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论四射珊瑚包珊瑚科(Amplexidae Chapman, 1893)的分类

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提要 讨论了包珊瑚科(Amplexidae Chapman 1893)的分类。把包珊瑚型隔壁限于仅在外端连续,向轴部变薄呈短而低的脊状,纵向呈不连续的着生于横板之上。包珊瑚型隔壁的微细构造以层状骨骼为主,其轴部有时可出现非晶棉型纤状骨骼,包括晶粒和短轴晶柱。泡沫珊瑚型隔壁由全晶棉,杆晶棉和复式杆晶棉组成。据此易于和包珊瑚型隔壁区分。包珊瑚科以具包珊瑚型隔壁为特征。有10个属可归入该科,它们是:*Estonielasma*, *Pilophyllia*, *Synamplexoides*, *Lindstroemophyllum*, *Amplexoides*, *Protopilophyllum*, *Siphonophrentis*, *Altaiophyllum*, *Amplexus*, *Bordenia*。还对 *Estonielasma*, *Synamplexoides*, *Siphonophrentis*, *Altaiophyllum* 和 *Bordenia* 作了讨论,并提出了包珊瑚科中一些属之间可能的亲缘关系。

关键词 四射珊瑚 包珊瑚科 包珊瑚型隔壁 骨骼构造 分类

ON TAXONOMY OF THE FAMILY AMPLEXIDAE CHAPMAN, 1893

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Abstract

This paper deals with taxonomy of the Family Amplexidae Chapman (rugose coral). Amplexoid septa are longitudinally continuous only on peripheral parts, but become attenuated and discontinuous in the axial part, occurring as short low ridges on upper surfaces of tabulae. They may be composed entirely of lamellar skeleton, or with axial ends containing non-trabecular fibrous granules and brachycolumns.

Amplexoid septa are similar to cystiphylids in some aspects, but the latter are composed of holacanth, rhabdacanth, and composite rhabdacanth, which are absent in the former. The Family Amplexidae contains 10 genera, namely, *Estonielasma*, *Pilophyllia*, *Synamplexoides*, *Lindstroemophyllum*, *Amplexoides*, *Protopilophyllum*, *Siphonophrentis*, *Altaiophyllum*, *Amplexus*, and *Bordenia*. Here diagnosed are the genera *Estonielasma*, *Synamplexoides*, *Siphonophrentis*, *Altaiophyllum*, and *Bordenia* with brief discussions. In addition, the relationships between some genera included in this family are proposed based on new interpretation of the structures.

Key words rugose coral, Amplexidae, amplexoid septum, skeletal structures, taxonomy

Introduction

The Amplexidae was proposed by Chapman(1893)based on the amplexoid septa of the genus *Amplexus* from the Lower Carboniferous of Limerick, Ireland. Greene(1901)put the genus *Brodenia* from the Lower Carboniferous of Indiana, U.S.A. in Amplexidae. Wang(1947)established two Silurian genera, *Amplexoides* and *Lindstroemophyllum* on the basis of the material from eastern Yunnan, China, and placed them under the subfamily Amplexinae Wang, 1947. The subfamily Amplexinae used by Wang(1950)consists of three genera, *Amplexus* Sowerby, 1814, *Amplexoides* Wang, 1947, and *Fletcheria* Edwards et Haime, 1851. In 1956, Hill included in her Amplexidae only one genus, *Amplexus*, while in 1981 she put in the family 6 genera, namely, *Amplexus* Chapman, 1814, *Amplexoides* Wang, 1947, *Bordenia* Greene, 1901, *Heterophrentis* Billings, 1875, *Lindstroemophyllum* Wang, 1947, and *Siphonophrentis* O'Connell, 1914, although she doubted the validity of the last three genera.

