Bull. Natn. Sci. Mus., Tokyo, Ser. C, **24**(3, 4), pp. 129–150, December 22, 1998

Early Carboniferous Corals from the "Omi Non-Calcareous Group", Niigata Prefecture

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Abstract An Early Carboniferous coral fauna was collected from the limestone blocks of late Visean (to Serpukhovian?) age within the "Omi Non-Calcareous Group", Niigata Prefecture, Central Japan. There are nine Rugosa including Heterocorallia: *Lithostrotion* (*Lithostrotion*) *decipiens* (M'Coy, 1849), *L.* (*Siphonodendron*) *kamiyai* n. sp., *Diphyphyllum* sp. indet., *Aulina* (*Pseudoaulina*) sp. aff. *A.* (*P.*) *sinense* Sando, 1976, *Aulokoninckophyllum carinatum* (Carruthers, 1909), *Pareynia*? sp. indet., *Hexaphyllia* sp. indet. 1, *H.* sp. indet. 2 and *Pentaphyllia* sp. indet., and a Tabulata: *Syringopora kotakiensis* n. sp. Some faunal links between the present fauna and that of the Ichinotani Formation, Gifu Prefecture are recognized.
Key words: Early Carboniferous, rugose corals, heterocorals, tabulate coral, "Omi Non-Calcareous Group", Niigata.

Introduction

This paper describes Early Carboniferous corals collected from some flat blocks of limestone in the Tsuchikura-zawa Valley that is situated in the upper reaches of the Kotaki-gawa River in Itoigawa City, Niigata Prefecture, Central Japan (Fig. 1). These limestone blocks, which consist of wackestone, packstone and biolithite with dark-gray to black in color, were derived from olistolith in the "Omi Non-Calcareous Group" (a provisional name proposed by Hasegawa *et al.*, 1982) as shown by a preliminary report of Kamiya and Niko (1996). A detailed description of geologic setting and subdivision concerning the olistostrome in this area is referable to Tazawa *et al.* (1984) and Ujihara (1985). The foraminifers, such as *Tetrataxis* sp., *Endothyra* spp., *Endothyranopsis* cf. *crassa* (Brady), *Archaediscus* sp., *Asteroarchaediscus* sp., *Mediocris breviscula* (Ganelina) and *Eostaffella* sp., confirm the present limestone age as the late Visean to Serpukhovian (middle to late Early Carboniferous) in chronostraigraphy (Kamiya and Niko, 1996; Nakazawa *et al.*, 1998). The limestones are more or less argillaceous. This is noteworthy because the equivalents in the adjacent Omi Limestone Group are composed of relatively pure limestone that was formed as a reef complex on the submarine volcanic mound. Lithofacies of the lime-

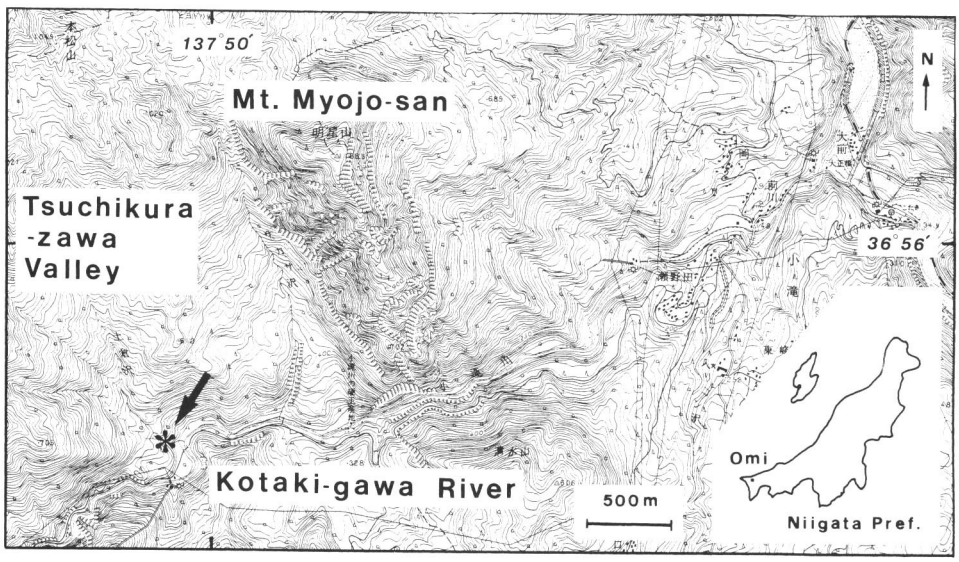


Fig. 1. Index showing coral locality in the Omi area, Niigata Prefecture. Base map, "Kotaki", 1 : 25,000 quadrangle of Geographical Survey Institution.

stones indicates rather a similarity with that of the Ichinotani Formation, Gifu Prefecture and the Onimaru Formation, Iwate Prefecture known as a shelf-type limestone.

Carboniferous corals of the Tsuchikura-zawa Valley have been attracted attention since Konishi (1956) and followed by Kato and Minato (1979), Hasegawa *et al.* (1982), Kamiya and Niko (1996) and Nakazawa *et al.* (1998), but these reports were no more than preliminary works. Thus this is the first detailed systematic description of the present corals. The assemblage includes *Lithostrotion* (*Lithostrotion*) *decipiens* (M'Coy), *L.* (*Siphonodendron*) *kamiyai* n. sp., *Aulina* (*Pseudoaulina*) sp. aff. *A.* (*P.*) *sinense* Sando, *Aulokoninckophyllum carinatum* (Carruthers), *Pareynia*? sp. indet., *Hexaphyllia* sp. indet. 1, *H.* sp. indet. 2, *Pentaphyllia* sp. indet. and *Syringopora kotakiensis* n. sp. With the exception *Lithostrotion* (*Lithostrotion*) *decipiens* and *Aulokoninckophyllum carinatum* that are known to range from late Visean to Serpukhovian, the age given by other corals is restricted to late Visean. In addition, this study clarifies the identification of sharp faunal differences between the present fauna and the corresponding coral fauna in the Omi Limestone Group, of which the latter is characterized by the presence of *Hiroshimaphyllum* and *Akiyoshiphyllum* (Yoshida *et al.*, 1987; Kato, 1990). Although closely related fauna with the Tsuchikura-zawa corals is not known in Japan at present, an only species *Lithostrotion* (*Lithostrotion*) *decipiens* is common to the Ichinotani Formation. This evidence suggests that there were some faunal links between the Tsuchikura-zawa corals and rather the fauna of the Ichinotani Formation than that of the Omi Limestone Group in Early Carbonifer-

ous age.

All specimens studied are deposited in the National Science Museum, Tokyo (NSM).

Systematic Paleontology

The terminology of the septal fine structure follows Kato (1963), and a morphological term *pseudoaulos*, proposed by Nakai (1990), is used herein.

Rugose Corals
(by Nobuo Yamagiwa and Shuji Niko)
Suborder Lithostrotionina Spasskiy and Kachanov, 1971
Family Lithostrotionidae d'Orbigny, 1852
Subfamily Lithostrotioninae d'Orbigny, 1852
Genus *Lithostrotion* Fleming, 1828
Subgenus *Lithostrotion* Fleming, 1828

Lithostrotion (*Lithostrotion*) *decipiens* (M'Coy, 1849)

(Figs. 2-1, 2)

Lithostrotion decipiens (M'Coy): Hill, 1940, p. 178–180, pl. 17, figs. 1, 2, with a list of previous references; Wu, 1964, p. 33, pl. 3, figs. 3, 4, 8, 9; Poty, 1981, p. 22–24, pl. 6, figs. 1–3, pl. 7, figs. 1, 2; Wu and Zhao, 1989, p. 104, pl. 24, fig. 2; Fontaine, 1991, p. 49, 50, pl. 3, fig. 3, pl. 4, fig. 5, pl. 13, fig. 2, pl. 17, figs. 1, 2.

