

Some Carboniferous Rugose Corals from Northeast Thailand

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Abstract Upper Carboniferous limestones exposed in the Loei–Wang Saphung area, northeast Thailand yield many various rugose corals and most of them are recently described by Fontaine. Since 1963, I have also collected many specimens of rugose corals in the same area but not yet described these materials. In this paper, I describe some of them such as *Pseudozaphrentoides lingwuensis* (Lee and Yü), *Donophyllum yanfangense* Wu and Zhao, *Lytvophyllum* cfr. *minor* Wu and Zhao, and *Amygdalophylloides* cfr. *kinophylloides* Wang and Zhao, which are not listed in the previous papers, but they are all known species in the Weining Formation exposed in Yunnan and Guizhou, Southwest China. Furthermore, I discuss some paleontological problems and paleobiogeographic significance of these rugose corals.

Key words: Carboniferous, Loei, rugose coral, Thailand, Wang Saphung.

Introduction

Igo made field survey in the Loei–Wang Saphung area, northeast Thailand in the winter of 1963–1964 and collected many fusulinacean limestone samples. I already described these fusulinaceans and first clarified the detailed geologic age of the Upper Carboniferous to lowermost Permian carbonate rock sequences in these areas (Igo, 1972). Very recently, Igo *et al.* (1993), Ueno and Igo (1993), and others have studied fusulinaceans in the Loei–Wang Saphung area and disclosed many new fusulinacean biostratigraphic and paleontologic data. These studies are still in progress.

During the preparation of thin-sections for previous Igo's fusulinacean study, I obtained many specimens of rugose corals in these thin-sections but did not describe any of them. Subsequently, Fontaine and his collaborators (*e.g.*, Fontaine *et al.*, 1982, 1991) reported the occurrence of various Carboniferous rugose corals elsewhere in northeast Thailand. Most of these rugose corals are duplicate with my undescribed collections, but some of them have not been listed in the above mentioned papers. I describe these rugose corals herein because they are all previously known species from the Weining Formation of Yunnan and Guizhou, Southwest China. This faunal evidence indicates that the Upper Carboniferous rugose coral fauna in the Loei–Wang Saphung area, northeast Thailand belongs to exactly the same paleobiogeographic province with that of Southwest China.

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tute of Geoscience, the University of Tsukuba for their fine photographic work to prepare figures of this paper. Laboratory work was undertaken at the Department of Geology, National Science Museum, which provided facilities in preparation of this manuscript.

Geologic Setting

Rugose corals described herein are *Pseudozaphrentoides lingwuensis* (Lee and Yü), *Donophyllum yanfangense* Wu and Zhao, *Lytvophyllum* cfr. *minor* Wu and Zhao, and *Amygdalophylloides* cfr. *kinophylloides* Wang and Zhao. The locality numbers of these rugose corals in the following lines and Fig. 1 are the same with those of Igo (1972).

Pseudozaphrentoides lingwuensis was collected from a limestone exposed at the locality LE-14, about 1,100 m east of Huai Luang, Wang Saphung. This limestone yields *Fusiella* sp., *Pseudostaffella sphaeroidea* (Möller), *Fusulinella gracilis* Kammerer, *Fusulinella fluxa* Lee and Chen, and *Fusulina pulchella* Gryzlova. Igo (1972) correlated this limestone with the upper Moscovian (Myachkovsky) in the former USSR. *Pseudostaffella sphaeroidea* is now transferred to *Neostaffella sphaeroidea* and its range is considered to be the upper Moscovian (Podolosky–Myachkovsky) by Russian specialists (e.g., Einor *et al.*, 1996). *Fusulina pulchella* is, however, now assigned to a representative of the lowermost Kasimovian (Einor *et al.*, op. cit.).

