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THE RUGOSE CORAL FAMILY PSEUDOPAVONIDAE

by

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(with 4 text-figures and 6 plates)

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Abstract

A hitherto little known group of rugose corals, Pseudopavonidae is reviewed and redescribed. The family now embraces *Amygdalophyllidium, Hiroshimaphyllum, Ozakiphyllum, Pseudopavona, Omiphyllum, Taisyakuphyllum* and *Ibukiphyllum.* These corals have been known solely from the Japanese Upper Carboniferous (*s.l.*). The origin of the family is yet uncertain.

Introduction

Yabe, Sugiyama and Eguchi (1943) established a new species of coral from the Carboniferous limestone of Taisyaku, West Japan, based on a single colony collected by their student, Mr. K. Harada. The coral was said to have associated with *Chaetetes, "Stylidophyllum"* and some other rugosa.

The coral was named as *Pseudopavona taisyakuana,* which represented their new genus, *Pseudopavona;* on that genus also the new family Pseudopavoniidae

was introduced.

As the generic name may imply, the coral now in question is quite unique in its general appearance which, in fact, is not unlike such a Scleractinian coral as *Pavona.* The coral has thamnastreoid corallum, trabecular septa, and according to the original authors pali-like structure. Thus they considered this was a representative of Scleractinia (=Hexacoral) in spite of the fact that this was definitely Carboniferous in age. Yabe, Sugiyama, and Eguchi claimed that *Pseudopavona* was one of the rare Palaeozoic records of "Hexacoral". In fact only other Palaeozoic "Hexacoral" thought by these authors was *Omphalophyllia yamanbaensis* Yabe & Sugiyama (1933). However this latter Permian species is, according to our view, probably a species of *Cyathocarinia.*

Since their description on *Pseudopavona* was made in Japanese and in a preliminary form, their article had been escaped from the notice of research workers outside this country, until Minato (1955) reintroduced *Pseudopavona* in his comprehensive work on Japanese Carboniferous and Permian corals (e.g. *Pseudopavona* was not quoted either in Treatise (1956) or in Osnovyi (1962).

Although *Pseudopavona* is a unique form and merits the recognition of a new family based on it, we consider that it is not Scleractinia but a Rugosa.

Trabecular nature of septa is, of course, not necessarily restricted to Scleractinia, and thamnatreoid corallum, even if it is meandrine in parts, is very common also in Rugosa. What appeared to be pali-like structure may be in fact discrete trabeculae of either septa or columella. *Psudopavona taisyakuana* possesses 8 to 10 major septa which in some cases show tetrameral symmetry. Therefore *Pseudopavona* should be treated as a group of rugose corals instead of being a Scleractinia, thus leaving no genuine representative of Scleractinia in Palaeozoic of Japan.

We consider, however, the family Pseudopavonidae is a good, distinct branch of Rugosa, of which we do not know the exact origin yet.

According to our understanding there are a number of corals which should be classified under this family and it is the aim of this article to review all of them.

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Major part of corals herein treated belongs to our own collection. But many people helped us in offering their collections and providing geological informations on them. In this concern we owe Dr. Y. Hasegawa of Niigata Univ., Dr. M. Ota of Akiyoshi Science Museum, Dr. K. Konishi of Kanazawa Univ., Mr. I. Nishikawa of Yuki and Messers T. Yoshida, K. Koseki and H. Inoue of Geological Survey of Japan. We thank Emeritus Professors S.

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History of Research

As early as 1924, what appear for us to be a member of the family Pseudopavonidae was described by Hayasaka. He described *Lonsdaleia floriformis crassiconus* (McCoy) Smith from the Carboniferous part of the Omi limestone, central Japan. But, as Hayasaka clearly described the Omi form has very thick wall, small lonsdaleoid dissepiments and small axial column. Therefore that can not be compared with *"Lonsdaleia" floriformis* group, which is Upper Viséan to lower Namurian in age.

Hayasaka's specimen has been probably misplaced and we could not examine it at the Tohoku University, but we have some other colonies lately collected from the Omi limestone. They show cerioid coralla, trabecular septa of two orders, somewhat carcinophylloid axial structures and very thick, bead shaped walls. Therefore these corals only superficially resemble cerioid *Lonsdaleia* (=*Actinocyathus* = *Stylidophyllum*), but in fact, are only distantly related to the latter group. They are certainly cerioid members of the family Pseudopavonidae. And Hayasaka (1924) was the first to illustrate this group of corals.

In the following year Ozawa (1925) described again *Lonsdaleia floriformis crassiconus* from the Carboniferous part of the Akiyoshi limestone, S.W. Japan. This falls, as is the case in the Omi form, in the same category with the Omi specimen, *viz.* a cerioid member of Pseudopavonidae. In Akiyoshi the coral was found associated with *Fusulinella* (Ozawa, 1952).

Ozawa (1925) also described a fasciculate form, *Lonsdaleia enormis* from the same horizon. This coral also appears to be belonging to Pseudopavonidae, unless it is a member of Carcinophyllidae.

In 1932 Hayasaka described *Orionastraea* from the Omi limestone. But this might be a coral which is not unlike *Pseudopavona.* This is certainly not *Orionastraea* (Yabe, Sugiyama, Eguchi, 1943; Kato & Mitchell, 1970).

It was in the year of 1943 when Yabe, Sugiyama, and Eguchi established *Pseudopavona* and Pseudopavoniidae, as is remarked earlier in this paper.

Incidentally, Pseudopavonidae is more appropriate than Pseudopavoniidae as it is based upon *Pseudopavona* and not on *Pseudopavonia.* In recent corals

Pavonia is a junior synonym of *Pavona* (Wells, 1956).

Minato in 1949 classified Ozawa's *Lonsdaleia enormis* as a *Lonsdaleoides* which genus should be, according to our recent study, a member of Geyerophyllidae. He already recognized that both Ozawa's and Hayasaka's *"Lonsdaleia floriformus"* were not identical with the so-named species but were belonging to different form, which he called *Lonsdaleia* sp.

In 1951 Minato erected *Amygdalophyllum naosoidea* based on a coral in Ozawa collection from the Akiyoshi limestone. The coral has naotic dissepiments or septa and centrally sagging tabulae. Septa are multi-trabecular and "cavernous" in their periphery. This would be the only solitary representative of Pseudopavonidae known up to now.

Minato published in 1955 a large, comprehensive monographic treatment on the Japanese Carboniferous and Permian corals. In this book all previously described Pseudopavonids, in the present sense, were redescribed. Besides them new forms of what we consider the member of Pseudopavonidae were added. They are *Lonsdaleoides toriyamai, Taisyakuphyllum rostfer* and *Wentzelella sekii.*

Minato & Kato (1957) reported on the stratigraphical occurrence of some Pseudopavonids from the Akiyoshi limestone, S.W. Japan.

Yokoyama (1957) clarified the stratigraphical position of *Pseudopavona* in Taisyaku as *Fusulinella* zone, and he added a new species of *"Stylidophyllum"*. He also recorded the occurrence of other Pseudopavonids in Taisyaku.

Minato & Kato (1958) redescribed *Lonsdaleoides toriyamai* from the Akiyoshi limestone, Akiyoshi. In the same year Sakaguchi and Yamagiwa described several Pseudopavonids from the Tanba region, central Japan. They are *Polythecalis* ? *meandroides, Stylidophyllum kameokense,* and *Stylidophyllum quadratam.* Although these corals are stated by their original authors to be Lower Permian age, limestone yielding these fossils is conglomeratic. We see related corals occurring in Middle Carboniferous; therefore we consider them derived fossils, unless they actually range upward until Permian.

