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GEYEROPHYLLIDAE MINATO, 1955

by

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(with 1 plate and 1 figure)

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Introduction

When the senior author (Minato) of the present paper proposed the family Geyerophyllidae in Rugosa in 1955, he included the following six genera into this family: *Geyerophyllum* Heritsch 1936, *Lonsdaleoides* Heritsch 1936, *Carinthiaphyllum* Heritsch 1936, *Carniaphyllum* Heritsch 1936, *Akiyosiphyllum* Yabe and Sugiyama 1942 and *Cionodendron* Benson and Smith 1923.

According to him, all genera above listed, excepting for *Cionodendron*, have corallites in a mature stage, showing a similar aspect with clisiophylloid corals, while the earlier ontogenic stages of these corals including *Cionodendron* do show a strong affinity with "lophophyllidiid" corals. Namely, the mature stage of these corals (except for *Cionodendron*) is characteristic in having complicate axial structure, rather broad peripheral area with or without lonsdaleoid dissepiments and radially arranged septa. Thus they may apparently resemble corals belonging to Clisiophyllidae Nicholson and Thomson 1883 and/or Carcinophyllidae Hudson 1942. However, in the earlier ontogenic stage, all the genera placed by Minato into Geyerophyllidae, have large and solid columella, narrow peripheral area without lonsdaleoid dissepiments, and septa arranged in pinnate pattern. In still earlier phase all the genera are characterized by lacking in dissepiments, but by having septa of pinnate arrangement and solid columella. Accordingly their similarity to lophophyllidiid corals, genus *Lophophyllidium* Grabau 1928 as an example, may be far from doubtful.

Axial structure of corals belonging to Clisiophyllidae and/or Carcinophyllidae, are generally composed of uniting distal part of septa and tabulae, or septal lamellae and axial tabellae, and if columella present, it is generally thin; viz. axial structure is constructed by thin, plate like columella, septal modification and tabulae modification. Eventually an axial structure of clisiophylloid corals is fundamentally different from that of lophophyllidiid coral. Therefore, Geyerophyllidae must be phylogenetically different either

from Clisiophyllidae or Carcinophyllidae, although its mature stage shows apparently similar aspects with both families.

T. A. Dobrolyubova (1962, p.330) accepted Geyerophyllidae as being valid, and summarized generic diagnosis as follows: "Solitary, rarely fasciculate or branched corals. In the earlier stage, septa are of pinnate arrangement. Large cysts or cystosepiments are present in a peripheral area. Septa are interrupted. Columella of the early stage is thick and solid". However, she (1962) transferred *Carinthiaphyllum* Heritsch into family Carcinophyllidae Hudson 1942, *Cionodendron* Benson and Smith 1923 into Lithostrotionidae d'Orbigny 1850, and newly placed *Kionophyllum* Chi 1931 (= *Cionophyllum* Lang, Smith and Thomas 1940) into Geyerophyllidae. Genera included by Dobrolyubova into Geyerophyllidae are thus enumerated below:

Lonsdaleoides Heritsch, 1936

Geyerophyllum Heritsch, 1936

Carniaphyllum Heritsch, 1936

Akiyosiphyllum Yabe and Sugiyama, 1942

Kionophyllum Chi, 1931

Dobrolyubova mentioned *Kionophyllum* to have septa of radial arrangement in a mature stage. Further, she noticed solid columella to unite with cardinal septum instead of counter one, lacking in fossula, and development of lonsdaleoid dissepiments. She also stressed on the fact, that columella is very thick, swollen, oval and solid in the earlier stage. Most remarkable fact pointed out by Dobrolyubova in *Kionophyllum* is however that tabulae are horizontal and/or concave, *viz.* the presence of clinotabulae.

As a matter of fact, Heritsch (1936) paid little attention on the longitudinal nature of corallites, when he proposed *Lonsdaleoides*, *Carniaphyllum*, *Carinthiaphyllum* and *Geyerophyllum*, and nothing on the nature of tabulae of corals above listed had been known until the work of De Groot 1963.

De Groot described *Lonsdaleoides hispanicus* De Groot from Northern Palencia, Spain 1963. Although she placed this species into Lonsdaleiidae Chapman 1893, instead of Geyerophyllidae, her species should be eventually belonging to *Lonsdaleoides* Heritsch 1936. According to her, this species has evidently clinotabulae, like *Kionophyllum* (= *Cionophyllum* Lang, Smith and Thomas 1940). Under such circumstances, presence of clinotabulae seems to be likely as an important basis to distinguish Geyerophyllidae from apparently resembled forms. The senior author thus reexamined his older material along this line, and he found *Geyerophyllum hunabuseum* Minato to have concave tabulae and/or clinotabulae, which were once unfortunately escaped by Minato from his observation in 1955.

Minato and Kato (1967) described *Carinthiaphyllum carnicum* Heritsch on

the basis of topotype specimen collected by the senior author in Carnic Alps in 1963. From the beginning of their study on this material, the present authors have tried to clarify whether or not clinotabulae are present in this species, and they found that clinotabulae are really developed in *Carinthiaphyllum carnicum* Heritsch 1936, although it is still unknown on the type species of the genus *Carinthiaphyllum* in this concern (which was originally designated by Heritsch as *Carinthiaphyllum kahleri* Heritsch 1936).

In the meantime, Rowett and Kato (1968) described *Darwasophyllum irregulare* forma *compacta* Pyzhjanov on the basis of specimens collected by Minato from the pre-*Fusulinella* zone of the Akiyoshi limestone plateau, Akiyoshi, S. W. Honshu, Japan. Prior to this, the specimens have been considered by Minato to be belonging to the genus *Darwasophyllum*, although they have been remained underscribed. The senior author of the present paper, quite agrees the results on specific indentification brought forth by Rowett and Kato 1968.