Donophyllum yanfangense Wu and Zhao collected from a black limestone exposed at the locality LE-35, Ban Sup, about 19 km northeast of Loei. The following fusulinaceans such as *Pseudoendothyra pseudosphaeroidea* (Dutkevich), *Profusulinella prisca timanica* Kireeva, and *P. yentaiensis* Sheng were recorded in this limestone, and Igo (1972) assigned the fusulinaceans to the upper Bashikirian *Profusulinella* Zone. *Donophyllum yanfangense* was originally reported from a 12.2 m-thick gray limestone of the Weining Formation exposed in Yanfang, Zhanyi County, Yunnan. This limestone is immediately underlain by the limestone including *Profusulinella* aff. *ovata* Rauser-Chernousova and *Pseudostaffella khotunensis* Rauser-Chernousova, hence the geologic age of these coral beds in Thailand and Yunnan is almost coeval each other.

Lytvophyllum cfr. *minor* Wu and Zhao was collected from a dark gray limestone (LE-5-11) exposed in Huai Bun Nak, east of Wang Saphung. This limestone yields a few numbers of unidentified smaller foraminifers. Fusulinaceans are entirely lacking in the limestone, but Igo (1972) correlated the limestone with his *Profusulinella parva* zone based on the stratigraphic view point.

Lytvophyllum minor was originally described from the Zhaojiashan Formation exposed at the Weining section, western Guizhou (Wu & Zhao, 1974). It also occurs in the Lower Weining Formation of the same area. The stratigraphic level of the present coral in Huai Bun Nak falls within the range confirmed in western Guizhou.

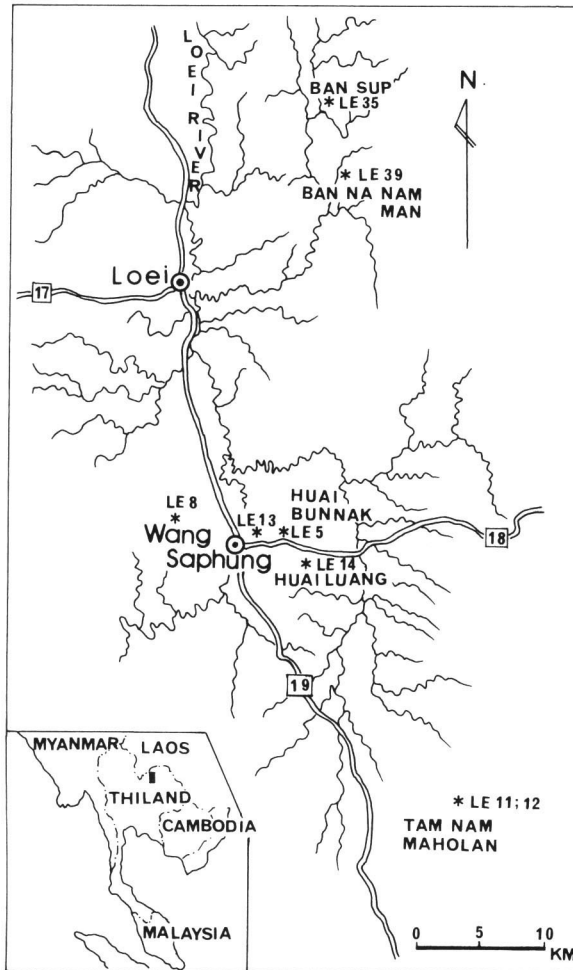


Fig. 1. Map showing fossil localities in the Loei-Wang Saphung area, northeastern Thailand (after Igo, 1972).

Amygdalophylloides cfr. *kionophylloides* Wang and Zhao was obtained from a gray limestone (LE-5-4) exposed in Huai Bun Nak in association with *Beedeina paradistenta* (Safonova). Similar specimens identified as *Amygdalophylloides* sp. were also reported from a limestone exposed at Ban Pha Noi, northwest of Wang Saphung by Fontaine *et al.* (1991). *A. kinophylloides* was originally reported from the upper part of the Weining Formation in Huize, Yunnan (Wang & Zhao, 1989):