In 1959 Kawano introduced a new subspecies of *Pseudopavona, Pseudopavona taisyakuana izutoensis* from Yamaguchi Pref., which does not essentially different from the *Ps. taisyakuana.* The coral is said to have been obtained from the Upper Permian; but the coral now in problem is so close to *Pseudopavona taisyakuana* that it is not separable from the latter species from the "middle" Carboniferous. We think that the coral should also be derived one that is embedded in Permian limestone, as we have seen quite a lot of such examples around the Akiyoshi limestone, where Carboniferous corals and fusulinids are commonly found in pebbles of the Upper Permian formations with *Yabeina-Lepidolina.*

In 1960 Yamagiwa described a new species of *Taisyakuphyllum,* which is quite similar to the type species, from the limestone of Permian Maizuru group. This was considered by Yamagiwa also of derived origin!

Yamagiwa (1961) found a new *Lonsdaleoides* from middle Carboniferous in Tokushima Prefecture. This coral is not known as to its longitudinal characters, and it may well be a member of Geyerophyllids, instead of being a Pseudopavonid.

In the same year Yamagiwa (1961) reported the occurrence of *Amygdalophyllum* from the Hyogo Prefecture. He compared this coral with *"Amygdalophyllum" naosoidea,* but it is not known that if this coral provides naotic periphery. It looks like a true *Amygdalophyllum,* unless it is a member of *Echigophyllum* with dense axial column.

Also in 1961 Kanmera described some Upper Carboniferous corals from Kyushu. In that article he described a new species of *Pseudopavona* from *Fusulina* zone, thereby extending the age of this group. Further he made clear in a number important points in Pseudopavonid corals. First he amended the spelling of the family to Pseudopavonidae from Pseudopavoniidae, and included *Taisyakuphyllum* in the same family. He gave for the first time diagnosis of Family Pseudopavonidae and genus *Pseudopavona.* And he discussed that Pseudopavonidae was not Scleractinia but Rugosa. Fine skeletal structure of *Pseudopavona crassisepta* is described in detail.

Yamagiwa (1962) expanded his study to the Permo-Carboniferous corals of the Atetsu limestone of West Japan. In that study he discriminated two Carboniferous coral zones in the Atetsu limestone, namely *Clisiophyllum awa atetsuense* zone in the lower and *Taisyakuphyllum fujimotoi* zone in the upper. And from the latter zone, which may correspond to *Profusulinella* to *Fusulinella* zone in fusulinid zonation, Yamagiwa described several Pseudopavonids, namely *Amygdalophyllum* cfr. *naosoidea, Pseudopavona taisyakuana, Taisyakuphyllum nakazawae, T. fujimotoi* & *T. hashimotoi.* The latter three species of *Taisyakuphyllum* may be, however, as will be later mentioned, conspecific with each other. In classification of Pseudopavonidae Yamagiwa followed Kanmera.

In 1962 Yü, Lin & Fan described a number of new rugose corals from the Sinkiang-Chinghai province of China. Among them *Wentzellophyllum sinense* from Middle Carboniferous is quite noteworthy, for it may be a sole representative of Pseudopavonidae outside Japan. But this is of course a subject to future confirmation.

In the next year Hasegawa (1963) published a geological map of the Akiyoshi limestone plateau. He, at the same time, listed fossils from each biostratigraphical unit. Several manuscript names of corals were quoted in his

list, in which *Amygdalophyllidium* was first introduced. Yamagiwa & Ota (1963) described some corals from a quarry in *Millerella* zone of the Akiyoshi limestone. *Lonsdaleoides toriyamai* and *Stylidophyllum ozawae,* n. sp. were included.

From the Omi limestone in Niigata Prefecture Rowett & Minato (1968) described two representative Pseudopavonids. Their description on both *Pseudopavona* and *Taisyakuphyllum* is in great detail, and morphology of the type species of both genera is much clarified. Clarification on septal insertion in both genera is a particularly important result achieved by them.

From the Akiyoshi limestone plateau several Pseudopavonids have been illustrated, though without description, by Ota (1968), Okafuji (1971) & Akiyoshi-dai Science Museum (1971).

Igi (1969) reported the occurrence of *Pseudopavona* from the Hyogo Prefecture in a tectonic belt called the Kami-gori zone. *Pseudopavona* was also recorded from S.W. Hokkaido with *Chaetetes* (Yoshida & Kakimi, 1970). Wide distribution of Pseudopavonidae in Japan, therefore becomes quite clear now.

Quite recently Cotton (1973) in his comprehensive treatment of rugose genera gave a diagnosis of *Pseudopavona.* But this seems to be merely a superficial definition.

Morphology

Pseudopavonidae includes both solitary and colonial forms. Solitary forms are mostly seemingly ceratoid. Fasciculate forms are dendritic. Massive forms contain cerioid and thamnastreoid forms, the latter of which may be in parts aphroid. Dominantly aphroid form is *Omiphyllum.*

Theoretically we can expect every possible growth form within the family, and various forms will turn up in future.

Internally Pseudopavonid corals are characterized by many skeletal elements. Axial structure is normally strongly developed, which may be in a form of solid bar or very thick axial column. In general appearance, thus, it looks like *Amygdalophyllum, Carcinophyllum* or *Lonsdaleia.* When septal lamellae and a median plate are differentiated, the whole structure may seem similar to that in *Carcinophyllum* or sometimes of *Lonsdaleia.* But when all such axial elements are so thick and they laterally united, they look very much the same structure with that we see in *Amygdalophyllum.* Ontogenetical change as well as stratigraphical occurrences, though not very conclusive, would suggest that the axial structure is solid at the beginning and then takes axial columnar forms later in many species of Pseudopavonids. Axial structure is originated at least in *Pseudopavona* from the cardinal septum.

Septa are also very peculiar skeletal structure in this family. They may be major and minors in radial alternation in mature corallites. But tertiary septa are present in a number of forms. The presence of tertiary septa is, though not uncommon in Permian corals, a rather rare feature as Carboniferous corals. Some forms of Pseudopavonidae, that are the members of Taisyakuphyllinae clearly have tertiary septa. These septa are often so thick that they almost completely filled the internal space of corallites, leaving no room for tabular or dissepimental plates. Septa are arranged distinctly in pinnate fashion in young corallites. Axial parts of septa are often said to be of rhopaloid shape.

Fine structure of these septa are also quite unique, as it clearly demonstrates trabecular nature. Trabeculae are either in single row or in many rows especially in septa at the periphery of corallites. These trabeculae are arranged vertically as inclined series of bars, and they have been called as "septal grating" by Minato (1955).

Septa often become naotic at their periphery, where small, flattened vesicles are arranged as if they are controlled by the presence of septal elongation. Naotic dissepiments are in broad sense a kind of lonsdaleoid dissepiments, which in many forms of Pseudopavonidae are not large but are more or less flattened.

Walls are extremely thick in Pseudopavonidae. They are constructed by lateral coalescene of bead shaped multitrabecular bundles of fibres.

In vertical section dissepiments are globose but are much elongated in case of the development of lonsdaleoid dissepiments. Tabulae are inclined inwards.

Affinity

Pseudopavonidae differs from Lithostrotionidae in having thick trabecular septa, solid, stout and large columella or axial column, clinotabulae, and sometimes lonsdaleoid dissepiments. In Lithostrotionidae septa consist of fine trabeculae; columella is small and has almost no denticutation on it; tabulae are arched upwards; lonsdaleoid dissepiments are nearly absent.

Pseudopavonidae is distinguishable from Lonsdaleiidae in possessing thick trabecular septa. Whereas in Lonsdaleiidae septa are diffuso-trabecular. Axial column in Lonsdaleiidae is never like solid club, but in a form of cobweb-structure in cross section. In some forms of Pseudopavonidae even tertiary septa develop. Although both families are in common in having clinotabulae and lonsdaleoid dissepiments, they are clearly discernible from one another.

