ends of them contiguous. Counter septum axially swollen, forming axial structure. Cardinal septum missing. Spines occasionally observed on sides of major septa. Minor septa about 1/5 to 1/3 length of major ones. Peripheral parts of both major and minor ones dilated. Axial structure compact and consists of short median lamella and numerous radiating lamellae. It subround in outline and about 2.5 mm in shortest diameter.

In longitudinal section, wall relatively thick. Tabularium wide. Tabulae probably complete and thin. They ascend toward axial structure and about 4 in vertical distance of 3 mm. Distinct horn-like spines formed on sides of edges of major septa. They also projected from wall.

Remarks: Although the cardinal septum is missing in the solely described

Fig. 4. *Bothrophyllum* sp. indet., IGSH-SN 10053, $\times 2.1$. 1. Transverse section; 2. Longitudinal section.

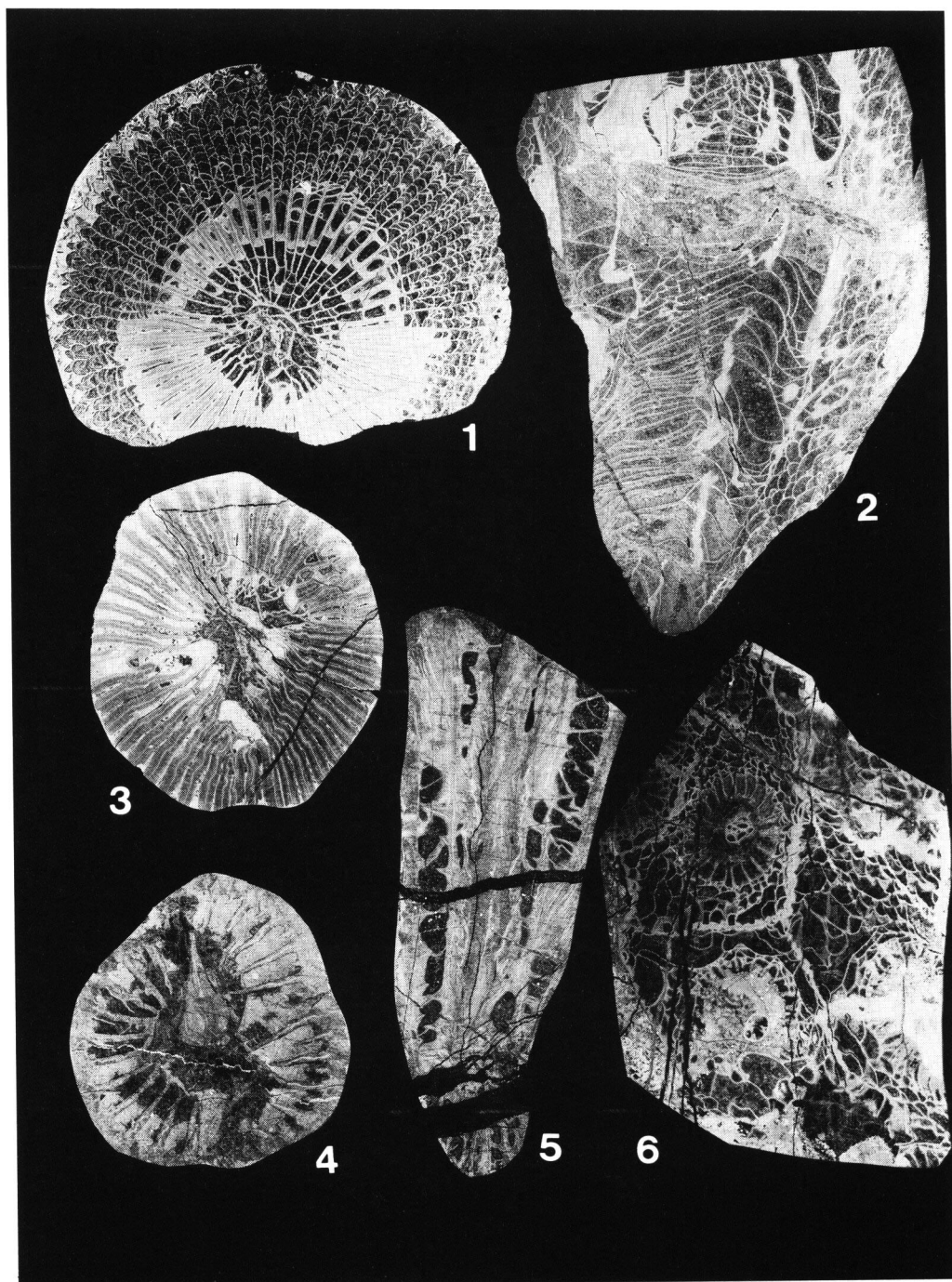


Fig. 5.

specimen, it closely resembles *Lophocarinophyllum acanthiseptatum* Grabau from the Taiyuan Series in Shantung, North China in many other morphological characters. It is similar to *Lophocarinophyllum suetomii* (Minato, 1955, p. 151–153, pl. 26, fig. 7, text-fig. 17; Minato, 1975, p. 117) from the basal part of the Sakamotozawa Series in Kitakami, northern Japan, but differs from the latter in having a less number of septa. It is also related to *Lophocarinophyllum* sp. indet. described by Yamagiwa, Ishii and Hayashi (1988, p. 52–53, pl. 1, fig. 5) from a limestone lens of Early Permian age in the Tamba Group, Osaka. However, the former can be distinguished from the latter in having larger corallite.