Of prime importance was the recognition by Rowett and Kato that the species has clinotabulae and clinotabellae. Therefore, they placed *Darwasophyllum* into Geyerophyllidae.

Rowett and Kato (1968) referred the following genera to the family Geyerophyllidae.

Kionophyllum Chi, 1931 (= *Geyerophyllum* Heritsch, 1936)

Carinthiaphyllum Heritsch, 1936

Lonsdaleoides Heritsch, 1936

Koninckocarinia Dobrolyubova, 1937

Amygdalophylloides Dobrolyubova and Kabakovich, 1943

Axolithophyllum Fomitchev, 1953

Darwasophyllum Pyzhjanov, 1964

In addition to this, Rowett and Kato assigned *Carniaphyllum* Heritsch 1936 and *Paracarruthersella* Yoh 1961 in the family Geyerophyllidae, with slight doubt.

Of them, at least so far as these genera as *Kionophyllum*, *Lonsdaleoides*, *Geyerophyllum*, *Carinthiaphyllum* and *Darwasophyllum* are concerned, it is proved that there are certain species having clinotabulae besides transverse tabulae, although this is not fully checked for the type species of each genus.

Before going into further, the authors think, it may be necessary to state briefly on septal arrangement of Geyerophyllidae. As previously stated, septa of this family are arranged in pinnate pattern, especially in the earlier ontogenic stage. As a matter of fact, Heritsch described (1936) that it is the counter septum which unites with swollen columella in an early stage. Although Minato (1955) followed Heritsch's view in this regard, De Groot (1963) doubted it. In this concern, she carefully examined species *L. hispanicus* and concluded that it

is not the counter septum but actually the cardinal septum which unites with solid columella in the early stage. This is indeed interesting and important observation. Following her description, Hayasaka and Minato (1966), tried to check this point when they described "*Lonsdaleoides*" *nishikawai*. Hayasaka and Minato reached a conclusion that it is the cardinal septum to unite with solid columella in the earlier phase of *Carinthiaphyllum*, *Carniaphyllum*, *Geyerophyllum* and *Lonsdaleoides*, after examination on illustrations given by Heritsch (1936) for the above listed genera. Hayasaka and Minato stated as follows: "Generally speaking, however, in majority of the genera of Geyerophyllidae, it may be quite safe that columella is connected, not with the counter septum but with the cardinal septum. Consequently, it may not be unanimous to assume Geyerophyllidae to have descended from the corals of the type of *Lophophyllidium*".

In the genus *Lophophyllidium*, solid columella unites with the counter septum in its early ontogenic stage, instead of the cardinal septum. Therefore, it may be unreasonable to regard an intimate relationship existing between Geyerophyllidae and Lophophyllidiidae as Minato once assumed. The present authors are now of opinion that *Amygdalophylloides* Dobrolyubova and Kabakovich 1948 should be referred to the family Geyerophyllidae. According to Dobrolyubova and Kabakovich (1948, P.23), the columella of *Amygdalophylloides* is connected with the cardinal septum, which may be a distinct key to separate this genus from *Lophophyllidium* and allied forms.

As a result, the diagnosis of the family Geyerophyllidae must be greatly revised in many important points, since the present family was originally proposed by Minato (1955). It must be especially worth while mentioned that this family is characteristic in having clinotabulae, solid columella connecting with cardinal septum and septa arranged in pinnate pattern in the early stage.

At the present, nine genera and about sixty nominal species are known in the family which ranges from the lowest Upper Carboniferous to Lower Permian. Geographically they are distributed from Spain to the west, Spitzbergen to the north, and as far as to the U.S.A. in the east. Majority of species of this family are found in the Tethyan province of Eurasia, but some are found even in North Africa and North America.

Classification of Geyerophyllidae Family Geyerophyllidae Minato 1955

- 1955 Geyerophyllidae Minato, p.155
- 1962 Geyerophyllidae, Dobrolyubova, p.330
- 1962 Koninckocariniidae Dobrolyubova, p.332 (par.)
- 1968 Geyerophyllidae, Rowett and Kato, p.37

- 1968 Geyerophyllidae, Cocke and Cocke, p.41
1969 Geyerophyllidae, Cocke and Cocke, p.942
1970 Geyerophyllidae, Cocke, p.40

Diagnosis: This family includes solitary and fasciculate corals having dif-fusotrabeular septa (Kato, 1963), clinotabulae (Minato and Kato, 1965, a,b) as well as transverse tabulae. The axial structure is a swollen solid columella in the early stage, but may become denticulated as far as it reaches carcinophyl-loid or axolithophylloid axial column in the later stage. Lonsdaleoid dissepiments may develop with variable degrees in the mature stage. Septa are arranged in bilateral symmetry in the early stage and radial pattern in the later stage. Septa occur in two orders. Cardinal septum unites with swollen and solid columella in the early stage. Peripheral thickening of septa may sometimes be laterally coalesced with each other to form a distinct stereozone. Normal dissepimentarium is often masked by the well developed stereozone. Fossula indistinct. Rejuvenescence common.

The following seven genera may be included in this family within the limit of the above described diagnosis.

Kionophyllum Chi, 1931

Carinthiaphyllum Heritsch, 1936

Lonsdaleoides Heritsch, 1936

Geyerophyllum Heritsch, 1936

Amygdalophylloides Dobrolyubova and Kabakovich, 1948

Axolithophyllum Fomitchev, 1953

Darwasophyllum Pyzhjanov, 1964

In addition, genera *Carniaphyllum* Heritsch 1936 and *Paracarruthersella* Yoh 1961 may be placed in this family with slight doubt.