Lithostrotion (*Lithostrotion*) *decipiens* (M'Coy): Igo and Adachi, 1981, p. 180, 181, pl. 26, figs. 1–3.

Material: A single specimen, NSM PA14339.

Description: Corallum compound, massive and cerioid.

In transverse section, corallites polygonal, generally five to seven sided and about 3.0 to 6.0 mm in shortest diameter in mature stage. Wall distinct and straight or slightly curved. Septa of two orders, major and minor in alternation, thin and straight or slightly sinuous. Septal fine structure can not see. Major septa long and generally attain to columella. They about 14 to 16 in number in mature stage. Minor septa more or less variable in length, ranging from 1/2 to 2/3 length of major ones. Dissepimentarium relatively wide, composed of several rows, generally concentric dissepiments, but pseudoherringbone or irregular ones in places. Tabularium also relatively wide. Tabulae generally concentrical. Columella small and elliptical in form. Fossula indistinct.

In longitudinal section, wall distinct and continuous. Dissepimentarium and tabularium relatively wide. Vesicle-like dissepiments arranged in 1 to 5 rows. Their convex sides facing upwards as well as inwards. Incomplete tabulae ascending towards columella. They about 5 to 7 in vertical distance of 2 mm. Columella generally continuous and straight or slightly sinuous.

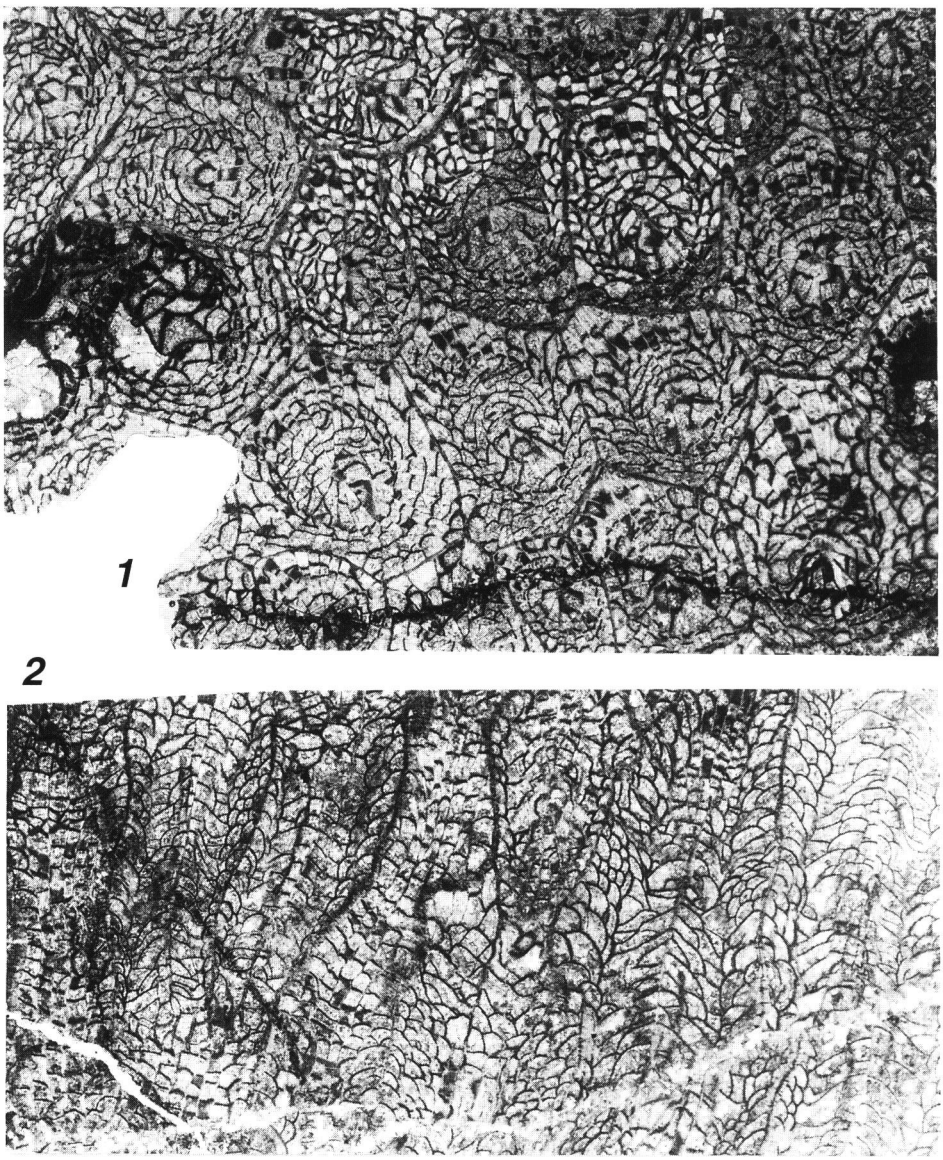


Fig. 2. *Lithostrotion* (*Lithostrotion*) *decipiens* (M'Coy), NSM PA14339. 1. Transverse section, ×5.0; 2. Longitudinal section, ×5.0.

Remarks: The present form much resembles *Lithostrotion* (*Lithostrotion*) *decipiens* (M'Coy) from the Upper Visean in Belgium and Scotland, the upper Lower Carboniferous in China and Thailand and the Upper Visean to Lower Namurian at Fukuji, Hida, Japan in having small corallites and small elliptical columella, incomplete

and rather tightly spaced tabulae which are ascending towards columella and other common morphological characters.

Subgenus *Siphonodendron* M'Coy, 1849

Lithostrotion (Siphonodendron) kamiyai n. sp.

(Figs. 3, 4)

Material: A single specimen, NSM PA14340 (Holotype).

Diagnosis: *Lithostrotion* (*Siphonodendron*) with medium sized corallites (8.0 to 9.0 mm in diameter) and relatively narrow dissepimentarium having generally 2 to 4 rows of vesicle-like dissepiments. Broad tabularium consists of compact incomplete tabulae which ascending towards columella.

Description: Corallum compound, fasciculate and phaceloid. Corallites subcylindrical and subparallel. They occasionally in contact. Increase by lateral.

In transverse section, corallites subcircular in outline. Corallites 8.0 to 9.0 mm in diameter in mature stage. Wall relatively thin, about 0.11 mm. Septa of two orders, major and minor in alternation; they straight or slightly sinuous. Septa slightly thickened at periphery, with gradually attenuated axial ends. Their fine structure diffuso-trabecular to fibro-nomal. Major septa long and 23 to 27 in number in mature stage. They attain to center of corallite, but most of them do not unite with columella. Minor septa relatively short, ranging from 1/3 to 1/2 length of major ones. Dissepimentarium relatively narrow. Dissepiments generally arranged concentrically, but in places irregularly in pattern. Tabularium wide; tabulae generally concentrical. Columella elongate fusiform, generally united with the counter septum. Fossula indistinct.

In longitudinal section, wall relatively thin. Dissepimentarium relatively narrow. It composed of vesicle-like dissepiments with convex sides facing upwards as well as inwards. Dissepiments generally arranged 2 to 4 rows. Tabularium wide. It occupies about 2/3 radius of corallite. Incomplete tabulae ascend towards columella; about 7 to 9 in vertical distance of 2 mm. Columella distinct and continuous. It straight or slightly sinuous.