Material: A single specimen, NSM PA14017.

Suborder Lonsdaleiina Spasskiy, 1974

Family Petalaxidae Fomichev, 1953

Genus *Nephelophyllum* Wu and Zhao, 1974

Nephelophyllum sp. indet.

(Fig. 5–6)

Description: Corallum compound, massive and cerioid to partly aphroid.

In transverse section, corallites irregularly polygonal. Distance between centers of neighboring corallites being 9–13 mm. Wall represented by stratotheca which consists of winding plates. It locally vanished. Dissepimentarium wide and consists of several rows of normal or irregular lonsdaleoid dissepiments of varying sizes. Septal crests on lonsdaleoid ones frequently recognized. They correspond to major and minor septa in position. Tabularium also wide. It clearly differentiated from dissepimentarium by inner wall. Septa in two orders, major and minor; they relatively thin, straight or slightly sinuous. Septal fine structure diffuso-trabecular. Septa present in tabularium. They also frequently observed within dissepimentarium as crests. In mature stage, major septa 20 in number. They long, but do not reach axial structure. In mature stage, minor septa frequently recognized within dissepimentarium. Fossula indistinct. Axial structure small, subround in outline. It composed of a few irregular disposed axial tabellae and septal lamellae. Median plate present.

There is no longitudinal section.

Remarks: The present form is similar to *Nephelophyllum simplex* Wu and Zhao (1974, p. 272, pl. 139, figs. 1, 2; Wu & Zhao, 1989, p. 172, 173, pl. 51, fig.

Fig. 5. 1–2, *Bothrophyllum domheri* forma *a* Fomichev, NSM PA14015, $\times 2.1$. 1. Transverse section; 2. Longitudinal section. 3, *Pseudotimania*? sp. indet., Transverse section, IGSH-SN 10054, $\times 2.1$. 4–5, *Lophocarinophyllum* sp. aff. *L. acanthiseptatum* Grabau, NSM PA14017, $\times 3.0$. 4. Transverse section; 5. Longitudinal section. 6, *Nephelophyllum* sp. indet., Transverse section, IGSH-SN 10055, $\times 3.0$.