Recently, the geologic evolution of Southeast Asia has been interpreted based on terrane analysis and collision tectonics (*e.g.*, Bunopas, 1982; Metcalfe, 1988, 1996; Huchinson, 1989; Sashida *et al.*, 1998). These authors allocated the Loei-Wang Sa-

phung area in the Loei Fold Belt, which extends N-S along the boundary between the Indochina and Sibumas (=Shan-Thai) blocks. According to the palinspatic map by Bunopas (1982) and comments concerning the paleogeographic evolution of South-east Asia by several authors (*e.g.*, Metcalfe, 1988), these blocks were situated close each other in later Carboniferous to Permian times. Sedimentary facies of the Upper Carboniferous carbonate rocks in both blocks, however, are contrasting and radically different. Carboniferous limestone beds in the Loei-Wang Saphung area are dark gray to black, thin, mostly argillaceous, and intercalated with shale and sandstone in which brachiopods, trilobites, and other shallow marine fossil organisms are gregarious in places. On the contrary, limestones of the same age exposed in Yunnan and Guizhou are mostly light gray to gray consisting of thick sequences, which were deposited in the extensive carbonate shelf in the South China block (Wu & Zhao, 1989). The Upper Carboniferous rugose coral fauna in the Loei-Wang Saphung area introduced by Fontaine *et al.* (1991) and the present paper is, however, strikingly similar to that of the South China block.

Description of Species

Family Cyathopsidae Dybowski, 1873

Genus *Pseudozaphrentoides* Shtukenberg, 1904

Pseudozaphrentoides lingwuensis (Lee and Yu, 1934)

(Figs. 2-6-8)

Caninia lingwuensis Lee and Yü, 1934, p. 63-64, pl. 11, figs. 8-11; Fontaine, 1961, p. 145-146, pl. 10, fig. 11, pl. 11, figs. 5-6, pl. 13, figs. 1 a-c, 3-4, pl. 16, fig. 3.

Haplolasma lingwuensis, Wu and Zhao, 1989, p. 52, pl. 5, figs. 4 a-b, 5 a-b; Luo and Xu, 1990, pl. 1, figs. 4a-b; Luo and Qi, 1990, p. 699, pl. 1, figs. 10 a-b, pl. 2, fig. 2.

Description: Corallite simple, small, and cylindrical horn-shaped. Diameter of corallite about 20 mm and length attains more than 50 to 70 mm at mature stage. Outer wall thin and consists of outer very thin dark epitheca and inner thicker transparent fibrous layer. In transverse section, no prominent septal furrows and interseptal ridges in outer wall, but weak and irregular transverse undulations present. Transverse furrows discernible in longitudinal section.

In oblique section of mature stage, diameter of corallite 20×25 mm. Major septa number 25, attain approximately 3/4 radius of corallite in length, more or less evenly thickened and flexuous in tabularium, and zigzag in dissepimentarium. One of them, cardinal septum, short and less than 1/2 length of other major septa and constitutes indistinct cardinal fossula. Minor septa alternating with major septa, incomplete in places, thin, zigzag, short, and restricted within dissepimentarium.

Dissepimentarium narrow and less than 1/3 radius of corallite. Dissepiments rarely concentric, mostly herringbone pattern, and irregularly inosculating major and minor septa in places of mature stage.

Another section representing ephelic stage and its corallite diameter about 15 mm with 25 major septa. These septa attain about 2/3 radius of corallite in length, slightly flexuous, and weakly dilated in cardinal quadrant. Minor septa alternate with major ones, short, 1/3 to 1/4 length of major septa, and discontinuous in places. Dissepimentarium narrow and consists mainly of concentric dissepiments but herring-bone pattern also present in places.

In longitudinal section, corallite separated into peripheral dissepimentarium and central wide tabularium. Dissepimentarium in counter quadrant wider than that in cardinal quadrant. Various sized vesicular dissepiments facing upward as well as inward and arranged in several rows in counter side. Single row of large vesicles occupies counter side of corallite in ephelic to mature stages. Dissepiments in cardinal side of corallite small, but various sized vesicles arranged in two to three rows and facing upward as well as inward. Tabulae mostly horizontal and complete, but slightly concave and incomplete with downturned edges in places. Tabulae number 7 to 8 per 5.0 mm in ephelic stage but 3 to 4 per 5.0 mm in mature stage.