Wang *et al*. (1986)considered that the Amplexidae comprises the genera *Pilophyllia* Ge et Yu, 1974, *Amplexoides* Wang, 1947, *Protopilophyllum* Ivanovskiy, 1965, *Amplexus* Sowerby, 1814, *Bordenia* Greene, 1901, and *Crenulites* Flower, 1961. Yu *et al*. (1983), He(1978, 1985), He *et al*. (1989) discussed the family respectively. In their revised classification of rugose corals based on microskeletal structures, Wang and Chen(1989) mentioned 15 genera in the Amplexidae, which are *Estonielasma* Weyer, 1973, *Prototryplasma* Ivanovskiy, 1963, *Protopilophyllum* Ivanovskiy, 1963, *Lindstroemophyllum* Wang, 1947, *Cyathopaedium* Schweiger, 1889, *Pilophyllia* Ge et Yu, 1974, *Synamplexus* Grabau, 1922, *Pycnostylus* Whiteaves, 1884, *Amplexoides* Wang, 1947, *Zelophyllum* Wedekind, 1927, *Leptelasma* Sytova, 1979, *Stylopleura* Merriam, 1973, *Thecaristatus* Strelnikov, 1973, *Synaptophyllum* Simpson, 1900, and *Amplexus* Sowerby, 1814.

For a long time, the genera of Amplexidae have been known from Ordovician, Silurian, and Carboniferous, but no forms are known from Devonian with certainty. Cao(1983), Oliver(1987, 1992), and Wang X.(Wang, 1994)studied the Devonian *Siphonophrentis* in detail. Their works indicate that *Siphonophrentis* bears typical amplexoid septa, and belongs to Amplexidae. Thus the family Amplexidae ranges from Ordovician to Carboniferous. Opinions differ in definition of the amplexoid septa and the content of Amplexidae, The present paper will discuss the features of amplexoid septa based on macro- and microskeletal structures, the definition and content of Amplexidae, and the possible phyletic relationship between some genera in the family.

Features of amplexoid septa

According to Hill(1956), amplexoid septa are longitudinally continuous only at peripheral ends, but extend and become thinner toward axis only as short low ridges developed on upper surface of tabulae. Due to difficulty in distinguishing amplexoid septa and lack of study on microskeletal structures, some genera without amplexoid septa have been placed in Amplexidae, such as *Prototryplasma*.

Microskeletal structures of rugose corals are of important taxonomic significance. Wang(1950)first pointed out that the septa of Amplexidae are composed of lamellar skeleton. In recent years, SEM study (Wang and Chen, 1989)has demonstrated that amplexoid septa are mainly composed of lamellar skeleton with a narrow axial fibrous non-trabecular zone(brachycolumns or granules)(Pl. Ⅰ, figs. 8—12).

The lamellar skeleton may thicken and connect laterally to form a marginal sterozone(Pl. Ⅰ, figs. 1, 2).

When marginal stereozones are well developed, as in *Pilophyllia involuta* (Pl. Ⅰ, fig. 1), the amplexoid septa are longitudinally continuous, thickened, and laterally connected within the marginal stereozone. But they become rapidly thinner toward axis and occur as short low ridges on the tabulae(Pl. Ⅰ, figs. 2, 3; Hill, 1981, p. 146, fig. 1c). In tangential section, the amplexoid septa appear as spines on tabulae(Pl. Ⅰ, fig, 3).

It should be pointed out that there are other kinds of discontinuous septa, including the acanthine, lonsdaleoid, perforate, and naotic septa. Acanthine septa differ from amplexoid septa in microstructure, and are composed of holacanth, rhabdacanth, and composite rhabdacanth. Amplexoid septa are stable in feature, bearing an important significance in taxonomy.

Definition and content of Amplexidae Chapman, 1893

Definition: Coralla solitary, rarely weakly compound. Septa amplexoid. Major septa well developed; minor ones short, with peripheral ends thickened and laterally connected to form stereozone. Septa composed entirely of lamellar skeleton or with a narrow axial non-trabeculate fibrous zone (brachycolumns or granules) embedded in lamellar skeleton. Brachycolumns and granules in axial parts usually dispersed, or forming simple tufts and fascicles, but no trabeculae. Dissepiments absent. Tabulae commonly complete, flat or slightly convex. Cardinal fossulae distinct, sometimes poorly developed.