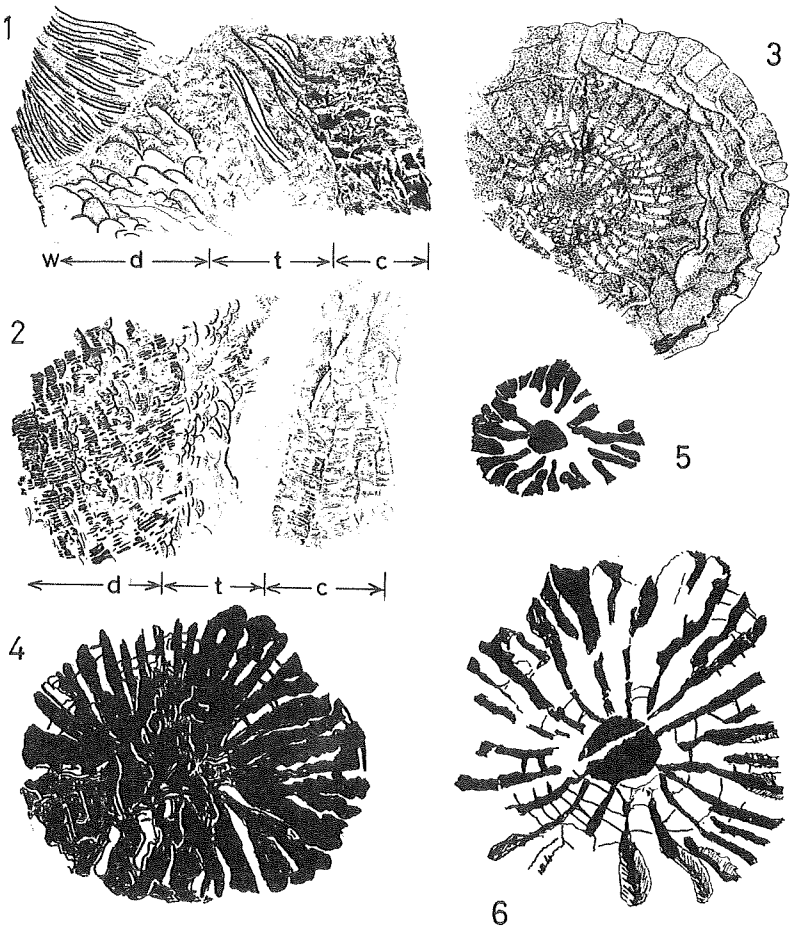
Pseudopavonidae is also different from Geyerophyllidae. Because the former has trabecular septa, many massive representatives, but the latter has

Fig. 1 Morphology of Pseudopavonid corals.

1 – *Amygdalophyllidium naosoideum* (Minato).
Longitudinal section. c-Amygdalophylloid axial column. t-tabularium with clinotabulae. d-dissepimentarium with steeply inclined naotic dissepiments on upper left. w-wall. Ozawa collection IV_2 from Ohkubo, Yamaguchi Prefecture. X 3.8

2 – *Taisyakuphyllum rostfer* Minato.
Longitudinal section. c-solid columella. t-tabularium with clinotabulae. d-dissepimentarium with globose dissepiments and bar like trabeculae.
Ozawa collection IV_6 from Ofukudai, Yamaguchi Prefecture. X 3.8

3,4,5 & 6 – *Hiroshimaphyllum toriyamai* (Minato)
Transverse sections. 3 – A mature corallite with an axial column, flattened lonsdaleoid dissepiments and thick wall. Iisaka collection from Omi limestone, Niigata Prefecture X 3 : 4 – Densely constructed axial column showing Carcinophylloid appearance. X 7.5 : 5 & 6 – Young corallites showing dense axial structure and pinnately arranged septa. X 7.5 : Figures 4- 6 are from the same colony, UHR 12707 from Ohkubo, Yamaguchi Prefecture.



Minato del.

diffuso-trabedular septa, and solitary, only rarely fasciculate forms. The nature of axial structure, especially in its configuration, and the presence of clino-tabulae are the common features among them.

In comparison to Carcinophyllidae Pseudopavonidae has members with colonial coralla and tertiary septa. Also axial structure of *Pseudopavona* is much different from that of Carcinophyllidae.

Classification

Family ***Pseudopavonidae*** Yabe, Sugiyama & Eguchi, 1943

1943 Pseudopavoniidae Yabe, Sugiyama & Eguchi, p.245 (*nom. transl.* Kanmera, 1961, p.221)

Diagnosis (Kato & Minato, 1974):

Corallum simple or compound. Corallites small to medium in size. Axial structure is represented by a solid columella or a stout axial column which is originated from a solid columella. Septa are in two or more orders. Fine structure of septa is distinctly trabecular. Tabulae are composed of clino-tabulae, and flat, or saucer shaped transverse tabulae. Lonsdaleoid dissepiments may develop in various degrees, and they often tend to become "Naotic".

Genera:

Pseudopavona Yabe, Sugiyama & Eguchi, 1943
Taisyakuphyllum Minato, 1955
Omiphyllum Kato, 1967
Amygdalophyllidium Kato & Minato, 1975
Hiroshimaphyllum Kato & Minato. 1975
Ozakiphyllum Kato & Minato, 1975
Ibukiphyllum Kato & Minato, 1975

Distribution: Upper Carboniferous (s.l) of Japan and China?

Remarks: The family is further divisible into two subfamilies based on the character of septal insertion. Thus Pseudopavoninae includes Pseudopavonid corals with only major and minor septa; while similar corals with tertiary septa comprise Taisyakuphyllinae. This procedure, as we experienced in Waagenophyllidae (Minato & Kato, 1965), appears to be more reasonable than to adopt growth forms as criteria for subfamily classification.

Key to genera:

I. Tertiary septa absent ..... Pseudopavoninae
Corallum solitary. Naotic dissepiments develop
..... *Amygdalophyllidium*
Corallum fasciculate. Lonsdaleoid dissepiments develop.

. . . . . *Hiroshimaphyllum*
Corallum cerioid. Lonsdaleoid dissepiments develop
. . . . . *Ozakiphyllum*
Corallum thamnastreoid . . . . . *Pseudopavona*
Corallum aphroid . . . . . *Omiphyllum*
II. Tertiary septa present . . . . . Taisyakuphyllinae
Corallum fasciculate . . . . . *Taisyakuphyllum*
Corallum cerioid . . . . . *Ibukiphyllum*

Subfamily **Pseudopavoninae** Yabe, Sugiyama & Eguchi, 1943

Forms of Pseudopavonidae with major and minor septa only are grouped here as Pseudopavoninae which contains at present the following five genera: *Pseudopavona* Yabe, Sugiyama & Eguchi, 1943; *Omiphyllum* Kato, 1967; *Amygdalophyllidium* Kato & Minato, 1975; *Hiroshimaphyllum* Kato & Minato, 1975; *Ozakiphyllum* Kato & Minato, 1975.

Genus ***Amygdalophyllidium*** Kato & Minato, 1975

1963 *Amygdalophyllidium (nom. nud.)* in Hasegawa, p.34
1975 *Amygdalophyllidium* Kato & Minato
Type species: *Amygdalophyllum naosoidea* Minato, 1951
Generic diagnosis:

Corallum simple. Axial structure is like that of *Amygdalophyllum*. Septa are in two orders. Axial portion of septa is rhopaloid, whereas they are "cavernous" and "naotic" in the periphery. Septa are trabecular, and multi-trabecular especially in the periphery. Longitudinally, "naotic" dissepiments are thin, flat, and dense. Normal dissepiments are large. Clinotabulae present.

Included species:
Amygdalophyllidium naosoideum (Minato), 1951 (Pl. 1, figs.1,2; text-fig.1-1)
Minato, 1949, p.5 (*nom. nud.*); 1951, p.3, figs.a1-3, 1955, p.145, pl.30, figs.1,2; pl.34, fig.7, text-figs.13, a1-3. Holotype: IV1,2, Ozawa Collection, Tokyo Univ. Ohkubo, Ohda, Yamaguchi Prefecture. Lower part of the Akiyoshi limestone Group. Namurian.
Remarks:

Amygdalophyllidium superficially resembles *Amygdalophyllum*. *Amygdalophyllum* has solid, stout axial structure and pseudoherringbone dissepiments

which are sometimes weakly lonsdaleoid.

Axial structure of *Amygdalophyllidium* is very much like that of *Amygdalphyllum,* and septa in both genera are all trabecular.