Microstructure of septa typical diffusio-trabecular.

Remarks: The generic assignment of this type of caninid species is a complex problem. As already pointed out by Fontaine (*In Fontaine et al.*, 1991), actual *Caninia* is rare but some previous coral specialists assigned this type of caninid to the genus *Caninia*, which has been repeatedly revised by many authors. The genus diagnosis of this type of caninid shows close affinity with that of the genera *Pseudozaphrentoides* Shtukenberg, *Arctophyllum* Fedorowski, and *Haplolasma* Semenoff-Tian-Chansky. *Pseudozaphrentoides* was synonymized with *Caninia* by Dobrolyubova (1952) and Fedorowski (1975), but it has been commonly assigned to the independent genus by most of the European authors (*e.g.*, de Groot, 1963; Semenoff-Tian-Chansky, 1974; Ivanowskiy, 1987). Previous to Dobrolyubova's revision in 1952, Moore and Jeffords (1945) criticized this genus in detail, hence subsequent American authors such as Sutherland (1958), Ross and Ross (1962), Fagerstrom and Eisele (1966), and Fagerstrom and Marcus (1967) assigned that *Pseudozaphrentoides* is a valid genus.

Arctophyllum is northern Europe to Arctic caninid rugose corals which are characterized by very strong development of alar septa and shortening of counter septum in the neanic stage. Fedorowski (1975) called that this ontogeny is "plerophylloid" neanic stage.

The type species of the genus *Haplolasma* is characterized by a large corallite, numerous septa, and regularly concentric dissepiments. Recently, Chinese specialists assigned this genus to caninids similar to the present species, *Caninia lingwuensis* Lee and Yü (1934), which was originally described from the Maping Limestone of Hunan Province, South China. Luo and Xu (1990) and Luo and Qi (1990) reported this species from the Upper Carboniferous to Lower Permian of Fujian, South China and assigned to the genus *Haplolasma* Semenoff-Tian-Chansky. These Chinese spec-

imens, however, have much smaller numbers of septa than those of the typical *Haploplasma* species known in the Lower Carboniferous. Furthermore, this species has herringbone (manx-shaped by Chinese authors) dissepiments in places. On the basis of these characters I might hesitate to assign this species to *Haploplasma*. The present specimen differs from the original Chinese specimen, "*C.*" *lingwuensis*, in more well developed and complex herringbone dissepiments at the mature stage. Luo and Qi (1990) illustrated thin sections of two specimens of this species. One of their specimens illustrated on Plate 2, fig. 2 shows similar development of herringbone dissepiments to my specimen, but it has longer major septa than this Thai specimen. Wu and Zhao (1989) also described this species from the Zhanyi section of Eastern Yunnan. Their illustrated specimens resemble the present material in many points.

According to Lin (1995), *Haplolasma* is synonymized with *Pseudozaphrentoides*. I concur with this recent view by the Chinese authorities and consider that the present species and other similar caninids should be assigned to *Pseudozaphrentoides* rather than *Caninia* or *Haplolasma*, in moderately well developed dissepiments showing herringbone pattern and fewer numbers of septa.

Fontaine (1961) described this species from the Nhommarat Limestone, Laos about 300 km east of the Loei area. This limestone is correlated with the Maping Limestone of South China. Fontaine's Laos specimens are similar to the present Thai material, but the latter has more dense tabulae.

Locality and age: LE-14 (late Moscovian)

Reg. no. IGUT-75133

Family Yatsengiinae Hill, 1956

Genus *Donophyllum* Fomichev, 1939

Donophyllum yanfangense Wu and Zhao, 1989

(Figs. 2-1-4)

Donophyllum yanfangense Wu and Zhao, 1989, p. 125-126, pl. 38, figs. 1 a-d.