Remarks: Dobrolyubova (1962) established a new family Koninckocariniidae on the basis of the genus *Koninckocarinia* and included the genus *Amygdalophylloides* into her family. However, both of these genera have an axial column originally composed of the prolongation of cardinal septum, and clinotabulae, and closely resemble Geyerophyllidae. Therefore the junior author of the present paper regarded with Rowett (1968) that the family Koninckocariniidae Dobrolyubova might be synonymous with Geyerophyllidae and this view has been maintained by Minato & Kato (1971) as they presented a short note on Geyerophyllidae when the International Paleontological Symposium on corals was held at Novosibirsk.

Nevertheless, genus *Koninckocarinia* should be regarded to be quite distinct from all other corals, once included by Rowett and Kato (1968) into Geyerophyllidae, especially in rather simple and thin axial structure, composed

of mere prolongation of the cardinal septum. In the genus *Koninckocarinia*, axial structure is consisting in rather thin plate even in the earlier stage of ontogeny, in spite of the fact that most geyerophyllid corals hitherto known, have, without exception, very thick swollen columella in cross section of the early growth stage.

The authors are now in belief that *Koninckocarinia* should be placed after all into Koninckocariniidae, instead of Geyerophyllidae, although *Amygdalophylloides* must be still a member of Geyerophyllidae and transferred from Koninckocariniidae.

The genera *Cionodendron* and *Akiyosiphillum*, which were once assigned into Geyerophyllidae by the senior author (1955), have however septa of trabecular type and must be transferred from the family Geyerophyllidae.

Genus *Amygdalophylloides* Dobrolyubova and Kabakovich, 1948

Type species: *Amygdalophyllum ivanovi* Dobrolyubova, 1937 from the Upper Westfalian (Myatchkovo horizon) of the Moscow basin.

Generic diagnosis: Corallum simple, small and ceratoid in general. Calyx deep. Axial structure may be composed of solid columella with or without irregularly arranged and poorly developed axial tabellae. This may be an axial elongation of the cardinal septum in origin. Minor septa are commonly short or sometimes lacking. Peripheral stereozone may develop. Lonsdaleoid dissepiments are absent. Rejuvenescence is common.

Comparison: From the genus *Axolithophyllum* Fomichev, 1953, the genus is easily distinguished from the complex nature of the axial column. In the former genus axial tabellae are more or less well developed than the latter. Further, lonsdaleoid dissepiments are more well developed in the genus *Axolithophyllum*. The present genus is also distinct from the genus *Koninckocarinia* Dobrolyubova from the more slender or less swollen nature of columella in cross section of the latter. From the genus *Kionophyllum* Chi, 1931, the genus *Amygdalophylloides* is distinguished from the rudimentary development of minor septa, and absence or almost non development of lonsdaleoid dissepiments.

Included Species:

Russian plateau: Upper Moscovian to the Uralian.

(Dobrolyubova, 1937; Dobrolyubova and Kabakovich, 1948)

A. ivanovi (Dobrolyubova) 1937, Dobrolyubova 1937, p.60, pl.19, figs.15-20, Dobrolyubova and Kabakovich, 1948, p.24. Horizon: Moscovian (Myatshkovo horizon).

A. ivanovi (Dobr.) var. *kovrovi* Dobrolyubova and Kabakovich, 1948, p.24, pl.8, figs.5-11. Horizon: C_{III}⁰

A. monoseptatus Dobrolyubova and Kabakovich, 1948, p.26, pl.14, fig.1. Horizon: C_{II}^3

A. monoseptatus var. *robusta* Dobr. et Kab. 1948, p.27, pl.14, figs.2-8. Horizon: C_{II}^3

A. rareseptatus Dobrolyubova and Kabakovich, 1948, p.28, pl.12, figs.4-10. Horizon: C_{III}^0

A. crassicolumellatus Dobr. and Kab. 1948, p.30, pl.14, figs.9-18. Horizon: C_{III}^0

Spitzbergen: Moscovian to the Uralian.

A. ivanovi (Dobrolyubova), Forbes, Harland and Hughes, 1958, p.470, listed only.

Spain (Palencia): Moscovian.

A. ivanovi (Dobrolyubova), De Groot, 1963, p.103, pl.26, fig.1.

Carnic Alps: Lower Permian (Schwagerinenkalk).

A. sp. = *Lophophyllidium profundum* Milne Edwards and Haime 1850 of Heritsch 1936, (non Grabau 1936), p.108, pl.17, figs.15-18, text-fig.1.

Yugoslavia (Bosnien): Lowest Upper Carboniferous.

A. sp. = *Lophophyllidium sp.* of Kostic-Podgorska, 1955, p.171, pl.1, figs.1-2. The horizon of this species may be the oldest Upper Carboniferous, although it was found in association with *Millerella*.

North Viet Nam: Moscovian.

A. vietnamense (Fontaine) = *Lophophyllidium vietnamense* Fontaine, 1961, p.78, pl.3, figs.6 and 7, pl.4, fig.4; pl.11, fig.4. Nature of tabulae is not fully known!

China (Kueichow): Moscovian.

A. sp. = "Aberrant Lithostrotionidae" of Chi 1931, p.32, pl.3, fig.11.

Japan: Namurian to Stephanian.

Amygdalophylloides uzurensis (Yamagiwa and Ota) 1963

1963 *Lophophyllidium uzurensis* Yamagiwa and Ota, p.91, pl.1, fig.6; pl.2, figs.1-5.

Holotype: ASM 1005a,b,c.

Horizon: Namurian-Lower Bashkirian, lower than the *Profusulinella* zone Uzura, Akiyoshi, Southwest Honshu.