Remarks: The present form much resembles *Lithostrotion* (*Siphonodendron*) *ondulosum* described by Poty (1981, p. 26, 27, pl. 8, figs. 1–3) from the Middle Visean in Belgium in its size of corallite, number and form of septa, inclinational form of incomplete tabulae and form of columella. However, the former can be distinguished from the latter in having less numerous rows of dissepiments and more crowded tabulae in longitudinal section.

Etymology: This species is named for Mr. Toshiaki Kamiya, who found the specimen of this new species.

Fig. 3. *Lithostrotion* (*Siphonodendron*) *kamiyai* Yamagiwa and Niko n. sp., holotype, NSM PA14340, transverse section, ×5.0.

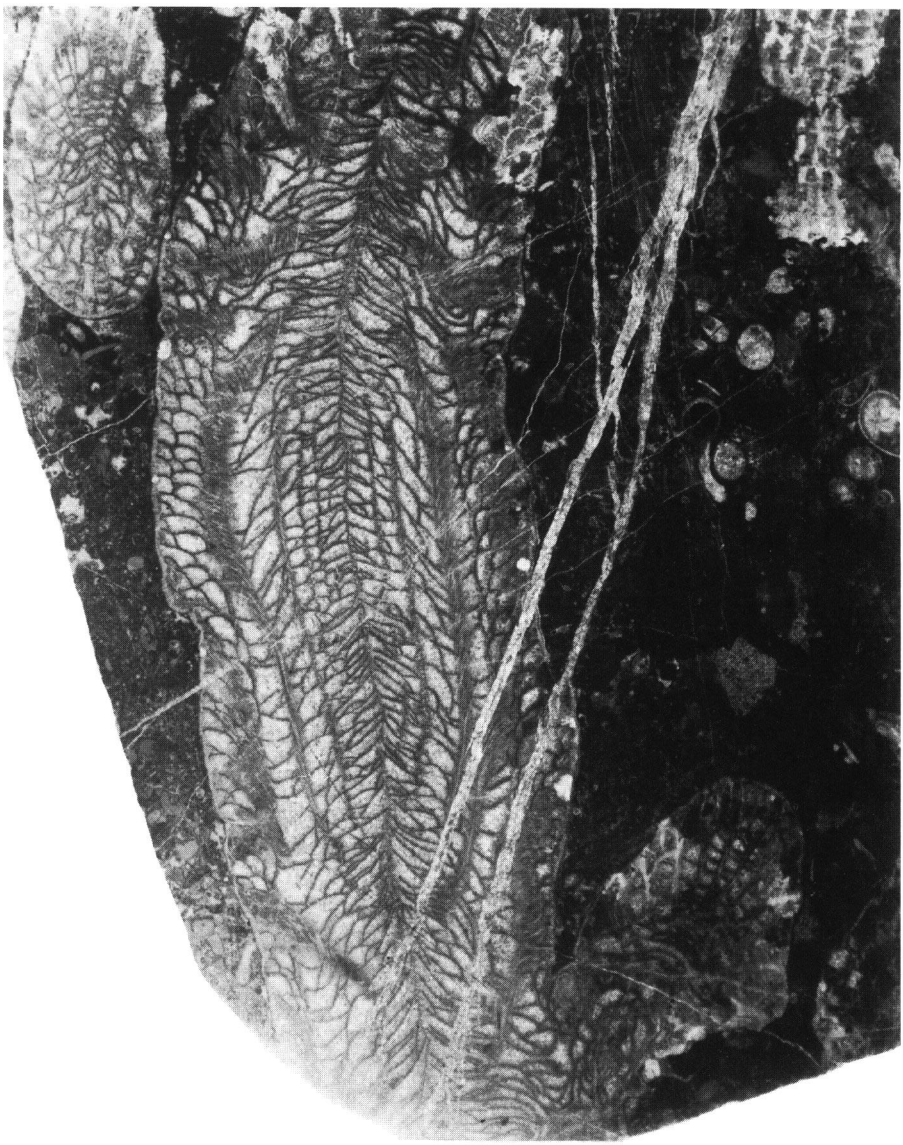


Fig. 4. *Lithostrotion* (*Siphonodendron*) *kamiyai* Yamagiwa and Niko n. sp., holotype, NSM PA14340, longitudinal section, ×5.0.

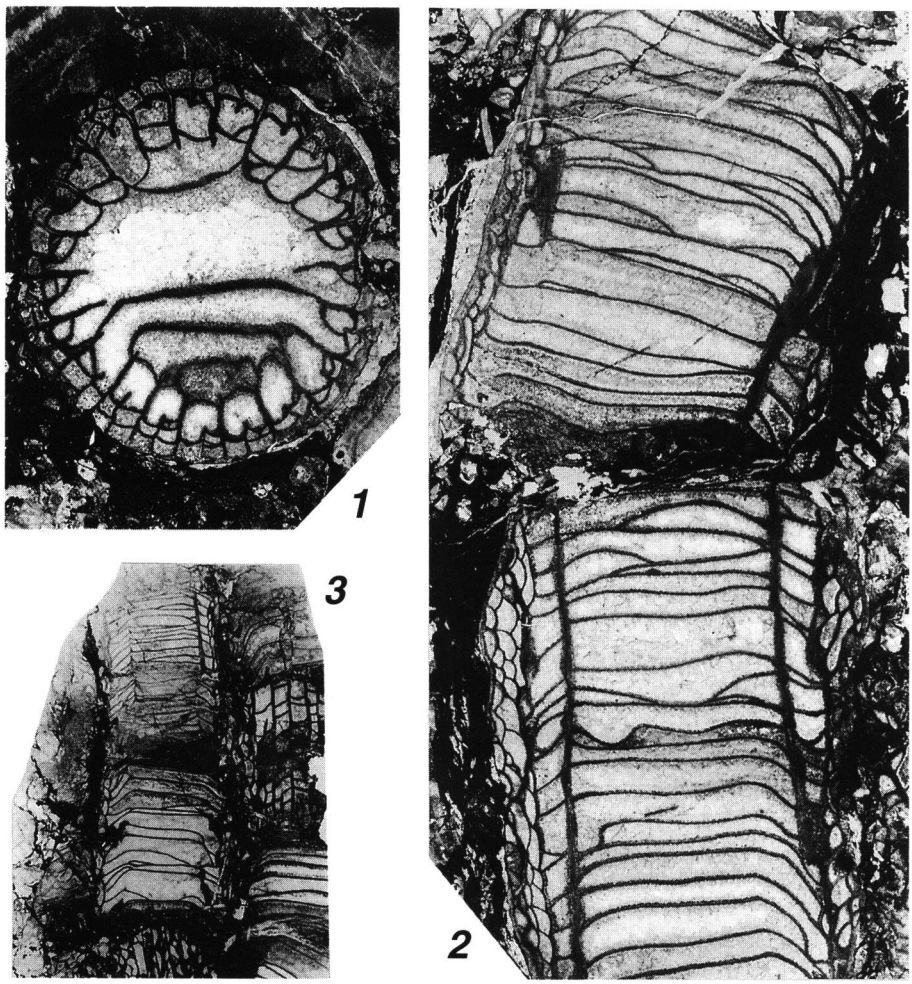


Fig. 5. *Diphyphyllum* sp. indet., NSM PA14345. 1. Transverse section, ×5.0; 2, 3. Longitudinal sections, ×5.0 and ×2.1, respectively.

Subfamily Diphyphyllinae Dybowski, 1873
Genus *Diphyphyllum* Lonsdale, 1845
Diphyphyllum sp. indet.
(Figs. 5-1–3)

Material: A single specimen, NSM PA14345.