Genera included: *Estonielasma* Weyer 1973, O_2-O_3; *Pilophyllia* Ge et Yu 1974, S_1-S_2; *Synamplexoides* Stearn 1956, S_1-S_3; *Amplexoides* Wang 1947, S_1-S_3; *Lindstroemophyllum* Wang 1947, S_1-S_2; *Protopilophyllum* Ivanovskiy 1963, S_1-S_2; *Siphonopyrentis* O'Connell 1914, D; *Altaiophyllum* Ivaniya 1955, D_{2-3}; *Amplexus* Sowerby 1814, C_1; *Bordenia* Greene 1901, C_1.

Geological distribution: Middle Ordovician to Early Carboniferous.

Discussion on some genera of Amplexidae Chapman, 1893

Amplexus and *Amplexoides* have been widely accepted as members of Amplexidae. *Pilophyllia*, *Lindstroemophyllum* and *Protopilophyllum* were discussed in detail and put in Amplexidae by Wang *et al*. (1986). The other five genera will be discussed below, including *Estonielasma*, *Synamplexoides*, *Siphonophrentis*, *Altaiophyllum*, and *Bordenia*.

Genus *Estonielasma* Weyer, 1973

Type species: *Tryplasma hemicymatelasma* Reiman in Kaljo, 1957.

Diagnosis: Coralla solitary. Septa radial in arrangement, long, reaching the axis in early stage and amplexoid in late stage, composed of lamellar skeleton and non-trabeculate fibrous skeleton. Minor septa short. Tabulae thin, closely spaced, horizontal. Dissepiments absent.

Discussion: In erecting *Estonielasma*, Weyer (1973) included it in his Lambelasmatidae Weyer (1973); this was followed by Hill(1981). Wang and Chen(1989) placed it under Amplexidae. According to Weyer's definition, in this genus, the coralla are solitary with perforated septa but no synapticu-

lae; the calices are relatively flat; the septa are radial in arrangement, not joined axially, and shortened in old age; the tablulae are numerous and thin; and the dissepiments are absent. Hill(1981, p. 184, fig. 4a, 4b) described and illustrated the amplexoid septa of this genus, although she put the genus in Coelostylinae Weyer, 1973 under Lambelasmatidae Weyer, 1973. This genus shows clearly amplexoid rather than perforated septa. In longitudinal section, the septa appear as short ridges on upper surfaces of tabulae. In transverse section the septa are discontinuous and variable in length. All these indicate that *Estonielasma* is a typical genus in Amplexidae.

Geological and geographical distribution: late Middle Ordovician to Late Ordovician; Estonia and China.

Genus *Synamplexoides* Stearn, 1956

(Plate Ⅰ, figures 6, 7)

Type species: *Synamplexoides varioseptatus* Stearn, 1956

Diagnosis: Phaceloid coral consisting of slender cylindrical corallites. Increase lateral. Septa continuous and well developed in early stage and amplexoid in late stage. Tabulae complete and horizontal. No dissepiments.

Discussion: The type species of this genus is erected on the materal of Silurian in Canada. According to original definition the septa are well developed and lamellar in early stage, and become amplexoid in late stage. Hill(1981) placed the genus under Stauriidae Milne-Edwards et Haime, 1850. The illustration given by Stearn(1956, p. 142, pl. 8, figs. 4, 8) shows clearly amplexoid septa, which are continuous at peripheral ends and appear as short low ridges on upper surfaces of tabulae in transverse section, and discontinuous axially in longitudinal section. Since *Synamplexoides* collected from the Lower Silurian Leijiatun Formation of Guizhou, China is fasciculate with typical amplexoid septa(Pl. Ⅰ, figs. 6, 7), this genus is an undoubted member of Amplexidae. Stearn(1956) mentioned that *Synamplexus* is possibly synonymous with *Synamplexoides*, while Wang (1950) regarded *Synamplexus* as a synonym of *Pycnostylus*. The illustration of *Synamplexus* indicates a possible *Amphyllum* or a fasciculate form of *Tryplasma*. For these reasons, *Synamplexus* is considered as invalid here.

Geological and geographical distribution: Silurian; Canada and China.