Description: Corallum simple, corallite cylindrical, with usually 7-11 mm in diameter. Septa are of two orders, numbered 20 to 21 for each order. Both are very dilated to form septal wall. Structure of septa is of diffusotrabeular. Solid columella seems to connect with cardinal septum. Lonsdaleoid dissepiments are present, although they are only poorly developed. Tabulae are sometimes concave or inclined downwards or/and from outer to interior of corallite.

Remarks: The present species is primitive as a member of *Amygdalophylloides* in having relatively smaller corallite, solid columella even in the mature stage, and poorly developed dissepiments. Because of possessing clinotabulae and lonsdaleoid dissepiments it can not be placed in the genus *Lophophyllidium* but must be assigned into *Amygdalophylloides*.

Amygdalophylloides gracilis (Hayasaka)

pl. 1, figs. 1-5

1925 *Axophyllum gracile* Hayasaka, p. 23, pl. 4, figs. 10, 11, 12, 13.(?) 1961 *Amygdalophylloides gracilis* (Hayasaka), Kanmera, p. 215, pl. 15, figs. 1-8.

Remarks: The present species may be slightly advanced in type than the foregoing species in having more numerous septa (30 + 30 – 32 + 32), broader peripheral area, and larger corallite (diameter reaching 15 to 18 mm).

Hayasaka described this species to be a solitary form and Kanmera also accepted it. This may be probably true. However, in the illustration given by Hayasaka in plate 4, fig. 10, three corallites are observed to be nearly placed with each other in a cross section and two of which are almost connecting. Accordingly the present authors hold a slight doubt whether the present species is really solitary in form. Notwithstanding of this, the Hayasaka's thin section shows the carbonate rock in which the present coral is embedded to be a calcirudite and corallites of originally solitary form belonging to different individuals, cannot be denied to have been transported from somewhere and became deposited in a same place.

In putting the growth form of the present coral aside for a while, there remains also another doubt whether Kanmera's material may be really conspecific with Hayasaka's coral, since Kanmera described his material to have a carinae structure in septa.

Amygdalophylloides sp. indet

pl. 1, fig. 6

This is specifically indeterminable because of lacking in longitudinal section. Dissepiments are rather well observable in cross section. Therefore it may be specifically distinct from both species above described. As to locality and horizon of this specimen, see the explanation of plate.

Genus *Carniaphyllum* Heritsch, 1936

Type species: *Carniaphyllum gortani* Heritsch 1936, p. 131, pl. 18, fig. 17, text-fig. 35 in text-fig. plate 4.

Horizon: Lower Permian (Schwagerina stage) of the Carnic Alps.

Diagnosis: Solitary coral. Columella showing carcinophylloid column in mature stage unites with cardinal septum. Peripheral area is very wide, with numerous dissepiments arranged in pseudo-herringbone pattern. Septa are of two orders. Of them, minor septa are normally thin, but the major septa are very thick in tabularium, although they are generally thin in dissepimentarium.

Remarks: The validity of the present genus may be beyond doubt, as D. Hill (1956) treated it as an independent one. Nevertheless, it may be not wise to include this coral into Geyerophyllidae until the time when detailed nature on the longitudinal character of corallites of the type species is clarified. The earlier stage of the type species is also quite unknown to the present.

Genus *Kionophyllum* Chi, 1931

Type species: *Kionophyllum dibunum* Chi 1931, Middle Carboniferous of South China, p.40, pl.3, figs.1a-b.

1931 *Kionophyllum* Chi, p.39

1940 *Kionophyllum*, Lang, Smith and Thomas, p.37

1962 *Kionophyllum*, Dobrolyubova, p.330

Original diagnosis given by Chi: Simple, conical to cylindrical, with numerous radial septa which do not penetrate at the peripheral zone, nor reach the epitheca. The structural divisions are, an outer broad cystose or cystosepiment zone defined within by a sclerotheca, a second zone of irregular tabulae and a very large median solid stereocolumella. Septa alternating in size, the larger ones continuing nearly to the center, having projections from their extremities, which unite with the central pseudocolumella. They are straight or very slightly twisted. Between the septa at the center of the corallum there is a deposit of stereoplasma, forming a pseudocolumella of very peculiar appearance somewhat resembling the stereocolumella of *Stereolasma* Simpson. This consists of a median plate which is continuous with both the cardinal and counter septa. The section of the columella is oval shaped, with a distinct boundary. There is no fossula.

Remarks: The present genus is distinct from the genus *Amygdalophylloides* in having rather well developed lonsdaleoid dissepiments and longer minor septa, besides more or less complex axial column. From the genus *Carniaphyllum*, which is however not well established because of insufficient knowledge of longitudinal nature, the present genus is only distinguishable in possessing rather short major septa, and the peripheral area with well developed lonsdaleoid dissepiments.

Included species:

South China (Yunnan, Kueichow): Moscovian.

Kionophyllum dibunum Chi, 1931, p.40, pl.3, figs.1a-b; Horizon: Middle Carb.; 1935, p.24, pl.2, fig.5; Middle Carb.

Kionophyllum ovatum Wu et Zhao in Wu et al, 1974, pl.6, figs.5,6, Without description; Western Kueichow, Bashkirian.

Kun-Lun (China) De Terra 1932, Upper Carboniferous

Kionophyllum sp. = *Caruthersella* sp. of Schindewolf, 1932, p.133, pl.17,

figs.6,7.

Donetz basin: Upper Bashkirian-Lower Moscovian

Kionophyllum planum Fomichev, 1953, p.430, pl.29, fig.7.

Igo reported *Kionophyllum carbonarium* Igo 1961 (p.131, pl.19, figs.16,17), from the Ichinotani formation (Middle Carboniferous) in Central Honshu.

This species has however tabulae ascending towards columella, and cannot be assigned into the genus *Kionophyllum*.