Description: Corallum fasciculate and phaceloid. Corallites slender, generally closely disposed, and in contact each other in places. Corallites circular in transverse section and attain 9.0 to 10.0 mm in diameter at mature stages. Wall rather thick compared with size of corallite diameter and 0.08 to 0.12 mm in large corallites. Septal furrow shallow and indistinct.

Septa two orders and alternating with major and minor. Major septa number 20 to 24 in mature corallites, and 12 to 16 in neanic to ephebic stages. They 1/3 radius of corallite in length, flexuous and zigzag, slightly thickened in dissepimental zone, interrupted and discontinuous where lonsdaleoid dissepiments developed. A few major septa including counter and cardinal septa extended into axis of corallite, connected each other, and make loose axial structure in some neanic to ephebic corallites as

shown in Fig. 2-3. Minor septa short, flexuous, and restricted to dissepimentarium. They commonly 1/2 to 1/3 length of major septa, more or less zigzag, and incomplete in places.

Dissepimentarium narrow and consists of one or two rows of concentric dissepiments in most growth stages of corallite. In some large corallites, three to four concentric dissepiments present in periphery with herringbone pattern in inner side. Lonsdaleoid dissepiments developed in restricted portion of corallite where new neanic corallites appear as peripheral increase.

In longitudinal section, narrow peripheral dissepimentarium and wide tabularium well discernible. Dissepiments large in one or two rows and facing upward as well as inward. In some other corallites dissepiments disposed in outer smaller ones and inner larger ones both facing upward as well as inward. Tabulae more or less thickened, mostly horizontal and complete, but slightly concave and incomplete with downturned edges. Tabulae number 7 to 10 per 5.0 mm and their spacing rather uneven.

Microstructure of septa diffuso-trabecular.

Remarks: The present specimen is similar to the Chinese original one described from the Upper Carboniferous Weining Formation exposed at Yanfang, Zhanyi County, Yunnan Province, Southwest China (Wu & Zhang, 1989) in many respects. The Thailand specimen, however, has generally slightly shorter and thinner major septa compared with those of the Chinese specimen. This species differs from the Russian species, *Donophyllum diphyphyloideum* Fomichev, in larger corallites and more numbers of major septa. Fomichev (1939) introduced this coral as a new species with two figures but did not mention any description. Subsequently, he described the same material in detail as a new species (Fomichev, 1953).

Locality and age: LE-35 (late Bashkirian)

Reg. no. IGUT-75155

Family Petalaxidae Fomichev, 1953

Genus *Lytvophyllum* Dobrolyubova, *In* Soshkina,

Dobrolyubova and Profirev, 1941

Lytvophyllum cfr. *minor* Wu and Zhao, 1974

(Fig. 2-9)

Compare:

Lytvophyllum minor Wu and Zhao, 1974, p. 270, pl. 138, fig. 1; Wu and Zhao, 1989, p. 135-136, pl. 43, figs. 1 a-b; 2 a-d, text-fig. 1.

?*Hillia guizhouensis* Wang, 1978, p.139-140, pl. 42, fig. 1.

?*Hillia minor*, Wang, 1978, p.140, pl. 43, fig. 3.

Description: Corallum fasciculate and phaceloid. Corallites slender, closely spaced, and in contact each other in places. Corallites circular or subcircular in trans-

verse section and attain 5.0 to 8.0 mm in diameter at mature stage. Wall thickened and 0.25 to 0.30 mm thick. Septal furrow shallow and indistinct.

Septa two orders, major and minor, but minor ones very short or almost rudimentary. Major septa 15 to 19, rarely 23 in number, their length generally $2/3$ radius of corallite but some of them attain center of corallite and constitute loose axial structure. These septa sinuous, more or less thickened in tabularium, and discontinuous where small lonsdaleoid dissepiments developed. Minor septa sporadically appear near periphery as short spines.