However difference between the two genera lies in the point that *Amygdalophyllidium* has extensively developed naotic septa and tabulae very steeply inclined towards the axial structure. In *Amygdalophyllum* tabulae are incomplete and ascending towards the axial structure, and moreover dissepiments are never like that in *Amygdalophyllidium.*

Amygdalophyllidium is thus not a member of Amygdalophyllidae, Clisiophyllidae or Aulophyllidae, but belongs to Pseudopavonidae.

The genus is known from the Akiyoshi limestone plateau where it is yielded from the lower part of the limestone at Ohkubo and Edo. (Minato & Kato, 1957)

"Amygdalophyllum" naosoidea was once identified from the Ohmama in Gunma Prefecture by Sato, but this has not been described to date.

"Amygdalophyllum" cfr. *naosoidea* was described by Yamagiwa (1962) from the *Taisyakuphyllum fujimotoi* Zone of Atetsu limestone.

Amygdalophyllum sp. (Yamagiwa, 1961) was recorded from the Hyogo Prefecture. Although this was said to be similar to *A. naosoidea,* it was a too imperfect specimen to make comparison with the latter species. It is lacking in peripheral parts; and thus we cannot say whether characteristic naotic dissepiments really exist in this form or not.

Overall range of the genus may be Namurian (pre-*Fusulinella* Zone).

Genus ***Hiroshimaphyllum*** Kato & Minato, 1975

1955 *Lonsdaleoides,* Minato, p.162 (*partim*) (*non* Heritsch, 1936).
1975 *Hiroshimaphyllum* Kato & Minato

Type species: *Lonsdaleoides toriyamai* Minato, 1955

Etymology: The generic name is derived from the Hiroshima Prefecture, where Taisyaku limestone plateau is involved.

Generic diagnosis:

Corallum compound, fasciculate and dendritic. Corallite consists of axial structure, tabularium, dissepimentarium and thick wall. Axial structure is an axial column of carcinophylloid or dibunophylloid appearance, and is sometimes densely constructed. Septa are trabecular and of two orders. They are radially arranged in mature stage, but are pinnately arranged in younger stage. Intrathecal dilation is often very prominent and inner wall is clear in that instance. Tabularium is wide. Clino-tabulae present. Large, flattened lonsdaleoid dissepiments develop. Budding by peripheral.

Remarks: *Hiroshimaphyllum* differs from *Lonsdaleia* in having very dense

skeletal elements, of which septa are trabecular instead of fibro-normal or diffuso-trabecular as in *Lonsdaleia*. *Lonsdaleoides* is a member of Geyerophyllidae, and thus is different from *Hiroshimaphyllum* which is clearly a member of Pseudopavonidae.

Amygdalophyllidium is simple, having solid columella and naotic dissepiments, and thus is distinguished from *Hiroshimaphyllum*. Its young stage, however, resembles a detached corallite of *Hiroshimaphyllum*. *Ozakiphyllum* is a cerioid representative of *Hiroshimaphyllum*.

Included species:

Hiroshimaphyllum toriyamai (Minato), 1955 (Pl.1, fig.3; pl.2, figs.2,3; text-figs.3-6)

Minato, 1955, p.165, pl.3, fig.6; pl.16, fig.7; pl.23, figs.1,2-3, text-figs.21,22. Minato & Kato, 1958, p.173, text-fig., Yamagiwa & Ota, 1963, p.90, pl.1, fig.4.

Holotype: UH Reg. No.17809, 17810 from Ohkubo, Yamaguchi Pref. Lower part of the Akiyoshi limestone.

In the Akiyoshi district the same coral has been found from Isa, Uzura Quarry, Daiyama, Tobinosu and a number of other localities. The geological age of this coral was said to be *Fusulinella* zone (Minato, 1955) or *Profusulinella* zone (Minato & Kato, 1958). But now it is known to be mostly pre-*Profusulinella* zone. The coral has been recorded from Omi limestone (Minato, 1955) and, Taisyaku limestone (Yokoyama, 1957). The latter is said to be from *Millerella* zone.

Hiroshimaphyllum enorme (Ozawa), 1925, p.69, pl.14, figs.1-4.

=*Lonsdaleoides enormis*, Minato, 1955, p.164, pl.23, figs.4,5, pl.36, fig.4.

Holotype: III 67-69, Ozawa Collection, Tokyo Univ. Tobinosu, Ohda, Yamaguchi Pref. Lower part of the Akiyoshi limestone.

The coral is said to be fasciculate in form, however, individual corallite looks very similar to *Symplectophyllum*. Axial column is not densely constructed as in the type species. Assignment of this species to *Hiroshimaphyllum* may be doubtful. Records of occurrences of the species from other localities than the type locality need further clarification. They may be *Hiroshimaphyllum toriyamai*.

Hiroshimaphyllum shikokuense Yamagiwa, 1961, p.88, pl.1, figs.1-5.

Holotype JPC 40028, Osaka Museum of Natural History.

Omidani, Sakashu, Naka-gun, Tokushima Pref. Upper Carboniferous.

This species resembles *Lonsdaleoides boswelli* Heritsch and *Lonsdaleoides nishikawai* Hayasaka and Minato. True systematic position of the coral is yet uncertain.

Genus *Ozakiphyllum* Kato & Minato, 1975

Lonsdaleia auct. (*non* M'Coy, 1849)
Stylidophyllum auct. (*non* Fromentel, 1861)
1975 *Ozakiphyllum* Kato & Minato

Type species: *Ozakiphyllum hayasakai* Kato & Minato, 1975

Etymology: The generic name is dedicated to the late Professor Kin-emon Ozaki, whose contribution to stromatoporoids, corals and brachiopods are very great.

Generic diagnosis: Corallum cerioid. Wall and septa trabecular. Lonsdaleoid dissepiments develop. Septa are of two orders. Axial structure is typically of axial column which is sometimes very much thickened by stereoplasmic deposits. Clinotabulae present.

Remarks:

Cerioid *Lonsdaleia* (=*Actinocyathus*) occurs in the Japanese Lower Carboniferous. They were previously called as species of *Stylidophyllum* (Minato, 1955; Sato, 1956).

However a number of other "*Stylidophyllum*" has been described from the Japanese Upper Palaeozoic. And many of them are now shown to belong to Waagenophyllidae (Minato & Kato, 1965), while some others will be focused here for clarification.

Hayasaka (1924) and Ozawa (1925) described *Lonsdaleia floriformis crassiconus* from Omi and Akiyoshi limestones respectively. They considered this form to denote the presence of Viséan in the two limestones, as the same named coral is one of the index fossils of upper Viséan in Europe.

However Minato (1955) casts doubt on their identification and thus on the correlation derived from it. He thinks (1955) that the both corals are belonging to the same species which is of *Fusulinella* Zone. Actually Ozawa (1925) seems to have recognized the coexistence of his "*Lonsdaleia*" and *Fusulinella,* but he thought that the coral might have extended into "middle" Carboniferous from Lower Carboniferous.

Lonsdaleia and *Actinocyathus* (=*Stylidophyllum*) are now known to range from Viséan to lower Namurian. Yet they clearly demonstrate fibro-normal or diffuso-trabecular septa. So, in this respect Japanese "*Lonsdaleia crassiconus*" reveals much difference. It has trabecular wall and septa, and each skeletal element is very thickly constructed as Minato once remarked (1955, p.132). Otherwise true *Actinocyathus* (=*Stylidophyllum*=cerioid *Lonsdaleia*) and the Japanese "*Lonsdaleia*" (later on called as *Stylidophyllum*) are both provided with cerioid coralla, lonsdaleoid dissepiments, axial column and saucer shaped tabulae. Yet they are dissimilar as above described.

So, Minato was right that the Japanese "*Lonsdaleia crassiconus*" was not

identical with the British species so named, but belongs to a different stock and thus of different age.