Genus *Axolithophyllum* Fomichev, 1953

Type species: *Axolithophyllum mefferti* Fomichev, 1953, Upper Carboniferous (s.l.) of the Donetz basin.

Diagnosis: Corallum solitary, conical to turbinate in form. Axial column is rather simply constructed, yet more complex than that of the preceding genus. Tabellae in the axial column is irregularly anastomosing and generally thickened. Major septa are rather long and reach generally to the wall, although lonsdaleoid dissepiments are fairly well developed.

Remarks: Fomichev (1953) and Dobrolyubova (1962) placed the present genus in the family Carcinophyllidae, but this genus is characterized in having concave tabulae and clinotabulae.

Included species:

Moscow and Donetz basin, Volga region: Upper Bashkirian, Lower Westphalian to the Middle Gshelian.

Axolithophyllum mefferti Fomichev, 1953, p.417, pl.28, figs.7-13,14 (holotype), 15; pl.29, fig.1. Horizon: Moscovian to Uralian.

According to De Groot (1963), this species may be synonymous with *Amygdalophyllum quiringi* Weissermel 1935, which may be further the same species with the coral described by her 1963 under the name of *Carcinophyllum (Axolithophyllum) quiringi* (Weissermel).

Axolithophyllum cylindricum (Dobrolyubova and Kabakovich), 1948 = *Axophyllum cylindricum* Dobr. et Kab. 1948, p.32, pl.15, figs.1-5; pl.16, figs.1-3, Horizon: C_{II}⁴

Axolithophyllum cavum (Trautschold) = *Axophyllum cavum* Trd., by Dobrolyubova 1937, and 1948, pl.7, figs.6-8; pl.1, figs.8-10. Horizon: Myatshkovian

Clisiophyllum cavum Trautschold, 1879 by *Stuckenberga* 1885, De Kon., 1872 = *A. quiringi* by Dobrolyubova. This species has well developed minor septa.

Axolithophyllum kaltivense Fomichev, 1953, p.423, pl.29, figs.2-3.

Axolithophyllum volgense (Stuckenberg), 1905, Upper Carboniferous.

Axolithophyllum konincki (Stuckenberg), 1905, Upper Carboniferous.

Spain: Moscovian

Axolithophyllum quiringi (Weissermel, 1935) = *Carcinophyllum* (*Axolithophyllum*) *quiringi* Weissermel of De Groot, 1963, p.98, pl.24, figs.2-3.

Axolithophyllum quiringi f. *major* De Groot, 1963, p.99, pl.24, figs.4-6.

China (Western Kueichow): Bashkirian.

Axolithophyllum cylindricum Wu et Zhao, 1974, pl.6, figs.17-18, without description.

Japan (Yayamadake): *Fusulinella-Fusulina* zone

Axolithophyllum forthyvesiculare Kanmera, 1961, p.218, pl.16, figs.1-9.

North Africa (Morocco): Westfalian.

Axolithophyllum sfaiensis (Termier & Termier) = *Carcinophyllum sfaiense* Termier & Termier, 1950, p.93, pl.44, fig.24; pl.45, figs.4-5.; pl.51, fig.8.

Kansas: Upper Pennsylvanian (Missourian).

Axolithophyllum cf. *cylindricum* Dobrolyubova & Kabakovich, = *Geyerophyllum cylindricum* of Cocke, p.51, pl.8, figs.14a-b,15.

Axolithophyllum patulum (Cocke, 1970) = *Geyerophyllum patulum* Cocke, 1970, p.40, pl.7, figs.6a-b, 7a-b.

Axolithophyllum jewetti (Cocke) = *Geyerophyllum jewetti* Cocke, 1970, p.42, pl.7, figs.1a-b, 2-5.

Axolithophyllum girtyi (Cocke) = *Geyerophyllum girtyi* Cocke 1970, p.45, figs.9-10; pl.7, figs.9a-b, 10a-b.

Axolithophyllum garnettense (Cocke) = *Geyerophyllum garnettense* Cocke 1970, p.50, pl.8, figs.11a-b, 12a-b,13.

Among the North American geyerophylloid corals described by Cocke and Cocke, 1968, 1969 and Cocke in 1970, *Geyerophyllum cylindricum*, *Gey. patulum*, *Gey. jewetti*, *Gey. girtyi* and *Gey. garnettense* may be better placed in the genus *Axolithophyllum* from their outer form and fundamental skeletal elements. Further, "*Gey.*" *patulum* and *jewetti* are noteworthy in having a very broad outer dissepimentarium with lonsdaleoid dissepiments regularly arranged in a number of rows.

The genus *Axolithophyllum* has been known from the Moscovian of the Moscow basin, Bashkirian to Gshelian in the Donetz basin, Moscovian of Spain, Bashkirian of China and probably from the Upper Carboniferous of Japan and Carnic Alps, and Middle Carboniferous of the North Africa (Morocco).

Genus *Geyerophyllum* Heritsch, 1936

Type species: *Geyerophyllum carnicum* Heritsch, 1936 from the Auernig (Uralian) formation of the Carnic Alps.

Diagnosis: Solitary form of geyerophylloid corals. Stereozone in the marginal area with septal ridges. Presence of inner wall is sometimes very remarkable. Amongst lonsdaleoid dissepiments, there are at least two kinds. One of them is composed of rather flat dissepiments and positioned near the wall; while the other kind is represented by irregular sized and more conical lonsdaleoid dissepiments in cross section.