Description: Corallum compound, fasciculate and phaceloid. Corallites cylindrical. Neighboring corallites more or less parallel, sometimes in contact.

In transverse section, corallites subcircular in outline and about 10.0 mm in di-

ameter in mature stage. Wall relatively thick, attaining 0.6 mm. Septa of two orders, major and minor in alternation. They straight or slightly sinuous. They show fine structure of diffuso-trabecular to fibro-nomal types. Major septa as long as about 2/5 to 1/2 radius of corallite. They 22 in number in mature stage. Minor septa about 1/2 length of major ones. Dissepimentarium narrow and composed of 1 to 3 rows of generally concentric dissepiments. Irregular dissepiments occasionally observed. Tabularium wide. Outer tabularium relatively narrow; concentric or irregular tabulae sometimes observed. Wide central area (inner tabularium, about 6.0 mm in diameter) surrounded by incomplete inner wall. Inner wall formed partly by union of deflected axial ends of major septa and partly by downtrend parts of tabulae. Fossula indistinct.

In longitudinal section, wall distinct. Dissepimentarium narrow and composed of 1 to 3 rows of generally vesicle-like dissepiments. Their convex sides facing inwards or upwards as well as inwards. Elongate dissepiments sometimes arranged. Tabularium wide. Tabulae unequally spaced, about 15 in vertical distance of 10 mm; they generally complete, but incomplete in places. In wide inner tabularium, tabulae generally horizontal, but convex or concave upwards in places. Outer tabularium relatively narrow; tabulae generally inclined towards dissepimentarium.

Remarks: It is similar to *Diphyphyllum maximum* described by Fontaine (1991, p. 50, pl. 17, figs. 3, 4, pl. 27, fig. 7) from the upper Lower Carboniferous in Thailand in many respects. However, the former is slightly different from the latter in having more crowded tabulae in longitudinal section. It differs from the type specimen of *Diphyphyllum maximum* Poty (1981, p. 36, pl. 14, figs. 1a, b) from the Upper Visean in Belgium in having less numerous septa and shorter minor septa. *Diphyphyllum maximum* by Fontaine (1991) is also distinguished from the type specimen of *D. maximum* in having the above mentioned characters.

Subfamily Aulininae Hill, 1981
Genus *Aulina* Smith, 1917
Subgenus *Pseudoaulina* Minato and Rowett, 1967
Aulina* (*Pseudoaulina*)** sp. aff. ***A.* (*P.*) *sinense Sando, 1976
(Figs. 6-1, 2)

Compare:
Aulina sp., Lo and Chao, 1962, p. 180, pl. 25, fig. 1.
Aulina (*Pseudoaulina*) *sinense* Sando, 1976, p. 425.

Material: A single specimen, NSM PA14346.

Description: Corallum compound, massive and usually aphroid, but occasionally thamnasterioid.

In transverse section, corallites variable in size; central distance about 2.0 to 5.0 mm. Corallites generally contact with lonsdaleoid dissepiments. Their septa occasionally confluent with septa of adjacent corallites. Wall rarely present. Septa of two

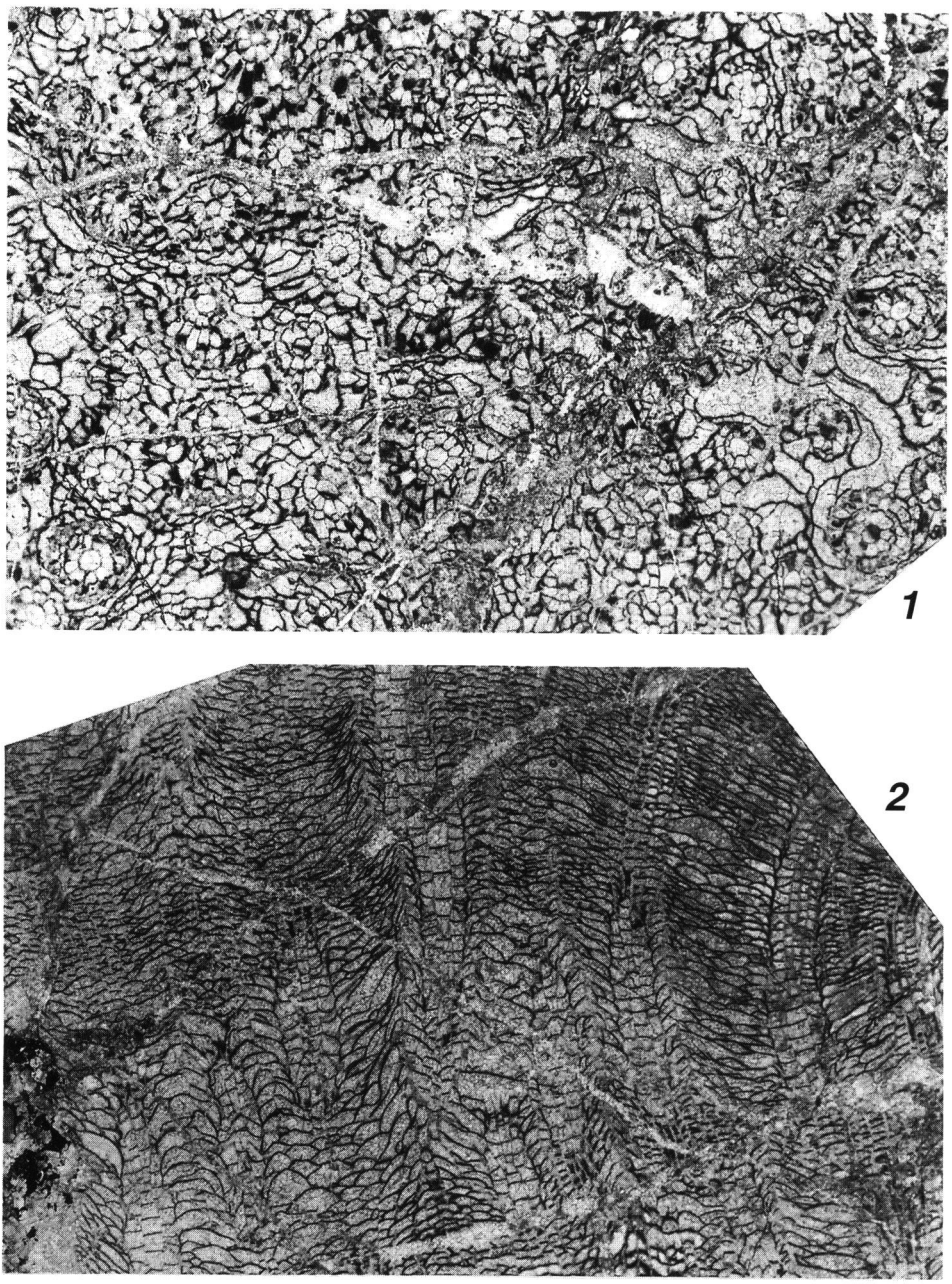


Fig. 6. *Aulina* (*Pseudoaulina*) sp. aff. *A.* (*P.*) *sinense* Sando, NSM PA14346. 1. Transverse section, ×5.0; 2. Longitudinal section, ×5.0.

orders, major and minor in alternation. They thin and straight or slightly sinuous. Major septa about 8 to 10 in number in mature stage. They confine within outer tabularium, but their extensions also observed within dissepimentarium. Aulos formed by united their deflected axial ends. Very short minor septa confine within the outer tabularium, but their extensions also observed within dissepimentarium. Dissepimentarium relatively wide and composed of several rows of dissepiments; lonsdaleoid dissepiments observed in greater part and concentric ones inner margin. Outer tabularium ranges from 0.2 to 0.4 mm in width. Round aulos area (inner tabularium) ranges from 0.2 to 0.5 mm in diameter.