Dissepiments concentric and less commonly herringbone pattern in inner, but small lonsdaleoid dissepiments well developed in periphery. In neanic corallites, lonsdaleoid dissepiments entirely lacking. Width of dissepimentarium commonly $1/2$ to $2/3$ radius of corallite.

Microstructure of septa not so clear by secondary mineralization, but it seems to be diffusio-tabecular.

Remarks: The present specimen is not well preserved, and corallites are crashed and broken in places. Furthermore, I could not prepare any well-oriented longitudinal section hence the detailed specific characters are unclear to identify. The specimen, however, shows close affinity with *Lytvophyllum minor* Wu and Zhao described from the Middle Carboniferous Weining Series, western Guizhou, Southwest China. This Thai material differs from the Chinese specimens in more numbers of major septa and less developed lonsdaleoid dissepiments.

Gorsky (1978) fully described *Lytvophyllum antiqua* from the Bashkirian of the western slope of Urals. This Russian species is similar to the present Thai specimen, but I refrain from identification because of my insufficient thin sections.

Locality and age: LE-5-11 (late ? Bashkirian)

Reg. no. IGUT-75111

Genus *Amygdalophylloides* Dobrolyubova and Kabakovich, 1948

Amygdalophylloides cfr. *kionophylloides* Wang and Zhao, 1989

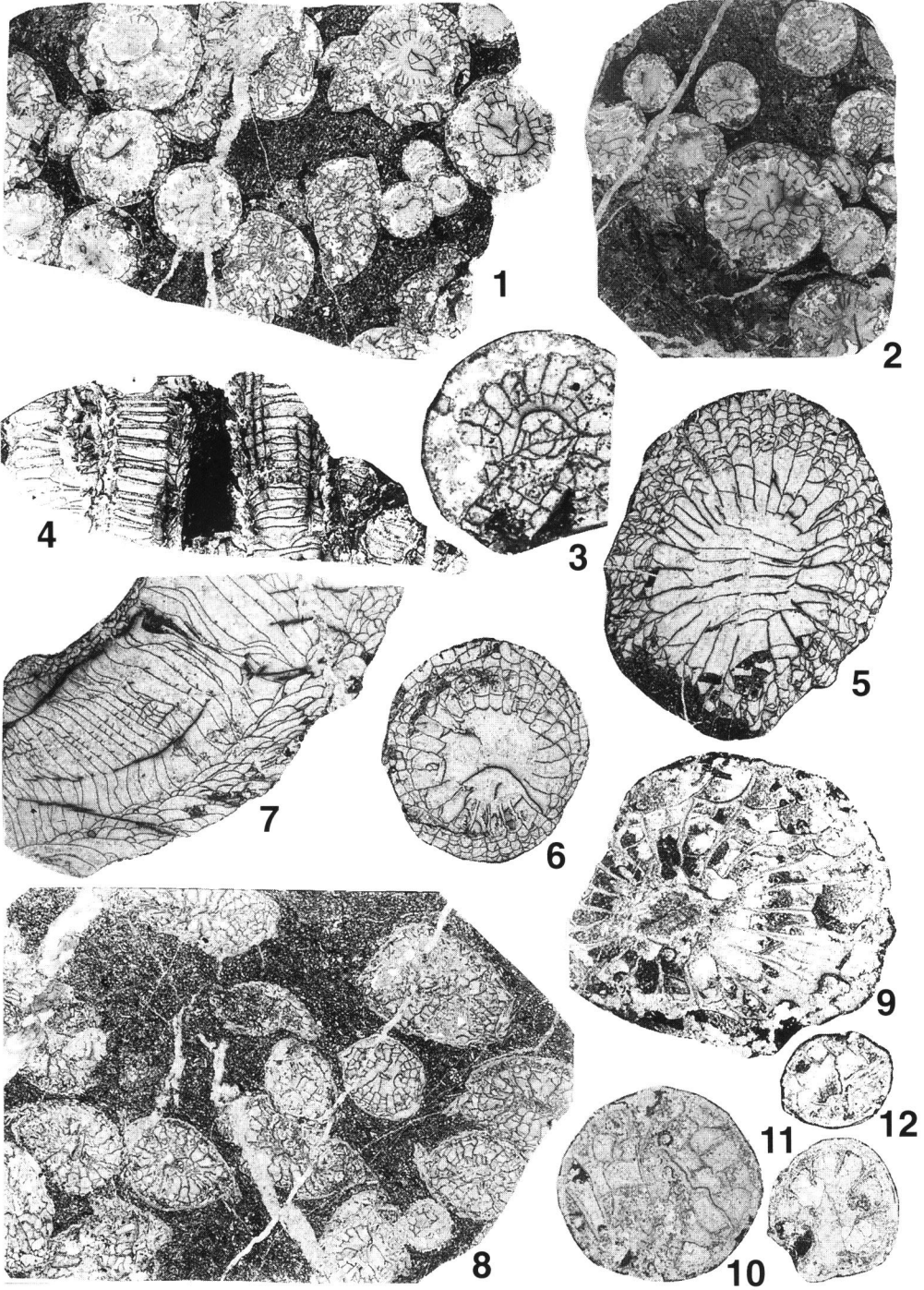
(Figs. 2-10-13)