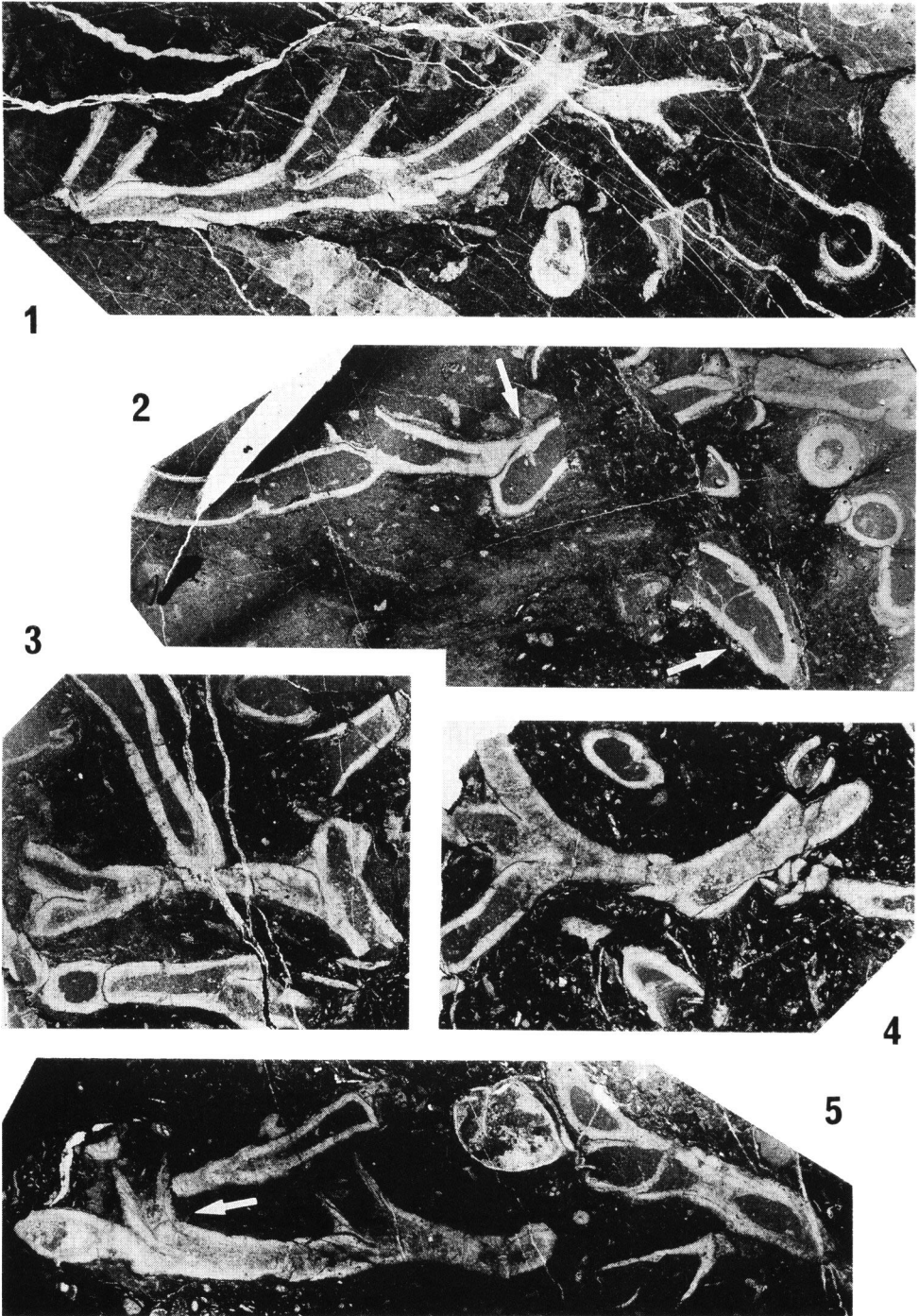


Fig. 6.

2, pl. 52, fig. 2, text-fig. 95; Wang, 1978, p. 163, pl. 5, fig. 1) from the Mapping Formation in Yunnan and Guizhou, South China, but differs from the latter in having more numerous major septa. It somewhat resembles *Nephelephyllum wangi* Yamagiwa and Maeda (1995, p. 154, 155, pl. 1, figs. 1–4) from the Chuanshan Formation in Zhejiang, South China. The former, however, differs from the latter in having a small axial structure with more simple structure. It can be distinguished from *Nephelephyllum compactum compactum* Wu and Zhao (1989, p. 175, 176, pl. 53, figs. 2, 4, text-fig. 98) from the Mapping Formation in Guizhou, South China in having shorter minor septa and a smaller axial structure with more simple structure.

Material: A single specimen, IGSH-SN 10055.

Tabulate Coral

(by Shuji Niko)

Order Auloporida Sokolov, 1947

Superfamily Auloporicae Milne-Edwards and Haime, 1851

Family Pyrgiidae Fromentel, 1861

Genus *Cladochonus* M'Coy, 1847

Cladochonus hamadai Igo and Adachi, 1980

(Figs. 6–1—5)

Cladochonus hamadai Igo and Adachi, 1980, p. 313, 314, text-figs. 2, 3, pl. 36, figs. 1, 2, pl. 37, figs. 1–4, pl. 38, fig. 1; Igo and Adachi, 1981, p. 102.

“*Cladochonus*” *hamadai* Igo and Adachi; Adachi, 1985, p. 66.

Description: Corallum mat-like, each corallite consists of proximal prostrate portion of subcylindrical form, 3.1–5.6 mm in length, and weakly inflate funnel-shaped free portion which forms oblique to erect calice, approximately 3.5 mm in length; cross section of corallites nearly circular, attains 2.0 mm in maximum diameter at aperture; daughter corallites opening at basal position of calice of parent; increase of corallite unilateral and rarely bilateral; walls of corallite mostly very thick, attain 0.55 mm, but partly variable in thickness, composed of outer thin, darker layer and inner thick, more translucent layer which has concentric

Fig. 6. *Cladochonus hamadai* Igo and Adachi, IGSH-SN 10046, thin sections, $\times 5$. 1. Nearly perpendicular to substrate, longitudinal section (left) and transverse section (right margin). Note relationship between parent and daughter corallites; 2. Nearly parallel to substrate, longitudinal section (left) and transverse section (right margin). Note unilateral increase. Arrows indicate septal spines; 3. Parallel to substrate, longitudinal section; 4. Parallel to substrate, longitudinal section (center) and oblique section (upper margin). Note bilateral increase; 5. Nearly perpendicular to substrate, longitudinal section (left) and oblique section (right). Arrow indicates complete tabula.

structure; septal spines distinct, but relatively rare; tabulae rare, convex distally, complete.

Remarks: The present specimens closely resemble the type specimens from Bashkirian rocks of the Ichinotani Formation, Fukuji area, Gifu Prefecture. *Cladochonus hamadai* is distinguished by the possession of distinct septal spines and complete tabulae from other species of the genus.

Material: Three coralla, IGSN-SN 10046-10048.

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