In longitudinal section, wall rarely present. Dissepimentarium relatively wide and composed of several rows of vesicle like to elongate dissepiments. Their convex sides mostly facing upwards, but those in inner margin facing upwards as well as inwards. Outer tabularium 0.2 to 0.5 mm in width; tabulae horizontal and 5 to 8 in vertical distance of 2 mm. Aulos area (inner tabularium) 0.2 to 0.5 mm in diameter; tabulae horizontal and 4 to 7 in vertical distance of 2 mm.

Remarks: The present specimen is characterized by its aphroid type corallum, small corallites and septal number, narrow aulos area. Besides, its septa are occasionally confluent with those of the adjacent corallites. The features mentioned above well agree with those of *Aulina* (*Pseudoaulina*) *sinense* Sando from the Upper Visean in the Chilien-shan Mountains, China. However, the former has rarely wall. Besides, the latter's longitudinal section is not observed.

Genus *Aulokoninckophyllum* Sando, 1976

Aulokoninckophyllum carinatum (Carruthers, 1909)

(Figs. 7-1, 2)

Camphophyllum carinatum Carruthers, 1909, p. 150, pl. 1, figs. 3–6; Smith and Yü, 1943, p. 52, 53.

Aulina carinata (Carruthers): Hill, 1938, p. 13, 1940, p. 190; Vasilyuk, 1960, p. 100, pl. 24, figs. 1–1 c; Fontaine, 1961, p. 121, 122, pl. 20, figs. 5, 6; Minato and Rowett, 1967, p. 385, 387; Semenoff-Tian-Chansky, 1974, p. 50–54, pl. 3, figs. 1–8, pl. 4, figs. 1–6.

Aulokoninckophyllum carinatum (Carruthers): Sando, 1976, p. 433, 434; Hill, 1981, p. 387, 388, figs. 253-2 a, b.

Material: A single specimen, NSM PA14357.

Description: Corallum solitary and trochoid?.

In transverse section, corallite subcircular? in outline and 13.0+ mm in diameter in mature stage. Wall missing. Septa of two orders, major and minor in alternation. They nearly straight and slightly thickened in middle portion, thinning towards both ends. Carinate type septal fine structure diffuso-trabecular. Major septa about 39 in number in mature stage. Cardinal septum somewhat shorter than other major ones. Minor septa generally 2/3 length of major ones. Dissepimentarium wide, but a part of its outer portion missing. Numerous dissepiments arranged in concentric pattern.

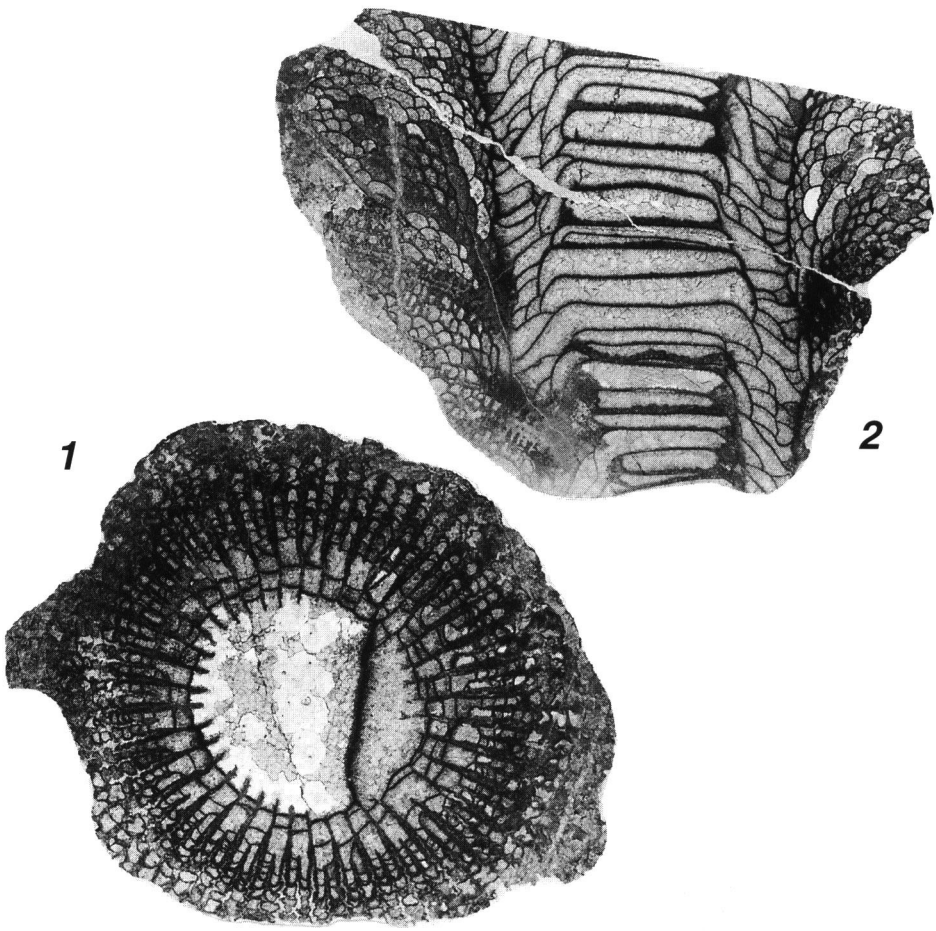


Fig. 7. *Aulokoninckophyllum carinatum* (Carruthers), NSM PA14357. 1. Transverse section, ×5.0; 2. Longitudinal section, ×5.0.

Tabularium also wide. Outer tabularium about 1.0 to 1.5 mm in width; tabulae generally concentrical. Round pseudoaulos area (inner tabularium) about 5.5 mm in diameter. It generally formed by downtrend part of tabulae, in which however axial ends of major septa a little intruded. Cardinal fossula present.

In longitudinal section, wall missing. Dissepimentarium wide (5.5+ mm in width) and composed of more than 12 rows of vesicle-like dissepiments. Their convex sides facing upwards as well as inwards or inwards. Tabularium also wide, about 7.0 to 8.0 mm in diameter. Pseudoaulos area (inner tabularium) about 4.0 to 5.0 mm in diameter; tabulae complete, horizontal and 9 in vertical distance of 5 mm. In outer tabularium, tabulae incomplete and slope down towards dissepimentarium. They about 11 in vertical distance of 5 mm.

Remarks: The present specimen much resembles *Aulokoninckophyllum carinatum* (Carruthers) from the Upper Visean in Russia, Laos and England and the Upper Visean to Lower Namurian in Sahara and Ukraina in having solitary corallum, almost the same size of corallite, large septal number, almost the same spaced tabulae in wide pseudoaulos area in longitudinal section, concentric dissepiments of numerous rows and cardinal fossula.

Suborder Lonsdaleiina Spasskiy, 1974
Family Axophyllidae Milne-Edwards and Haime, 1851
Genus *Pareynia* Semenoff-Tian-Chansky, 1974
Pareynia? sp. indet.
(Figs. 8-1, 2)

Material: A single specimen, NSM PA14341.

Description: Corallum solitary and large in size.