By definition, therefore, *"Lonsdaleia crassiconus"* of Hayasaka and Ozawa belongs to Pseudopavonidae and not to Lonsdaleiidae. And since no generic name is readily available we proposed the name of *Ozakiphyllum* for it.

Some other forms already described as members of *Stylidophyllum* are to be included in this new genus.

Included species:

Ozakiphyllum yokomizoi (Yokoyama), 1957, p.79, pl.11, fig. 1-2.
Holotype: IGSH, Y.T.Z., Hiroshima Univ. Shinmen, Yuki-cho, Hiroshima Pref. *Fusulinella* Zone. Generic position of this coral is not certain. It may be rather close to *Lithostrotionella* lineage.

Ozakiphyllum ozawae (Yamagiwa & Ota), 1963, p.89, pl.1, figs.1-3, Holotype: Akiyoshidai Science Museum 1001. Uzura Quarry, Ofukudai, Yamaguchi Prefecture. Early Namurian. This coral is characterized in having comparatively small axial column and thin wall for the genus. And the coral quite resembles if not identical to Hayasaka's as well as Ozawa's *"Lonsdaleia crassiconus"*. Similar corals are widely distributed in the Akiyoshi limestone plateau and in Omi limestone. Although the type specimen is in our opinion definitely below *Profusulinella* zone, the species may be ranging upwards until *Fusulinella* zone (Ozawa, 1925).

Two new species of *Ozakiphyllum* are described below.

Ozakiphyllum hayasakai Kato & Minato, n. sp.
Pl 4, figs. 1, 2

Holotype: III 96-98, Ozawa Collection, Tokyo Univ. Edo, Akiyoshi-dai, Yamaguchi Prefecture. Lower part of the Akiyoshi limestone.

Description:

Corallum compound, cerioid. In transverse section corallite is polygonal, consists of very thick wall, lonsdaleoid dissepiments, tabularium and axial column.

Corallite is 7mm in short diameter of the largest corallite. Wall is very thick, and is composed of lateral coalition of neighbouring septa in young corallites. But in mature corallites wall is separated from septa by the development of lonsdaleoid dissepiments and in bead shaped fashion. Lonsdaleoid dissepiments are not large and not in numerous rows, but are distinctly present. Septa are in two orders, trabecular and radially arranged. About 20 major septa are present

in larger corallites. They fall short to the axial column. Minors are long and sometimes they are indistinguishable from majors. Tabularium is wide, about 5mm in diameter. Axial column is 1.5 to 1.8 mm in diameter, consits of numerous radiating septal lamellae and a few tabellae. It gives carcinophylloid appearance.

In longitudinal section axial column is solid, pillar like. Dissepiments are narrow and less numerous. Tabulae are mostly complete and both ascending and descending towards the axial column.

Remarks: The specific name is after Professor Ichiro Hayasaka.

The present new species morphologically stands in between *Ozakiphyllum ozawae* and *compactum* which will be described below.

From *O. ozawae* it differs in providing more numerous septa, large and dense axial structure. Wall is more thick in this form compared to *O. ozawae*.

In view of extreme variation found in Akiyoshi corals intermediate forms between *O. ozawae* and the present form may eventually be turned up in future.

From *O. compactum, O. hayasakai* is easily distinguished in having much smaller corallites, less dense axial column and septa.

The geological age of the present coral is not exactly known. But limestone near Edo has been classified as belonging to *Millerella* zone, so the coral now in problem would also be of early Namurian.

Ozakiphyllum compactum Kato & Minato, n. sp.

Pl. 4, figs. 3-5

Holotype: MK 136 (i-v), Kato Collection, Hokkaido University.

Yakusen Quarry, Isa, Mine, Yamaguchi Pref. early Namurian.

Description:

Corallum compound, cerioid. Holotype is 6cm x 3cm wide, and about 2cm thick.

In transverse section corallites are polygonal, 7 to 9 mm in diameter. Axial column is composed of dense septal lamellae and almost completely solid, elliptical in outlie. It is sometimes exteriorly denticulated. Short diameter of axial structure reaches up to 2.2 mm. Septa are in two orders, but minor septa are very long, even as long as the majors in some instances. Axial ends of major septa do not actually touch the axial column but extend quite near to it. Septa are rhopaloid in their axial ends. Septa are multitrabecular in fine structure, thick, and they often extend to the periphery of corallite, where they form corallite wall. Tabularium is not differentiated from dissepimentarium. Lonsdaleoid dissepiments only partially and weakly developed. They are, when

present, thin, flattened plates of many rows. Wall is thick when differentiated.

In longitudinal section septa and septal lamellae are so thickly constructed by packed trabeculae that they almost completely masked the development of dissepiments, tabulae and tabellae.

Remarks: The specific name is attributed to the compact nature of all the vertical skeletal elements of the present form, which is so unique and thus is easily distinguished from the other species of *Ozakiphyllum*. See remarks on *O. hayasakai* for comparison to that species.

Genus ***Pseudopavona*** Yabe, Sugiyama & Eguchi, 1943

1943 *Pseudopavona* Yabe, Sugiyama & Eguchi, p.245.
1961 *Pseudopavona,* Kanmera, p.223.
1973 *Pseudopavona,* Cotton, p.171.
1975 *Pseudopavona,* Kato & Minato

Type species:

Pseudopavona taisyakuana Yabe, Sugiyama & Eguchi, 1943

Generic diagnosis:

Corallum massive, compound, thamnastreoid, may be partially aphroid. Sometimes wall may be remained and corallum is meandrine as a whole. Columella is solid. Septa are normally thick, trabecular in fine structure and of two orders. Dissepiments are small. Clinotabulae and transverse tabulae present.

Remarks: Meandrine nature of corallum in the holotype of *Pseudopavona taisyakuana* was particularly noted by its original authors. However morphology of *Pseudopavona* seems variable in many ways. First of all degree of septal dilation is different from specimen to specimen, or even from part to part. Septal continuation from one corallite to the other may be interrupted when skeletal elements loose thickening. In this way partially aphroid forms

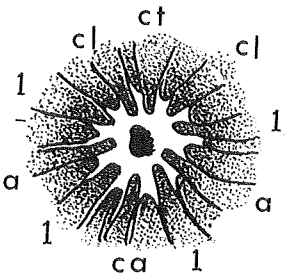


Fig. 2 Diagram showing the septal arrangement in a corallite of *Pseudopavona taisyakuana* Yabe, Sugiyama & Eguchi. ct-counter septum: ca-cardinal septum; a-alar septum; cl-counter lateral septum; 1- major septum of the first order insertion.

may occur. If the presence of wall is expressed in otherwise thamnastreoid colony we would expect meandrine corallum as s whole. In short colonial form of *Pseudopavona* is thamnastreod, which becomes meandrine or aphroid.

Included species:

Pseudopavona taisyakuana Yabe, Sugiyama & Eguchi, 1943. (P1.2, figs.1,6; P1.3, fig.1; P1.5, fig.) Yabe, Sugiyama & Eguchi, 1943, p.299, figs.1-2: Minato, 1955, p.180, pl.41, figs.1a-b: Yokoyama, 1957, p.80, pl.12, figs.1-2: Yamagiwa, 1962, p.108, pl.3, figs.7-8: Rowett & Minato, 1968, p.8, pl.8, figs.1-2, pl.9, fig.2.

Holotype: IGPS 90772, 90873, Tokoku University, Taisyaku gorge, Hiroshima Pref. *Fusulinella* Zone.

The coral is quite variable in its skeletal construction. The size of axial structure, for instance, is variable. Even diphymorphic corallites do occur. Columella is round in outline in some corallites but is denticulated in another. Septal thickness also varies considerably. They may be in most cases very thick and are in lateral contact, leaving no interspaces between them. In other cases, however, septa are very thin, and dissepimental vesicles are widely developed. Septa are mostly confluent with those of neighbouring corallites and thus show thamnastreoid corallum. But they may be interrupted either by the development of dissepimental vesicles or strong presence of wall.