Compare:

Amygdalophylloides kionophylloides Wang and Zhao, 1989, p. 84, 93, pl. 3, fig. 2, text-figs. 2-3.

Amygdalophylloides sp. Fontaine, *In Fontaine et al.*, 1991, p. 62, pl. 3, fig. 4; pl. 4, figs. 3-4.

→Fig. 2. 1-4. *Donophyllum yanfangense* Wu and Zhao. 1, 2, Transverse sections, $\times 2$; 3, enlarged corallite shown in fig. 2 of which major septa are long and constitute axial structure, $\times 5$; 4, longitudinal section, $\times 2$; IGUT-75155. 5-7. *Pseudozaphrentoides lingwuensis* (Lee and Yü). 5, Transverse section of mature stage; 6, transverse section of epebic stage, $\times 2$; 7, longitudinal section, $\times 2$; IGUT-75133. 8. *Lytvophyllum* cfr. *minor* Wu and Zhao. Transverse section, $\times 2$; IGUT-75111. 9-12. *Amygdalophylloides* cfr. *kinophylloides* Wang and Zhao. 9, Transverse section of mature stage, $\times 5$; 10-12, transverse sections of neanic stage, 10 $\times 8$; 11, 12 $\times 4$; IGUT-75108.



Description: Corallite simple, small, and cylindrical. Diameter of corallite about 10.0 mm in mature stage. Septa two orders, major ones long, reach near columella, and about 20 in number. They flexuous, thickened, and interrupted by lonsdaleoid dissepiments in places. Minor septa about 1/2 length of major septa and alternate with them. Columella solidified, oval in transverse section, and consists of median plate and radiating septal lamellae. Dissepiments both concentric and herringbone pattern. Lonsdaleoid dissepiments developed in places. In neanic to ephebic stages, corallite 2.5 to 3.0 mm in diameter and has 8 to 10 short major septa. One septum, probably counter septum, long, attains center of corallite, and slightly thickened.

Microstructure of septa diffuso-trabecular.

Remarks: Material is incomplete specimens, hence I could not prepare any preferred longitudinal section. The transverse section of mature stage is also not so complete for detailed identification, but the present specimen is similar to the Chinese specimens reported from the Weining Formation in Yunnan (Wang & Zhao, 1989). Fontaine (*In Fontaine et al.*, 1991) described *Amygdalophylloides* sp. from Ban Pha Noi, northeast of Wang Saphung. His specimens are very similar to the present specimen in several characters and probably belong to the same species.

Locality and age: LE-5-4 (late Moscovian)

Reg. no. IGUT-75108

Repository: All described specimens in this paper are housed in the Institute of Geoscience, the University of Tsukuba with prefix IGUT.

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