In transverse section, corallite suboval in outline at present. In mature stage, it about 38.0+ mm in shortest diameter. Wall missing. Septa of two orders, major and minor in alternation. They straight or slightly sinuous. No septal contact with wall, because interrupted by lonsdaleoid dissepiments. Septal fine structure diffuso-trabecular to fibro-normal types. Major septa about 46 in number in mature stage. They long and extend near axial structure. They slightly thickened in middle portion, thinning towards both ends. Minor septa thin and generally 3/4 to 4/5 length of major septa. Dissepimentarium wide, but a part of its outer portion missing. It composed of very elongate and closely spaced lonsdaleioid dissepiments in outer portion, somewhat irregular lonsdaleoid ones in middle portion and concentric, angulo-concentric and irregular ones in inner portion. Tabularium somewhat wide, about 2.0 to 5.0 mm in width. Tabulae rarely seen. Axial structure relatively large and subround in outline, occupying about 1/4 diameter of corallite. It composed of a median plate, septal lamellae and axial tabellae. Median plate relatively short and slightly thick. Septal lamellae numerous, slightly thick and irregularly curved. Axial tabellae numerous, thin and generally inwardly convex. Fossula indistinct.

In longitudinal section, wall missing. Dissepimentarium wide. Dissepiments arranged in numerous rows. Dissepimentarium composed of very elongate dissepiments in peripheral (outer) portion. They steeply or gently inclined inwards. Vesicle-like to elongate dissepiments developed in wide middle portion. Their convex sides upwards. Vesicle-like to elongate dissepiments developed in inner portion. Their convex sides facing upwards as well as inwards. Tabularium somewhat wide; it about 3.0 mm in width. It composed of somewhat wide horizontal tabulae and clinotabulae. Horizontal tabulae complete and 4 to 5 vertical distance of 2 mm. Axial structure about 1/4 diameter of corallite. It composed of a slightly thick median plate, slightly thick, irregularly flexuous septal lamellae and thin, steeply ascending axial tabellae

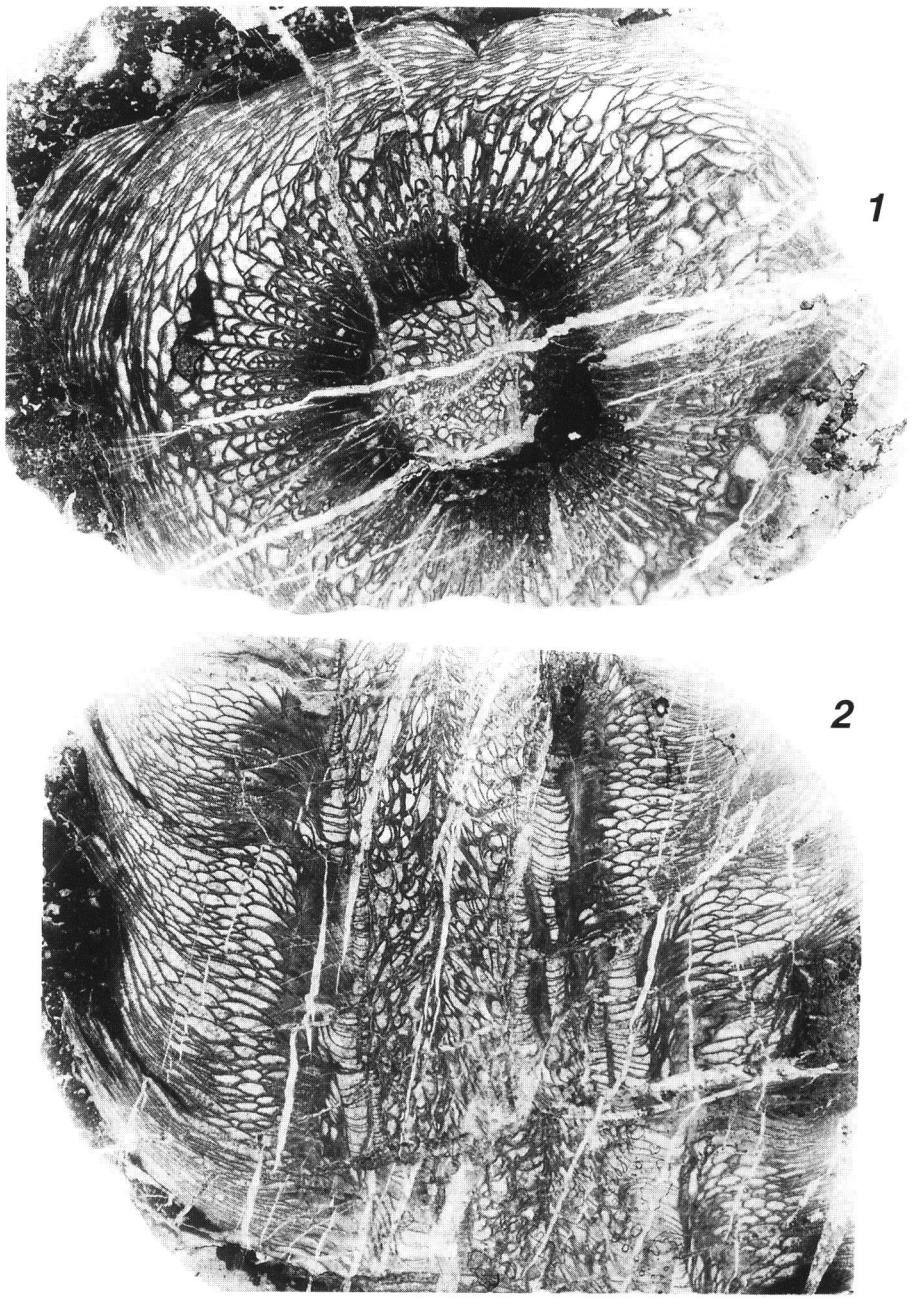


Fig. 8. *Pareynia*? sp. indet., NSM PA14341. 1. Transverse section, ×2.1; 2. Longitudinal section, ×2.1.

which are straight or inwardly convex. Median plate straight or slightly sinuous.

Remarks: The present form is similar to *Pareynia splendes densa* Semenoff-Tian-Chansky (1974, p. 246–248, pl. 64, figs. 1–3, pl. 65, fig. 3) from the Upper Visean in Sahara in having a large solitary corallum, very elongate and closely spaced lonsdaleoid dissepiments in peripheral portion of dissepimentarium and almost the same form of axial structure, but differs from the latter in having somewhat wide horizontal tabulae in longitudinal section. It also resembles *Pareynia splendes* described by Poty (1981, p. 64, 65, pl. 31, figs. 1, 2) from the Upper Visean in Belgium. However, the former can be distinguished from the latter in having a solitary corallum and more elongate and more closely spaced lonsdaleoid dissepiments. The corallum of the latter is compound.

The present form has somewhat wide tabulae in longitudinal section, but the species belonging to *Pareynia* can not observe horizontal tabulae. Except for this data, it possesses many distinct features of *Pareynia* such as a large and solitary corallum, very elongate and closely spaced lonsdaleoid dissepiments and other morphological characters. Therefore, we place it in *Pareynia* with some doubt at present.

Heterocorals and Tabulate Coral
(by Shuji Niko)

Order Heterocorallia Schindewolf, 1941

Family Heterophyllidae Dybowski, 1873

Genus *Hexaphyllia* Shtukenberg, 1904

Hexaphyllia sp. indet. 1

(Fig. 9-1)

Material: Three transverse thin sections were studied from three specimens (NSM PA14360–14362).

Description: Corallites prismatic with hexagonal cross sections, attain approximately 1.0 mm in diameter. Corallite wall moderate in thickness for genus. Septa conjoined axially, consisting of 2 simple tabular and 2 bifurcate forms; tabulae thin, adaxially convex in transverse section.