Since these morphological variations are apparent in a series of specimens or even in a specimen, they represent mere formae of this rather mutable species. The holotype was probably derived from *Fusulinella* limestone, but Kato recognized the occurrence of the same species with *Profusulinella* fauna in Taisyaku. In Akiyoshi, it is ranging from *Millerella* to *Fusulinella* zones, and this range would be for the species in other regions.

Pseudopavona taisyakuana izutoensis Kawano, 1959, p.183, pl.20, figs.1,2, Izuto, Yamaguchi Pref.

This coral does not essentially different from the type species as Rowett & Minato (1968) considered. The occurrence of this coral in Permain limestone is beyond doubt. However the actual age of that coral is quite likely of reworked origin. We have seen a number of such cases in Akiyoshi region, where limestone pebbles containing Carboniferous corals as well as fusulinids are embedded in Permian limestones.

Pseudopavona crassisepta Kanmera, 1961, p.224, pl.15, figs.12, 13; pl.17, figs.1-7; pl.18, figs.1,9, text-figs.4,5.

Holotype: GK-D 50204, Kyushu University. Yayamadake, Kumamoto Pref. *Fusulina* zone. This coral is distinguished from *Pseuodpavona taisyakuana*

in having large corallites and numerous septa. Although original author described the species to have tertiary septa, they are at least not widely present. They may be accordingly appearing in portions where new septal insertion is taking place.

Genus ***Omiphyllum*** Kato, 1967

1967 *Omiphyllum* Kato, p.105
1975 *Omiphyllum,* Kato & Minato.

Type species: *Omiphyllum confertum* Kato, 1967

Etymology: Omi is a place name in the western part of Niigata Prefecture, where enormous limestone masses of Permo-Carboniferous age are developed. Hayasaka (1924) first discovered Carboniferous brachiopods and fusulinids from the Omi limestone, and thereby clarified the existence of Carboniferous system in Japan.

Included species: Type species only.

Geological age: C_1 of the Omi limestone, Pre-*Fusulinella* Zone

Remarks: Type species shows sparsely distributed corallites within extensively developed, packed lonsdaleoid dissepiments.

So in general skeletal construction the genus is similar to *"Cystophora"*. But it may be more appropriate to define the coral as the aphroid representative of *Amygdalophyllidium.* Although no wall structure is detected in this coral, it is morphologically close to both *Pseudopavona* and *Ozakiphyllum.*

Subfamily **Taisyakuphyllinae** Kato & Minato, 1975

Forms of Pseudopavonidae with tertiary or more orders of septa are grouped here as Taisyakuphyllinae, which contains at present only two genera, *Taisyakuphyllum* Minato and *Ibukiphyllum* Kato & Minato.

Genus ***Taisyakuphyllum*** Minato, 1955

1955 *Taisyakuphyllum* Minato, p.143.
1961 *Taisyakuphyllum,* Kanmera, p.222.
1962 *Taisyakuphyllum,* Yamagiwa, p.106.
1973 *Taisyakuphyllum,* Cotton, p.207.
1975 *Taisyakuphyllum,* Kato & Minato.

Type species (original designation): *Taisyakuphyllum rostfer* Minato, 1955.

Etymology: Taisyaku is the name of limestone plateau in the Hiroshima Prefecture, Japan. Taisyakuten, from which the place name is originated, is

one of guardians of Buddhists.

Generic diagnosis: Corallum may be fasciculate. Corallite coninco-cylindrical. Corallite consists of very thick wall, also thick septa of three orders and thick axial structure. Dissepimentarium is often completely masked by the thick disposition of septa which are laterally touching with each other to leave no interspaces. But in some forms septa become comparatively thin and even discontinuous and small lonsdaleoid dissepiments are developed. Septa are all trabecualr. Axial structure is large and solid. Clinotabulae prominent.

Remarks: *Taisyakuphyllum* differs from *Amygdalophyllidium* in having teriary septa and ill developed lonsdaleoid dissepiments. It also differs from *Lonsdaleoides* in possessing compact axial column, tertiary septa and small lonsdaleoid dissepiments if present. *Ibukiphyllum* is a cerioid representative of *Taisyakuphyllum,* and thus is morphologically close to *Taisyakuphyllum.*

Hitherto described forms other than the type species:

Taisyakuphyllum nakazawae Yamagiwa, 1960.
T. fujimotoi Yamagiwa, 1962.
T. hashimotoi Yamagiwa, 1962.

Distribution:

Omi limestone, Niigata Pref. *Millerella-Fusulinella* Zone?
Maizuru zone, Kyoto Pref. derived fossil in Permian (Yamagiwa, 1960)
Tsuyama basin, Okayama Pref. "middle Carboniferous" (Konishi, MS)
Atetsu limestone, Okayama Pref. *Millerella-Profusulinella-Fusulinella* zones. (Yamagiwa, 1962)
Taisyaku limestone, Hiroshima Pref. *Millerella* zone and possibly later. (Minato, 1955, Yokoyama, 1957)
Akiyoshi limestone, Yamaguchi Pref. *Profusulinella-Fusulinella* zone. (Minato, 1955, Minato & Kato, 1957; Kato MS)

In short the genus has been known to occur from the S.W. Japan from "middle" Carboniferous.

Taisyakuphyllum rostfer Minato, 1955
Pl.2, figs.4,5; text-fig.1-2

1955 *Taisyakuphyllum rostfer* Minato, p.143, pl.22, fig.12, pl.25, fig.4; pl.34, fig.8; text-fig.15.
1968 *Taisyakuphyllum rostfer,* Rowett & Minato, p.12-26, pl.1, figs.1-3; pl.2, figs.1-2; pl.3, figs.1-3; pl.4, figs.1-2; pl.5, figs.1-3; pl.6. figs.1-2; pl.7, figs.1-2; pl.9, fig.1; text-figs.1-5. (see for further synonymy).

Holotype: IV_{4-6}, Ozawa Collection, Tokyo Univ., Ofukudai, Yamaguchi Pref.

Remarks: Observation of many specimens of *Taisyakuphyllum* from the Akiyoshi limestone reveals that it contain only one, very variable species,

Taisyakuphyllum rostfer.

Morphologically this species may be divided into at least three formae as follows:

forma 1 – With thin, platy columella, thin septa and lonsdaleoid dissepiments.

forma 2 – With spindle shaped, solid columella, thin septa and normal dissepiments.

forma 3 – With large, round columella, thick septa which cover the development of dissepiments.

But there are further gradational forms between these formae, and they often occur together at a locality. Therefore these formae are best considered as intraspecific variations of *T. rostfer* which is exemplified as the forma 2 in the above list.

Yamagiwa (1960, 1962) prosed three new species of *Taisyakuphyllum* besides the type species, but these may fall within the limit of variation of *T. rostfer.* In this connection Rowett & Minato (1968) expressed the same opinion when they described in detail *T. rostfer* from the Omi limestone.

In the Akiyoshi limestone *Taisyakuphyllum* is confined in the *Profusulinella-Akiyoshiella-Fusulinella* limestones, and the geological age of the genus in other regions is quite likely to be mostly, if not exclusively within the range shown in Akiyoshi.

Genus ***Ibukiphyllum*** Kato & Minato, 1975

1975 *Ibukiphyllum* Kato & Minato.

Type species: *Wentzelella sekii* Minato, 1955

Etymology: The generic name is taken affer the Mt. Ibuki in central Japan. The type specimen of *"Wentzelella" sekii* was collected from the eastern foot region of the Mt. Ibuki.

Generic diagnosis: Corallum massive, cerioid. In transverse section corallites are composed of very thick wall, trabecular septa of three orders and also thick axial structure. Small lonsdaleoid dissepiments may develop. Longitudinally the presence of clinotabulae is characteristic. The genus may be simply defined as cerioid *Taisyakuphyllum.*

Included species:

Ibukiphyllum sekii (Minato), 1955, p.108-110, pl.26, fig.9, text-figs.8, D.1-4, Loc: Oishi-zawa, Iwate-mura, Fuwa-gun, Gifu Prefecture. May be of derived origin. Originally "middle" Carboniferous ? Holotype: no.108, Inst. Geol. & Paleont., Tohoku Univ., Sendai. The specimen is a broken colony embedded in reddish, tuffaceous limestone which is partly dolomitic. It has

clearly trabecular septa, and cannot be placed in Waagenophyllidae to which the genus *Wentzelella* belongs.