Comparison: The present genus is most allied to the genus *Lonsdaleoides* in many points, but the latter is fasciculate in form. From the fasciculate genus *Carinthiaphyllum*, the present genus is distinguishable from rather complex nature of dissepimentarium and complex axial structure in the latter. Yu, Lin and Fan (1962) redefined the genus *Kionophyllum* based on the new material called *Kionophyllum dibunum* var. *longiseptatum* Fan, and described it from the Middle Carboniferous of Sinkiang province. The new material shows certain similarity to the genus *Geyerophyllum* especially to the type species in having distinct inner walls, septal ridges in the outer wall, rather long major septa and flat lonsdaleoid dissepiments. The axial structure is not clearly known in this form so far as illustrated figures are concerned. Thus, this may be placed either in the genus *Geyerophyllum* or *Axolithophyllum*. Nevertheless, it may be still assignable into the genus *Koninckocarinia*, if the axial column is composed of less swollen columella.

Included species:

Carnic Alps: Gshelian.

Geyerophyllum carnicum Heritsch, 1936, p.132, pl.18, figs.18, 22, text-figs.36, 37 in text-fig. of pl.IV.

Geyerophyllum broilli Heritsch, 1936, p.133, pl.18, figs.6, 14, 15; text-fig.38 in text-fig. of pl.IV.

Croatien: Upper Carboniferous.

Geyerophyllum carnicum Heritsch, by Kostic-Podgorska, 1956

Japan: Uppermost Carboniferous to Permian

Geyerophyllum hunabuseum Minato, 1955, p.158, pl.16, figs.1, 6,9; pl.25, fig.3; pl.30, fig.7.

Geyerophyllum gerthi (Ozawa), 1925, Minato 1955, p.159, pl.41, fig.5; pl.42, figs.8a-b, and 10.

Geyerophyllum nishikawai (Hayasaka & Minato) = "*Lonsdaleoides*" *nishikawai* Hayasaka & Minato, 1966, pl.274, pl.33, text-fig.1-3.

North America (Kansas): Missourian

Geyerophyllum sp. cf. *G. broilli* by Cocke, 1970, p.49, fig.11; pl.8, figs.1 a-b, 2-6, 7a-b, 8, 9a-b, 10.

Geyerophyllum nishikawai (Hayasaka and Minato) 1966

1966 *Lonsdaleoides nishikawai* Hayasaka and Minato, p.274, pl.33, text-figs.1-3.

1968 "*Lonsdaleoides*" *nishikawai*, Minato and Rowett, p.177, figs.1-2.

Holotype specimen UHR 18485, Paratype 18486, 18487, 18488.

Locality: 3045 of Mr. I. Nishikawa, Miharanoro, Hiroshima Prefecture.

Horizon: The uppermost Carboniferous or the lowest Permian.

Description: The present species has corallite being trochoid in form, slightly curved, with cardinal quadrants on convex side, while counter quadrants on concave. In the cross section, counter septum is short, and alar fossulae are conspicuous in the earlier stage. Tabellae of axial structure are scarcely observable even at the mature stage. The solid columella connects with the cardinal septum in the earlier growth stage. Septa are of diffusio-trabecular in fine skeletal structure.

The outer wall of this coral has a kind of septal wall called beading type (Minato and Kato, 1965, a, p.9). The outer dissepimentarium is composed of wider and elongate lonsdaleoid dissepiments which are normally untraversed by any septa, while the inner dissepimentarium is composed of major and minor septa and dissepiments arranged in pseudoherringbone pattern. Both major and minor septa become very thick at the boundary between dissepimentarium and tabularium, and gradually thinner towards axial area. Thus stereotheca is prominently developed. It is also remarked that septa are arranged in bilateral symmetry in the early ontogenic stage, although they tend to take radial symmetry in the mature stage. In the longitudinal section, strongly inclined clinotabulae are well developed.

Remarks: As Hayasaka and Minato (1966) stated the present species resembles strongly the type species of the genus *Lonsdaleoides* Heritsch 1936 in the fundamental features, which are redescribed in the foregoing lines, and they referred this species to the genus *Lonsdaleoides* with slight doubt.

Now, the problem has been still remained in concern to a growth form, both the type species of *Lonsdaleoides* and the Japanese species described under the name of "*L.* *nishikawai*."

First of all, Hayasaka and Minato (1966) doubted whether or not *Lonsdaleoides boswelli*, the type species of *Lonsdaleoides*, is really of fasciculate in growth by the original author.

Secondly, Hayasaka and Minato found two growth types in respect of their species "*Lonsdaleoides*" *nishikawai*. According to them, the holotype specimen is apparently simple in form but it has a few smaller offsets, although three

paratype specimens show to be a simple corallite without buddings. Later on Minato and Rowett (1968) concluded in this concern that the holotype specimen must be called simple budding individual, while the paratype specimens should be called solitary individuals. According to their view, the holotype specimen of this species, now under consideration represents an asexual generation while the paratype specimen, a sexual one in which no budding is observable. Hence, "*Lonsdaleoides*" *nishikawai* may be regarded to be belonging to the coral of solitary in form in term of original growth form, but has two different corallites; solitary form without budding and simple form with budding corallites.

In the next, if the type species of *Lonsdaleoides* is really fasciculate in form, as Heritsch described it and De Groot agreed it, to place "*Lonsdaleoides*" *nishikawai* into the genus *Lonsdaleoides* is not correct at all and must be placed in *Geyerophyllum*.

Genus *Paracarruthersella* Yoh, 1961

Type species: *Paracarruthersella bryocolumellata* Yoh, 1961, Late Carboniferous of South China (Maping limestone).

The present genus very much resembles *Darwasophyllum* in many points, although the latter is said to be fasciculate in form, while the former seems to be solitary in corallum with slight doubt. Yoh described that the type species shows branching of corallites from the old corallite. However this may be interpreted to represent a stage of an asexual generation of simple coral, *viz.* simple budding form (Minato & Rowett, 1968). If it is not the case, and this coral actually belongs to the fasciculate form showing lateral increase as Yoh described, the present genus may be still valid and must be distinguished from the genus *Darwasophyllum*, because of the presence of distinct carinae on septa.