Genus *Siphonophrentis* O'Connell, 1914

(Plate Ⅱ, figures 5—8)

1914 *Siphonophrentis* O'Connell, p. 187.

1949 *Breviphrentis* Stumm, p. 13.

1949 *Breviphyllum* Stumm, p. 25.

1949 *Amplexiphyllum* Stumm, p. 9.

1982 *Baoshanophyllum* Sung, p. 21.

1983 *Puanophyllum* Wang, Z. P., p. 66.

Type species: *Caryophyllia gigantea* Lesueur, 1821, p. 296.

Diagnosis: Solitary, cylindrical to ceratoid coral. Septa amplexoid. Major septa unequal in length; minor septa variously developed, with peripheral ends thickened and contiguous with the major septa to

form a stereozone. Fossulae distinct or poorly developed. Tabulae commonly complete, slightly convex, flat or depressed axially, down turned on periphery. No dissepiments.

Discussion: Opinions differ widely on the taxonomic position of *Siphonophrentis*. Most authors have used *Siphonophrentis* for rugose corals with typical amplexoid septa. Up to now, almost all species described under *Siphonophrentis* have typical amplexoid septa.

Cao *et al*. (1983, p. 61, 62) and Oliver (1987, p. D3; 1992, p. B6, B26) confined *Siphonophrentis* only to the solitary corals with amplexoid septa, complete or nearly complete mesashaped tabulae, but no dissepiments, and referred it to Amplexidae. Wang X. (1994) studied *Siphonophrentis* and its relationship with *Heterophrentis* in detail based on abundant material from western Yunnan, and regarded *Breviphrentis*, *Breviphyllum*, *Amplexiphyllum*, *Puanophyllum*, and *Baoshanophyllum* as synonyms of *Siphonophrentis*.

Stumm (1949) erected the genus *Breviphrentis* for Devonian corals with fossula and amplexoid septa, which differs from *Heterophrentis* mainly in the very short septa. Merriam (1973, 1974) regarded *Breviphrentis* as a subgenus of *Siphonophrentis*, and believed that *Siphonophrentis* (*Breviphrentis*) differs from *S*. (*Siphonophrentis*) in its more slender and markedly segmented growth habit with evident rejuvenescence flanges. Oliver (1960, 1987) once regarded *Breviphrentis* as a synonym of *Siphonophrentis* due to the presence of relatively short, amplexoid septa in both forms, but separated *Breviphrentis* from *Siphonophrentis* in 1992. Hill (1956, 1981) considered *Siphonophrentis* and *Breviphrentis* as two distinct genera. Birenheide (1978) noted the similarity in *Siphonophrentis* and *Breviphrentis*, but recognized both genera. According to Stumm's original description, *Breviphrentis* has amplexoid septa as in *Siphonophrentis*, and therefore the only difference between the two is the presence or absence of a fossula. A distinct fossula also may be present in some species of *Siphonophrentis*. For example, *S*, *elongata* (Rafinesque et Clifford), usually considered as a typical species of that genus, has a clear cardinal fossula distinguished by short cardinal septa. Therefore, the fossula appears to have no generic significance. Moreover, this kind of corals may vary widely in size, even within a species. The material from western Yunnan indicates that the type species *Siphonophrentis gigantea* is extremely variable in size, with a diameter ranging from 12.0 to 21.4 mm. In addition, the weakly developed rejuvenescence flanges as an external feature probably vary with the environments, and have only a value in distinguishing different species. On the whole, it may be better to regard *Breviphrentis* as congeneric with *Siphonophrentis*.