Discussion: The simple corallite morphology of *Hexaphyllia* involves serial sections including the adult stage for specific identification. In addition, longitudinal section of *Hexaphyllia* sp. indet. 1 can not detect, thus the author has left this species in open taxonomy.

Hexaphyllia sp. indet. 2

(Figs. 9-2, 3)

Material: Two transverse thin sections were studied from a single specimen (NSM PA14363).

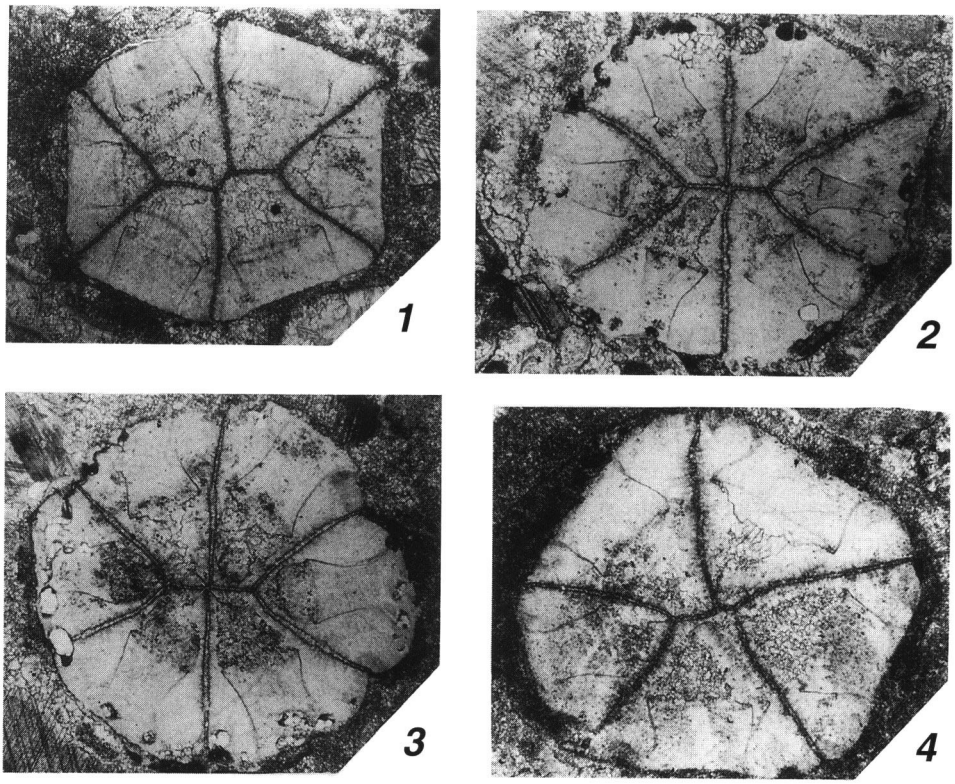


Fig. 9. 1, *Hexaphyllia* sp. indet. 1, transverse thin section, NSM PA14361, ×40. 2, 3, *Hexaphyllia* sp. indet. 2, transverse thin sections, NSM PA14363, ×40. 4, *Pentaphyllia* sp. indet., transverse thin section, NSM PA14364, ×40.

Description: Corallite cylindrical with subcircular cross section, attains approximately 1.2 mm in diameter. Corallite wall thick for genus. Septa conjoined axially, consisting of 2 simple tabular and 2 bifurcate forms. Surface longitudinal depression bears at each peripheral edge of septum. Outer corallite wall porous (ascribing to boring by epiorganisms?).

Discussion: The cylindrical corallite with thick wall of *Hexaphyllia* sp. indet. 2 suggests a relationship with *H. mirabilis* (Duncan, 1867, pl. 31, figs. 5 a–h), that elected on the basis of specimens from the Lower Carboniferous of Scotland. However, the lacking of knowledge from longitudinal section of this present specimen prevents comparison at the specific level. Cossey (1997) stated that *Hexaphyllia mirabilis* is a junior subjective synonym of *H. marginata* (Fleming, 1828).

Genus *Pentaphyllia* Yü *et al.*, 1978

Pentaphyllia sp. indet.

(Fig. 9-4)

Material: Two transverse thin sections were studied from a single specimen (NSM PA14364).

Description: Corallite subprismatic with nearly pentagonal cross section, attains approximately 1.2 mm in diameter. Corallite wall moderate to relatively thick for genus. Septa conjoined axially, consisting of 1 (or 3?) simple tabular and 2 (or 1?) bifurcate forms.

Discussion: This present specimen differs from a Lower Carboniferous species *Pentaphyllia regulare* Yü *et al.* (1978, pl. 16, figs. 5 a, b, 6 a, b, 7, 8, text-figs. 7 a, b from Xingjiang, North China; Sugiyama, 1984, pl. 4, figs. 6–8, text-fig. 14 from the Akiyoshi Limestone, Yamaguchi Prefecture) in its somewhat thicker corallite wall. However, there is not enough material to the specific identification.

Order Auloporida Sokolov, 1947

Superfamily Syringoporicae Fromentel, 1861

Family Syringoporidae Fromentel, 1861

Genus *Syringopora* Goldfuss, 1826

Syringopora kotakiensis n. sp.

(Figs. 10-1–6)

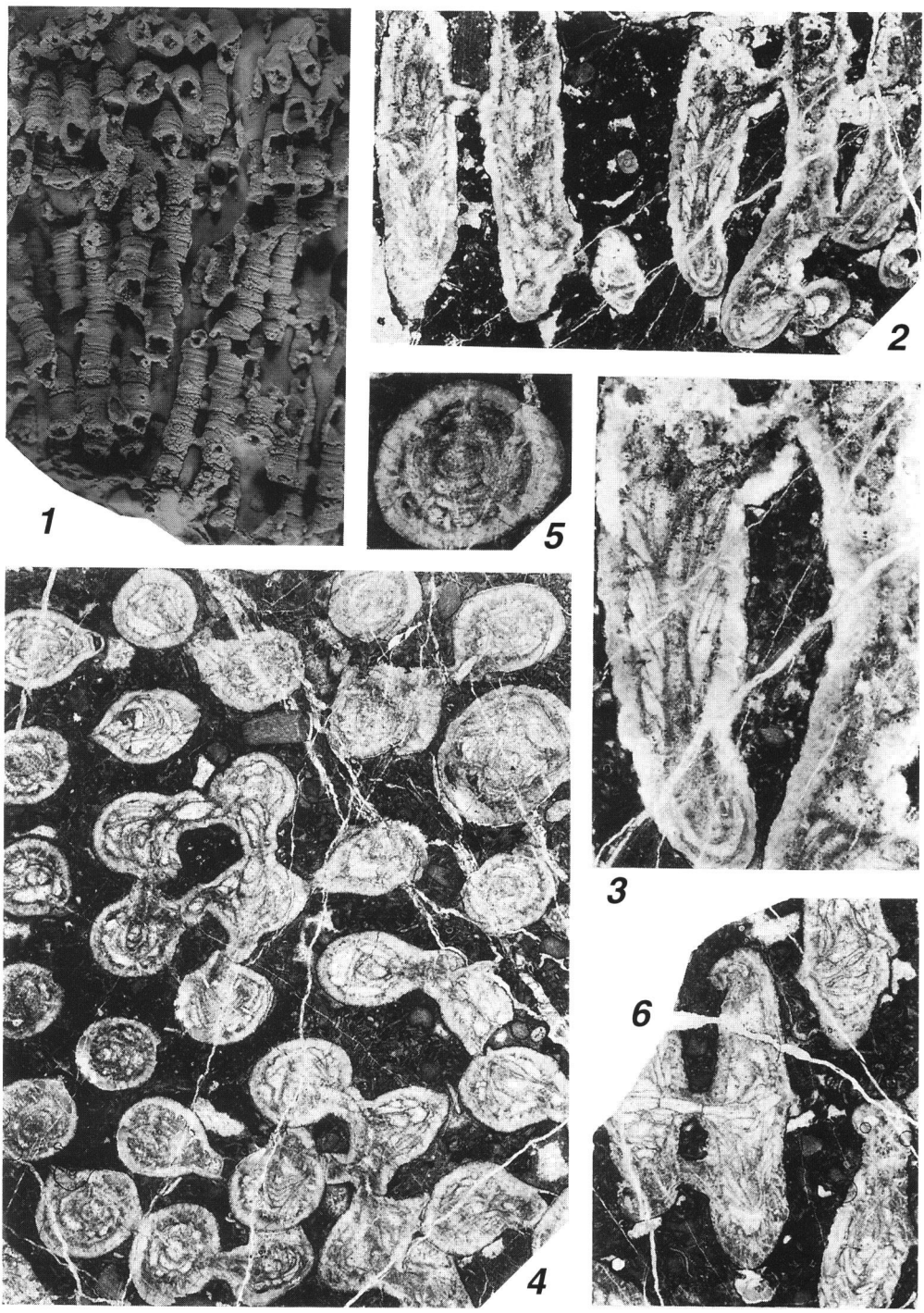
Syringopora sp.; Kamiya and Niko, 1996, p. 19, figs. 1–3.