The species is characterized in having rather thin septa which are continuous with wall. In other words lonsdaleoid dissepiments are absent. Axial structure is rather small. The size of corallites may reach up to 10 mm in diameter. Major septa are more than 20 in number.

Ibukiphyllum meandroides (Sakaguchi & Yamagiwa), 1958, p.172, pl.3, figs.2a-b. Loc: Oji, Shino-mura, Minami kawata-gun, Kyoto Pref. Holotype: No.59016 IAGG Osaka Univ. of Liberal Arts & Education.

Ibukiphyllum kameokense (Sakaguchi & Yamagiwa), 1958, p.173, pl.3, fig.4; pl.4, fig.1; pl.5, fig.l. Loc. as above. Holotype: No.59017; repository as above.

Ibukiphyllum quadratum (Sakaguchi & Yamagiwa), 1958, p.173-174, pl.4, figs.2-4, Loc. Inukanno, Nishibetsuin-mura, minami kuwata-gun, Kyoto Pref. Holotype: Nos.59019~59020, IAGC.

Remarks: The above quoted three forms are in fact morphologically very similar with each other. They have almost same sized corallites (about 5–6 mm in diameter) and the same number of major septa (about 12 to 13 in number). The first one is a corallum in which increase is commonly occurring. The last named form is a crashed specimen. They are from the same locality or from a place nearby. And we are inclined to think that they are in reality representing a single species, which should be called as *Ibukiphyllum meandroides.* This species has smaller corallites, less numerous septa and lonsdaleoid dissepiments, compared to the type species. Longitudinal characters of the type species are not known owing to the lack of well oriented sections, however, they are clearly demonstrated especially in *Ibukiphyllum quadratum.*

All these specimens are said to have come from Lower Permian *Pseudofusulina vulgaris* zone. Derivation is quite certain, but the age of these corals is questionable, as *Clisiophyllum* and *Dibunophyllum* with Carboniferous aspects occur also. The actual age for them may be accordingly Carboniferous.

Ibukiphyllum sinense (Fan), Yü, Lin & Fan, 1962, p.26, pl.4, fig.5. Holotype, Co 263, Changchun Geological College Kuruktak, Sinchang, China. Middle Carboniferous.

This coral is said to have cerioid corallum, thick, denticulated wall, dilated septa of which tertiary order of them exist. Also clinotabulae are present. Therefore if septal structure is trabecular, the coral is definitely a member of Pseudopavonidae, and belongs to *Ibukiphyllum.* If so, this would be the sole exception of the member of Pseudopavonidae occurring outside Japan.

A new species of *Ibukiphyllum* is to be added below.

Ibukiphyllum densum Kato & Minato, n. sp.

Pl.6, fig.1

Material: Omi 572 (four thin sections) (Holotype); Omi 341-a (four thin sections); Omi 341-c (two thin sections), all from the glory hole of the Shin-etsu chemical Industry Co., Uta, Omi-cho, Niigata Prefecture. Omi 405' (one thin section) from Daiseru Quarry, also of Uta, Omi-cho, Niigata Pref. Coll. by M. Kato. "Middle Carboniferous" *Fusulinella* Zone.

Specific diagnosis: *Ibukiphyllum* with large corallites and large axial structure. Major septa are thick and numerous.

Description:

Corallum massive, compound and cerioid. The height of corallum is considerable compared to the lateral expansion in Omi 341-a. In transverse section corallites are polygonal, consisting of axial structure, tabularium, dissepimentarium and wall. Axial structure is large, subround in outline, and measures 1.5 to 1.8 m in short diameter. Axial structure is in reality an axial column which sometimes shows the presence of axial tabellae, but is otherwise quite densely constructed.

Tabularium is not clearly differentiated from dissepimentarium, with about 5 mm diameter. Axial portions of septa are somewhat rotated around the axial structure. Thick major septa are also not easily separable from minors. Tertiary septa present.

Septa are getting thinner in dissepimentarium where they are a little discrete and become a row of trabecular rods. Thus very small lonsdaleoid dissepiments develop, but they are never large and laterally flattened. Increase by peripheral. Small offsets appear in the dissepimentarim of "mother" corallites, and walls appear in between (Omi 572).

Walls are very thick, composed of laterally coalesced trabeculae, which more or less gradually turned into the other sets of trabecular wall of the neighbouring corallite. Thus no distinct dark line bounding the two adjacent corallites is seen. Thickness of wall between the two corallites measures more than 1 mm.

Sometimes peripheral portion of corallum is loose, and half detached corallites may be observed. No well oriented longitudinal section is available. But dissepiments are rather small and globose. Wall is composed of vertical series of fans of divergent trabeculae.

Remarks:

The species reveals variability in skeletal construction. For example a specimen (Oni 405') from Daiseru Qy. shows thinner septa, and small, irregular shaped axial structure. Corallites of Omi 341-a specimen is much smaller than that of holotype.

Yet in comparison to the type species and *Ibuki. meandroides* the present form is characteristic in having larger corallites, numerous thick septa and large axial column. Therefore it is clearly distinguishable from the other two species, and merits for the erection of new species.

Distribution: *Fusulinella* Zone, "middle" Carboniferous.

Niigata Prefecture, Central Japan.

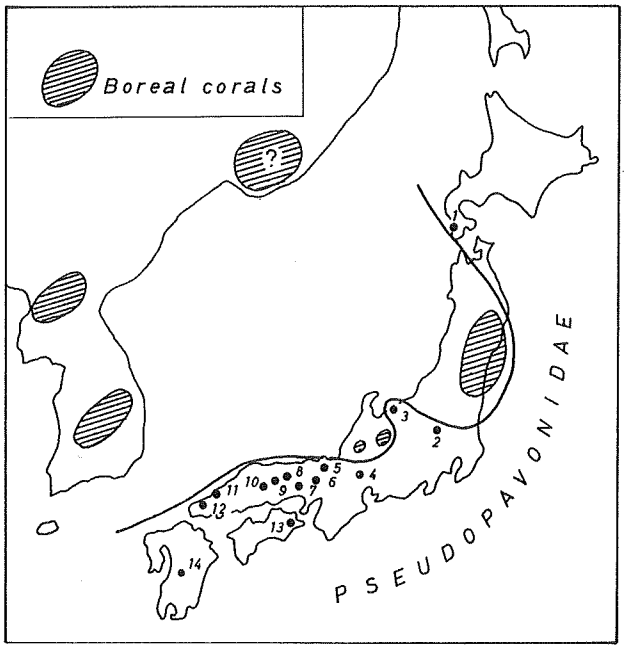


Fig. 3 Geographical distribution of Pseudopavonidae

1 – Era, S.W. Hokkaido
2 – Ohmama, Gunma Pref.
3 – Omi, Niigata Pref.
4 – Otaki, nea Mt. Ibuki, Gifu Pref.
5 – Maizuru, Kyoto Pref.
6 – Nishiyama, Kyoto Pref.
7 – Kamigori, Hyogo Pref.
8 – Kanbano-taki, Okayama Pref.
9 – Atetsu limestone plateau, Okayama Pref.
10 – Taisyaku limestone plateau, Hiroshima Pref.
11 – Handa, Yamaguchi Pref.
12 – Akiyoshi limestone plateau, Yamaguchi Pref.
13 – Sakashu, Tokushima Pref.
14 – Hikawa, Kumamoto Pref.

Distribution

Corals of Pseudopavonidae have been found exclusively from limestone, which may be micritic, sparitic or bioclastic. And these corals are rather sporadically embedded in matrix, often associated with other corals, notably chaetetids foraminifera, and bryozoas. Largest colony we have seen is only of cobble size.