Breviphyllum was founded by Stumm (1949) to include Devonian corals that had been placed previously in *Campophyllum*. In original definition, Stumm believed that *Breviphyllum* has pronounced amplexoid septa and narrow dissepimentarium composed of a few rows of inclined dissepiments. Stumm (1937, 1949) did not illustrate the longitudinal section of the holotype of the type species *Amplexus lonensis*, and so the longitudinal skeletal features remain unclear. Merriam (1974) showed both transverse and longitudinal sections of the holotype of *Amplexus lonensis*, the type species of *Breviphyllum* Stumm, and pointed out that it lacks in fact dissepiments and on this account synonymized *Breviphyllum* with *Siphonophrentis* (*Breviphrentis*). *Amplexiphyllum* Stumm (1949, p. 9) bears amplexoid septa and complete tabulae in late stage; its major septa are fused at axial ends to form a stereo-

columella in early stage. Up to now the septal character of *Siphonophrentis* in early stage is not very clear, but in a few ceratoid *Siphonophrentis cantabrica* Birenheide (Wang X., 1994, pl. 10, fig. 3), the major septa may reach the axis and join each other as in *Amplexiphyllum*. At least *Amplexiphyllum* in late stages is very close to *Siphonophrentis* in character. Wang, Z. (1983) erected *Puanophyllum* (type species *P. gigantum*.) and believed that *Siphonophrentis* is different from *Puanophyllum* in having nearly horizontal and rather widely spaced tabulae. In fact, in most species described under *Siphonophrentis* the tabulae are almost complete, horizontal in the wide axial part and down turned on the periphery. Only a few species have nearly horizontal tabulae. The abundant material from western Yunnan shows that the number of tabulae within a limited distance is variable within a species, even within different parts of one specimen. Song (1982) erected a genus *Baoshanophyllum* with amplexoid septa, whose its type species *B. cylindricum* Song (1982) is very close to *Amplexiphyllum minor* Song (1982), and they may belong to the same species.

In short, those regarded as the synonym of *Siphonophrentis* include *Breviphrentis*, *Breviphyllum*, *Amplexiphyllum*, *Puanophyllum*, and *Baoshanophyllum*.

Siphonophrentis is similar to *Altaiophyllum* (including *Zmeinogorskia*) in having amplexoid septa and complete tabulae, but the latter differs in having more dilated septa in cardinal quadrants. *Siphonophrentis* resembles *Zelophyllia* Soshkina (1952) in having well developed stereozone, complete tabulae and shorter septa, but can be easily distinguished from the latter by the amplexoid septa and mesa-shaped complete tabulae, instead of the continuous septa and concave tabulae as in *Zelophyllia*. In *Metaxyphrentis* Oliver (1992) and *Enallophrentis* Oliver (1992), the septa are continuous, which can serve to differen tiate the two genera from *Siphonophrentis*. *Heterophrentis* is similar to *Siphonophrentis* in some aspects, but can be easily distinguished from the latter by its continuous instead of amplexoid septa.

Geological and geographical distribution: Early and Middle Devonian; China, North America, Europe, Altai.

Genus *Altaiophyllum* Ivaniya, 1955

(Plate Ⅱ, figurs 9—15)

1955 *Altaiophyllum* Ivaniya, p. 85.

1960 *Zmeinogorskia* Spasskiy, p. 100.

Type species: *Altaiophyllum belgebaschicum* Ivaniya, 1955, p. 85.

Diagnosis: Solitary, subcylindrical or ceratoid coral. Septa of two orders, amplexoid. Septa in cardinal quadrants thicker and pinnate in arrangement, with axial ends curved around the inner edge of cardinal fossula, short in mature stage. Septa in counter quadrants thinner than those in cardinal quadrants. Minor septa well developed. Tabulae commonly complete, flat or somewhat sagging with downturned edges in some species accessory tabellae present. No dissepiments.

Discussion: *Altaiophyllum* is very similar to *Siphonophrentis* in having amplexoid septa and complete tabulae, but can be easily distinguished from the latter by the pinnately arranged thicker septa in the cardinal quadrants. It resembles *Heterophrentis* in their features of tabulae, but differs from the lat-

ter in its amplexoid septa. *Kobeha* Merriam(1974)(tpye species *Kobeha walcotti* Merriam)has amplexoid septa more strongly dilated in cardinal quadrants than in counter quadrants, as in *Altaiophyllum*. However, in *Kobeha* the presence of dissepiments can serve to distinguish it from *Altaiophyllum*.