Holotype: NSM PA14366, from which nine thin sections were made.

Other specimens: Eight thin sections and two etched pieces were studied from the four paratypes (NSM PA14365, 14367–14369).

Diagnosis: Species of *Syringopora* characterized by low-domed to thick turf-like growth form, possession of frequent connecting tubuli with mural tunnel, and thick walls; corallites diameter approximately 2.4 mm, their spacing usually 8–11 per cm^2; number of tabulae usually 9–13 in 5 mm of corallite length.

Description: Coralla low-domed to thick turf-like in growth form with maximum observed size 90 mm in diameter and 50 mm in height, phaceloid. Corallites almost cylindrical, diameter ranging from 1.9 to 3.5 mm (usually 2.2–2.6 mm, mean 2.4 mm in holotype); outer surface of epitheca with growth lines and well-developed transverse wrinkles, in addition weak longitudinal septal grooves partly recognized; spacing of corallites usually 8–11 per cm^2; neighboring corallites joined by frequent connecting tubuli, diameter approximately 1.1 mm, or by direct contact in rare case at distal portion; some connecting tubuli linked together by horizontal mural tunnel in tabularium; off set occurs from connecting tubule. Corallite walls thick for genus, attain 0.38 mm, composed of thin outer layer of epitheca and inner thicker layer of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stereoplasm with microlamellar structure; septal spines relatively long, attain 0.46 mm in length, well-developed, usually 8–11 per corallite in any transverse sections, mostly horizontal; tabulae thin infundibuliform, abundant, usually 9–13 in 5 mm of corallite length, forming axial syrinx in central to subcentral position of corallites; diameter of axial syinx 0.6–0.7 mm; vertical diaphragms recognized in mural tunnel.

Discussion: Among the known species of *Syringopora*, *S. kotakiensis* n. sp. is somewhat similar to *S. intermixa* Reed (1927, pl. 4, figs. 1, 2; Chi, 1933, pl. 4, figs. 1 a–c), which occurs from the Lower Carboniferous in Yunnan, South China, in its corallite diameter and spacing, and wall thickness. *Syringopora intermixa*, however, exhibits the sparser connecting tubuli, and somewhat irregular shaped and fewer (5–10 in 5 mm of corallite length) tabulae. A Chinese species ascribing to *Syringopora hoffmanni* Stuckenberg (1895, pl.1, figs. 16, 17) based on the material from the Lower Carboniferous of eastern Qing Ling (Tsin-lin, Chinlin) of the suture zone between North and South China (Lin, 1958, pl. 1, figs. 1 a–e) and Nan Ling of South China (Lin, 1963, pl. 9, figs. 2 a–c), is also characterized by the possession of the mural tunnel. The absence of the septal spines is most diagnostic feature of this Chinese form. Yabe and Hayasaka (1915) referred some specimens from the Onimaru Formation, Southern Kitakami Mountainous to *Syringopora reticulata* Goldfuss (1826, pl. 25, fig. 8; Milne-Edwards and Haime, 1852, pl. 46, figs. 1, 1 a) that has the mean corallite diameter approximately 1.5 mm and poorly developed connecting tubuli.

Etymology: The specific name is derived from the Kotaki-gawa River. The type locality of the present new species is situated in the upper reaches of this river.

Acknowledgments

We would like to thank Mr. Toshiaki Kamiya (Kasugai, Aich Prefecture) for donation of important specimens and field assistance. Thanks are also due to Drs. Makoto Kato (Sapporo, Hokkaido), Fujio Masuda (Kyoto University) and Yoichi Ezaki (Osaka City University) for providing paleontological information. We are indebted to Dr. Hisayoshi Igo (National Science Museum), who gave many textural comments.

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Fig. 10. *Syringopora kotakiensis* Niko n. sp., 1–3, paratype, NSM PA14365. 1. Etched corallum fragment, ×2; 2, 3. Longitudinal thin sections, ×5 and ×10, respectively. 4–6, holotype, NSM PA14366. 4, 5. Transverse thin sections, ×5 and ×10, respectively; 6. Nearly longitudinal section, note mural tunnel and diaphragms, ×5.

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Appendix

Carboniferous coral specimens used in Niko *et al.* (1997; *Bull. Natn. Sci. Mus., Tokyo*, Ser. C, **23** (1, 2): 35–49) from the Oboradani Formation, Fukui Prefecture, have been transferred from the Department of Earth and Planetary Systems Sciences, Faculty of Science, Hiroshima University (IGSH) to the National Science Museum, Tokyo (NSM). The abbreviation and number changes of the specimens indicate in the following list.

IGSH-SN 10046	*Cladochonus hamadai*		⟶	NSM PA14025
IGSH-SN 10047	*C.*	*hamadai*	⟶	NSM PA14026
IGSH-SN 10048	*C.*	*hamadai*	⟶	NSM PA14027
IGSH-SN 10049	*Bothrophyllum domheri* forma a		⟶	NSM PA14028
IGSH-SN 10050	*B.*	*domheri* f. a	⟶	NSM PA14029
IGSH-SN 10051	*B.*	*domheri* f. a	⟶	NSM PA14030
IGSH-SN 10052	*B.*	*domheri* f. a	⟶	NSM PA14031
IGSH-SN 10053	*B.*	sp. indet.	⟶	NSM PA14032
IGSH-SN 10054	*Pseudotimania*? sp. indet.		⟶	NSM PA14033
IGSH-SN 10055	*Nephelophyllum* sp. indet.		⟶	NSM PA14034
IGSH-SN 10056	*Bothrophyllum* sp. indet.		⟶	NSM PA14035
IGSH-SN 10057	*B.*	sp. indet.	⟶	NSM PA14036
IGSH-SN 10058	*B.*	sp. indet.	⟶	NSM PA14037
IGSH-SN 10059	*B.*	sp. indet.	⟶	NSM PA14038
IGSH-SN 10060	*B.*	sp. indet.	⟶	NSM PA14039
IGSH-SN 10061	*B.*	sp. indet.	⟶	NSM PA14040
IGSH-SN 10062	*B.*	sp. indet.	⟶	NSM PA14041