According to Yoh, 1961, the material of the type species was collected from an unknown locality a long time ago and it may need further study to settle the geological horizon of this coral precisely. Here the authors wish to follow the opinion held by Yoh: the Uppermost Carboniferous.

All the genera described in the foregoing pages are solitary in form, while the following genera to be described are said to be fasciculate in growth form which may be enumerated below: *Carinthiaphyllum* Heritsch 1936, *Lonsdaleoides* Heritsch 1936 and *Darwasophyllum* Pyzhjanov 1964. Of them, *Carinthiaphyllum* seems to be rather primitive in the construction of corallites.

Genus *Carinthiaphyllum* Heritsch, 1936

1936 *Carinthiaphyllum* Heritsch, p.134.

1961 *Carinthiaphyllum*, Schouppé, p.123.

1962 *Carinthiaphyllum*, Dobrolyubova, p.330.

1967 *Carinthiaphyllum*, Minato and Kato, p.313.

Type species (by original designation): *Carinthiaphyllum kahleri* Heritsch, 1936, p.135, pl.17, fig.29, pl.18, figs.5, 7-13, text-figs.39, 40.

Generic diagnosis given by Minato and Kato (1967): Fasciculate corals with a long cardinal septum, the axial end of which usually is expanded to form a prominent, solid columella in the neanic to ephebic stages. The columella may be, however, somewhat modified to form an axial structure with a median plate, a few septal lamellae, and some irregular axial tabellae-like structure in the latest ontogenetic stage. Septa are of two orders, pinnately arranged, especially in the early ontogenetic stage, but tend to show more or less radial symmetry in the mature stage. The fine structure of septa is fibro-normal to diffusio-trabecular. Dissepiments are concentrically disposed between septa in transverse section. Lonsdaleoid dissepiments occur only rarely in the late stages. Tabulae are mostly inclined axially and include steeply or gently inclined clinotabulae.

Discussion: Heritsch (1936) established the genus *Carinthiaphyllum* and designated *C. kahleri* from the Carnic Alps as the type species. He thought this coral to be solitary in form, and stated that the corallites were separated from one another by some distance. However, this does not necessarily imply a solitary growth form. In many specimens of *Carinthiaphyllum* the corallum consists of loosely aggregated corallites, which nevertheless are basically fasciculate. The specimens of *Carinthiaphyllum yezoense* described by Minato and Rowett (1967) from Hokkaido, for example, consists of corallites, many of which are in close contact and which apparently reproduced by lateral budding. Therefore it can be deduced that Heritsch's specimens of *Carinthiaphyllum* may actually have represented a widely spaced fasciculate corallum, rather than solitary forms.

The longitudinal characters of *Carinthiaphyllum* had not heretofore been studied in detail, which prevented determination of the actual systematic position of this genus. The present authors' own study on topotype specimen of *C. carnicum* indicates that *Carinthiaphyllum* has distinct clinotabulae. The presence of clinotabulae can also be deduced in Heritsch's (1936) figures of obliquely cut examples of the type species, *C. kahleri*, although this fact seems not to have been noted until now (see especially text-fig.40, p.139, mislabeled as *C. carnicum*).

Heritsch also stated that the axial structure in *Carinthiaphyllum* is

continuous with the counter septum. However, close examination of illustrated species of *Carinthiaphyllum* and study of new material of *C. carnicum* collected by the senior author from the Carnic Alps clearly reveals that the column actually is formed from the axial end of the cardinal septum.

Included species:

Carnic Alps: Uralian to Lower Permian.

Carinthiaphyllum kahleri Heritsch, 1936, p.135, pl.17, fig.29, pl.18, figs.5,7-13; text-figs.39, in text-fig. pl.IV, 40, in V; Homann, 1971, p.126, pl.3, fig.18 Horizon: Uppermost Carboniferous to Lowest Permian.

Carinthiaphyllum carnicum Heritsch, 1936, p.137, pl.16, figs.11-13; text-fig.41 in text-fig. pl.V; Minato and Kato, 1967, p.316, pl.38, figs.1-12, text-figs.1-2. Homann, 1971, p.124, pl.3, figs.20,24; pl.4, figs.29,30. Horizon: Uralian, the Auernig formation to Low. Permian.

Carinthiaphyllum suessi Heritsch, 1936, p.139, text-fig.42 in text-fig. pl.V; Homann, 1971, p.128, pl.2, fig.13. Horizon: Lower Permian.

Yugoslavia (Slowien): Uralian to the Lower Permian.

Carinthiaphyllum crassesseptatum Gräf and Ramovs 1965, p.171, pl.6, fig.2. Horizon: Lower Permian.

Greek: Lower Permian.

Carinthiaphyllum suessi Heritsch, Schouppé, 1961, p.124, pl.19, text-figs.2-3. Horizon: Lower Permian?

Japan (Hokkaido): Moscovian.

Carinthiaphyllum yezoense Minato and Rowett, p.123, pl.39, figs.1-5, pl.40, figs.1-6.

Donetz basin: Upper Carboniferous (s.l.)

Carinthiaphyllum sp. of Fomichev, 1953, p.399.

Darwas (Central Asia):

Carinthiaphyllum maklayi Pyzhjanov, 1966, p.279, pl.5, figs.3a-b, 4, 5.

Carinthiaphyllum heritschi Pyzhjanov, 1966, p.278, pl.5, figs.1-2.

China (Western Kueichow), Bashkirian.

Carinthiaphyllum exquisitum Wu et Zhao, 1974, pl.6, figs.15-16.