Altaiophyllum has been reported from the Middle Devonian of Altai, the Urals, Kazakhstan, China and Spain; it is also distributed in North America with certainty. The forms by the name of *Siphonophrentis gigantea* (Lesueur)in Wang and Chen(1989, p. 23, pl. 2, fig. 8; pl. 20, figs. 7—12), and those put under *Siphonophrentis elongata* (Rafinesque and Clifford)by Oliver(1992, p. B20, pl. 20, figs. 1—4; pl. 21, figs. 1—4; pl. 22, figs, 1—7)were all collected from the Middle Devonian of Ohio. Since they bear remarkably dilated septa in the cardinal quadrants, it may be better to refer them to *Altaiophyllum*.

Geological and geographical distribution: Middle Devonian; Altai, Kazakhstan, the Urals, China, Spain, North America.

Bordenia Greene, 1901

Type species: *Bordenia zaphrentiformis* Greene, 1901.

Diagnosis: Small solitary coral, irregularly ceratoid to trochoid with talon. Major septa long but amplexoid; minor septa short. Tabulae complete, widely placed, horizontal, with downturned edges. Dissepiments absent.

Discussion: The holotype of the type species *Bordenia zaphrentiformis* is from the Lower Carboniferous of Indiana, U. S. A. Wang (1950) considered *Bordenia* as a synonym of *Amplexus*. Hill (1956)doubted the validity of *Bordenia*, and placed it under Cyathopsidae Dybowski, 1873. In 1981, Hill regarded *Bordenia* as a separate genus and put it in Amplexidae. Yu *et al*. (1983)and Wang *et al*. (1986)held the same view which is followed in the present paper.

Possible phyletic relationship between some genera in the family

Wang *et al*. (1986)discussed the possible phyletic relationship between some genera in the Amplexidae, and regarded the family as a special type of rugose corals representing a primitive lineage, which ranged from Ordovician to Early Carboniferous, with comparatively limited members of genera, and are relatively simple in skeletal structure. No obvious change can be seen in the genera from Ordovician through Carboniferous.

Wang *et al*. (1986)regarded *Amplexus*, *Bordenia*, *Amplexoides* and *Zelophyllum* in Amplexidae as more primitive forms characterized by poorly developed or no fibrous skeleton. *Lindstroemophyllum* seems belonging to the primitive type, while *Pilophyllia* and *Protopilophyllum* represent a more advanced lineage, and bear well developed fibrous skeleton. The evolutionary series of *Amplexoides* → Protopilophyllum → Pilophyllia seems to exist in the light of microskeleton and marginal stereozone. *Lindstroemophyllum* which may represent another clade derived from *Amplexoides* is different from the related genera in having a narrow stereozone and long major septa extending to and convolute in the axial region. The Ordovician *Estonielasma* and the primitive forms of *Amplexoides* are considered to originate from the columnariids with simple skeletal structures, short septa, complete and horizontal tabulae.

and no dissepiments. This kind of corals is closely related to *Tabularia*, in which the exterior wall is composed entirely of lamellar skeleton, the septa are restricted to the stereozone and formed by the inward folding of the wall lamellar skeleton, the tabulae are complete and horizontal, and the dissepiments are absent. He (1985) believed that *Amplexoides* originated from *Tabularia*. However, the septa of *Tabularia* are very short and not amplexoid in nature *Tabularia* should therefore not be included in Amplexidae. *Siphonophrentis* is close to *Pilophyllia*; in both genera, the septa become suddenly thinner in tabularium, mainly composed of lamellar skeleton (Pl. I, figs. 8—10), the stereozone is wide, and the tabulae are usually complete or arranged in groups.

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Explanation of plates

All specimens illustrated inthe present paper are stored in China University of Geosciences, Beijing, China. Magnification of SEM figures in plate I, figs. 9—12 and plate Ⅱ, figs. 13—15 is indicated by micrometer scale.

Plate I

1,2. *Pilophyllia alternata* Chen 1974

1. Transverse section, X1.5; 2. Longitudinal section, X1.5. Lower and Middle Silurian Ningqiang Formation, Erlangba, Ningqiang, Shaanxi, China. Field no. SD-2; Cat. no. S018.

3. *Pilophyllia* sp.

Oblique longitudinal section, showing clearly amplexoid septa with low ridges developed on upper surfaces of tabular. Lower and Middle Silurian Ningqiang Formation, Dazhuba, Ningqiang, Shaanxi, China. Field no. SD-2; Cat. no. S203.

4,5. *Pilophyllia breviseptata* (Cao)

4. Transverse section, X1.5; 5. Oblique longitudinal section not passing through axis, X 1.5, showing tabular fossula and amplexoid septa. Lower and Middle Silurian Ningqiang Formation, Dazhuba, Ningqiang, Shaanxi, China. Field no. SD-2; Cat. no.

S228.

6,7. *Synamplexoides* sp.

6. Transverse section, X2; 7. Longitudinal section, X2. Lower Silurian Leijiatun Formation, Baisha, Shiqian, Guizhou, China. Field no. GB-5; Cat. no. GSL-050.

8. *Pilophyllia tenuiseptata* (Cao)

Magnification of septa in transverse section showing fibrous skeleton in the axial zone and lamellar skeleton in the lateral zones. X8. Lower and Middle Silurian Ningqiang Formation, Dazhuba, Ningqiang, Shaanxi, China. Field no. SD-2; Cat. no. S004.

9,10. *Pilophyllia tenuiseptata* (Cao)

9. Outline of a septum in transverse section and position of magnified part, upper part of the figure facing inner end; 10. Square in fig. 9 enlarged, showing fibrous skeleton with granules and brachycolumns in the axial zone between the arrows and lamellar skeleton with vertical flakes in lateral zones. Lower and Middle Silurian Ningqiang Formation, Dazhuba, Ningqiang, Shaanxi, China. Field no. SD-1; Cat. no. S001-46013(9)-46012(10).

11,12. *Amplexoides pilophylloides* He

11. Outer part of a septum in transverse section, upper part of the figure facing inner end. Position located by upper arrow representing axis of septum, showing septa composed almost entirely of lamellar skeleton with vertical flakes in lateral zones, and some irregular granules enveloped by small flakes in nearly horizontal position in the axial zone; position from lower arrow to lower right representing wall, showing vertical flakes. 12. Middle part of fig. 11 enlarged; area between two arrows representing axial zone of septum. Lower Silurian Yangpowan Formation, Locunba, Ningqiang, Shaanxi, China. Cat. no. KSR008-38549(11)-38552(12).

Plate Ⅱ

1,2. *Amplexoides pilophylloides* He

1. Transverse section, X5; 2. Longitudinal section, X5. Lower Silurian Yangpowan Formation, Locunba, Ningqiang, Shaanxi, China. Cat. no. KSR008.

3,4. *Lindstroemophyllum* sp.

3. Transverse section, X1.5; 4. Longitudinal section, X1.5. Lower and Middle Silurian Ningqiang Formation, Erlangba, Ningqiang, Shaanxi, China. Field no. SEⅡ-9; Cat. no. S182.

5,6. *Siphonophrentis gigantea* (Lesueur)

5. Transverse section, X2; 6. Longitudinal section, X2, Devonian, upper part of the Heyuanzhai Formation, Shidian, Yunnan, China. Cat. no. Mf010028.

7,8. *Siphonophrentis minor* (Sung)

7. Transverse section, X2; 8. Longitudinal section, X2, Devonian, upper part of the Heyuanzhai Formation, Shidian, Yunnan, China. Cat. no. Mf009017.

9.10. *Altaiophyllum sagsayicum* (Spasskiy)

9. Transverse section, X1; 10. Longitudinal section. X1, Devonian, upper part of the Heyuanzhai Formation, Shidian, Yunnan, China. Cat. no. Mf00X014.

11—15. *Altaiophyllum* sp.

11. Transverse section, X1; 12. Longitudinal section, X1; 13. Outer part of septum in transverse section, upper part facing inner end, area in square showing axial zone; 14, 15. Square in fig. 13 magnified, showing some granules enveloped by nearly horizontally disposed flakes in the axial zone, and lamellar skeleton with vertical flakes in the wide lateral zones. Middle Devonian, Columbus, Ohio, North America. Cat. no. SEM-021.