Genus *Darwasophyllum* Pyzhjanov, 1964

1964 *Darwasophyllum* Pyzhjanov, p.170.

Type species: *Darwasophyllum irregulare* Pyzhjanov, 1964

Generic diagnosis: Loosely fasciculate geyerophylloids with well developed flat lonsdaleoid dissepiments and carcinophylloid axial column. Wall is thick with septal ridges. Stereozone prominent, especially in the young stage.

Darwas, Central Asia: Upper Bashkirian.

Darwasophyllum irregulare Pyzhjanov, 1963

D. irregulare forma *compacta* Pyzhjanov, 1964

Japan: Namurian.

Darwasophyllum irregulare Pyzhjanov, described by Rowett & Kato 1968 from the Namurian of S. W. Honshu.

Genus *Lonsdaleoides* Heritsch, 1936

Type species: *Lonsdaleoides boswelli* Heritsch, 1936

Diagnosis: Fasciculate in form. Wall thick with septal ridges. Narrow stereozone may develop at the peripheral area. Peripheral zone occupied by lonsdaleoid dissepiments is rather narrow. Major septa mostly reach the outer wall. Columella is amygdalophylloid in early stage, and carcinophylloid in the mature stage.

Included species:

Carnic Alps: Lower Permian.

Lonsdaleoides boswelli Heritsch, 1936, p.129, text-fig.33 in text-fig.pl.3

Spain: Moscovian.

Lonsdaleoides hispanicus De Groot, 1936, p.101, pl.25, figs.2-5.

Namurian species described by Minato (1955) and Minato and Kato (1958) under the name of *Lonsdaleoides enormis* (Ozawa), and *Lonsdaleoides toriyamai* Minato should be transferred from Geyerophyllidae into the Family Pseudopavonidae Yabe, Sugiyama and Eguchi, because of the different nature in their fine structure of septa.

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A number of literatures on corals mentioned in the present paper are to be found in the following catalogues and indices, except for the two papers above listed.

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Postscript: During the preparation of the present manuscript we had pleasure to be given various informations on American Geyerophyllids from Dr. J. M. Cocke, Central Missouri State University, through correspondence.

After the completion of the manuscript he recently informed us (Nov. 17, 1974) his new finding of Geyerophyllids from Kansas and Oklahoma.

We are very grateful to Dr. Cocke for his very kind cooperation.

Figure: Distribution of Geyerophyllid genera in space and time.

		Up. Viséan	Namurian	Westfalian			Stephanian		Autunian			
				Bashkirian	Moscovian		Gshelian (Uralian)		"Sakmarian"			
		Millerella		Pseudostafella	Profusulinella	Eofusulina	Fusulinella	Fusulina	Protiridites	Tritidites	Pseudoschwagerina	"Pseudofusulina"
Amygdalophylloides	Moscow basin	-----										
	Spitzbergen	-----										
	Spain (Palencia)	-----										
	Carnic Alps	-----										
	Yugoslavia (Bosnien)	-----										
	Viet Nam	-----										
	China	-----										
	Japan	-----										
Carnia- phyllum	Carnic Alps	-----										

Kione- phyllum	China (Yunnan & Kueichow) (Kun-Lun)	-----										
	Donetz basin	-----										
Axoltho- phyllum	Donetz and Moscow basin	-----										
	Spain	-----										
	Morocco	-----										
	Kansas	-----										
	Japan	-----										
	China	-----										
Geyerophyllum	Carnic Alps	-----										
	Croatian	-----										
	Kansas	-----										
	Japan	-----										
Para- carruthers- sella	China (Maping)	----- → (?)										
Carruthia- phyllum	Carnic Alps	-----										
	Slowien	-----										
	Greek	-----										
	Donetz basin	----- (?) ----- (?)										
	Darwas (Central Asia)	-----										
	Japan	-----										
	China	-----										
Darwaso- phyllum	Darwas	-----										
	Japan	-----										
Lons- daleoides	Carnic Alps	-----										
	Spain	-----										

Explanation of Plate
(All figures four times natural size)

- Fig. 1** *Amygdalophylloides gracilis* (Hayasaka)
a,b-Transverse section. c-Longitudinal section. Note the presence of "double wall". MK 233 from Daiyama 42409, Shuho-cho, Yamaguchi Prefecture. *Millerella-Profusulinella* Zone. Coll. by M. Kato
- Fig. 2** *Amygdalophylloides gracilis* (Hayasaka)
Transverse section of calicular portion showing very thick wall. MK 179 from Isa Quarry, Isa-cho, Yamaguchi Prefecture. *Millerella-Profusulinella* Zone. Coll. by M. Kato
- Fig. 3** *Amygdalophylloides gracilis* (Hayasaka)
a,b,c-Serial transverse sections. a,b-Calicular portions. d-Longitudinal section. MK 169 from Daiyama 42409, Shuho-cho, Yamaguchi Prefecture. *Millerella-Profusulinella* Zone. Coll. by M. Kato
- Fig. 4** *Amygdalophylloides gracilis* (Hayasaka)
Transverse section. MK 233 from Daiyama 42409, Shuho-cho, Yamaguchi Prefecture. *Millerella-Profusulinella* Zone. Coll. by M. Kato
- Fig. 5** *Amygdalophylloides gracilis* (Hayasaka)
Transverse section showing thick wall. MK 147 from north of Irimi, Mine-gun, Yamaguchi Prefecture. *Fusulinella?* Zone. Coll. by M. Kato
- Fig. 6** *Amygdalophylloides* sp.
Transverse section showing normal dissepiments and irregularly shaped axial structure. 1-93, Akiyoshi-daiyama, Yamaguchi Prefecture. *Fusulinella?* Zone. Coll. by Y. Ozawa