No Pseudopavonids have been found from Lower Carboniferous or Upper Carboniferous (s.s.) = Uralian. All the rocords are from "middle" Carboniferous. In fusulinid zonation they may range from *Eostaffella* zone to *Fusulina* (=*Beedeina*) zone. Range of each genus is shown in fig.4, which probably indicates that solitary form comes first and colonial forms follow it. Advanced forms with tertiary septa occur later.

As may be seen from the text-figure 3, the distribution of Pseudopavonids is quite wide in Japan. Yet, they have not been recorded so far from the "middle Carboniferous" Nagaiwa series of N.E. Japan and the Ichinotani formation of Central Japan. These limestone formations yield such boreal corals as *Sciophyllum, Thysanophyllum, Lithostrotionella, Koninkocarinia,*

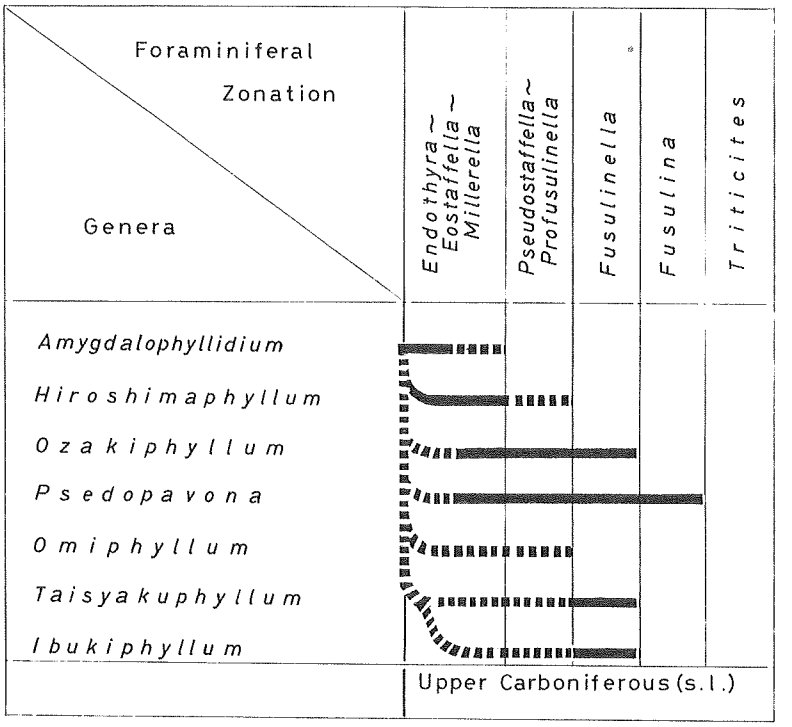


Fig. 4 Geological range and inferred phylogeny of Pseudopavonidae

Arachnastraea etc., which are not at all common in other limestone bodies where Pseudopavonids occur. Palaeobiogeographically, therefore, the distributional pattern of Pseudopavonids is quite interesting and that must have something to do with the Carboniferous geotectonic, sedimentological condition in the Japanese islands.

A check list of previously described forms of Pseudopavonidae
(arranged by chronological order)

Lonsdaleia floriformis crassiconus (McCoy) Smith, Hayasaka, 1924 = *Ozakiphyllum*
Lonsdaleia floriformis crassiconus M'Coy, Ozawa, 1925 = *Ozakiphyllum*
Lonsdaleia enormis Ozawa, 1925 = *Hiroshimaphyllum* ?
Orionastraea sp. Hayasaka, 1932 = *Pseudopavona* ?
Pseudopavona taisyakuana Yabe, Sugiyama & Eguchi, 1943, Yokoyama, 1957; Yamagiwa, 1962; Kanmera, 1959: = *Pseudopavona*
Amygdalophyllum naosoidea Minato, 1951 = *Amygdalophyllidium*
Lonsdaleoides toriyama Minato, 1955 = *Hiroshimaphyllum*
Taisyakuphyllum rostfer Minato, 1955 = *Taisyakuphyllum*
Wentzelella sekii Minato, 1955 = *Ibukiphyllum*
Stylidophyllum yokomizoi Yokoyama, 1957 = *Ozakiphyllum* ?
Lonsdaleoides toriyamai Minato, 1955, Minato & Kato, 1958, Yamagiwa & Ota, 1963 = *Hiroshimaphyllum*
Polythecalis meandroides Sakaguchi & Yamagiwa, 1958 = *Ibukiphyllum*
Stylidophyllum kameokense Sakaguchi & Yamagiwa, 1958 = *Ozakiphyllum* ?, *Ibukiphyllum*?
Stylidophyllum quadratum Sakaguchi & Yamagiwa, 1958 = *Ibukiphyllum*
Taisyakuphyllum nakazawae Yamagiwa, 1960 = *Taisyakuphyllum*
Pseudopavona crassisepta Kanmera, 1961 = *Pseudopavona*
? *Lonsdaleoides shikokuensis* Yamagiwa, 1961 = *Hiroshimaphyllum* ?
Amygdalophyllum sp. Yamagiwa, 1961 = *Amygdalophyllum* ?
Amygdalophyllum cfr. *naosoidea* Minato, Yamagiwa, 1962 = *Amygdalophyllidium*
Taisyakuphyllum fujimotoi Yamagiwa, 1962 = *Taisyakuphyllum*
Taisyakuphyllum hashimotoi Yamagiwa, 1962 = *Taisyakuphyllum*
Taisyakuphyllum sp. = *Taisyakuphyllum*
Wentzellophyllum sinense Fan, in Yü, Lin & Fan, 1962 =? *Ibukiphyllum*
Stylidophyllum ozawae Yamagiwa & Ota, 1963 = *Ozakiphyllum*
Lonsdaleoides toriyamai Minato, Yamagiwa & Ota, 1963 = *Hiroshimaphyllum*
Omiphyllum confertum Kato, 1967 = *Omiphyllum*

Pseudopavona cfr. *taisyakuana* Yabe, Sugiyama & Eguchi, Rowett & Minato, 1968 = *Pseudopavona*

Pseudopavona sp. Yoshida & Kakimi, 1970 = *Pseudopavona*

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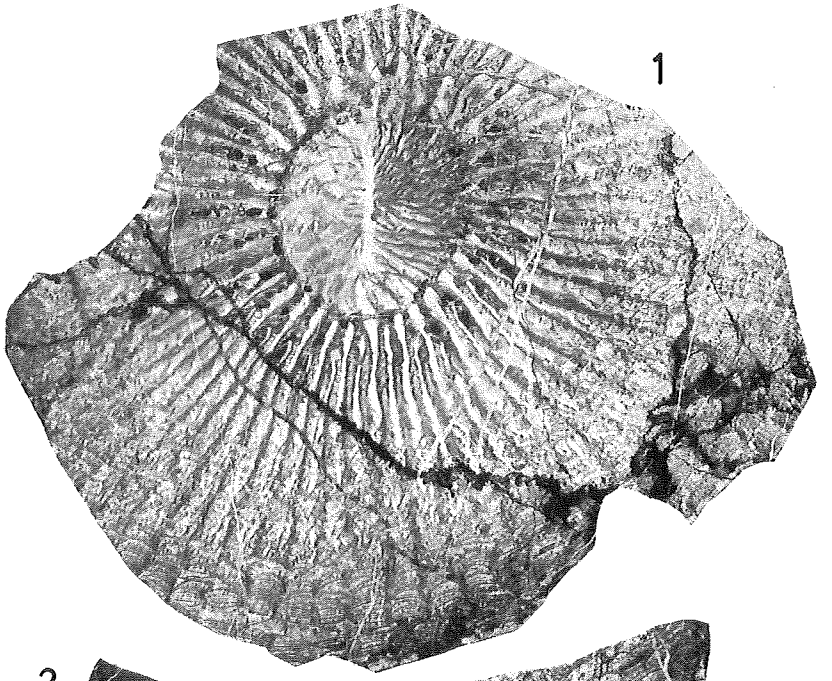
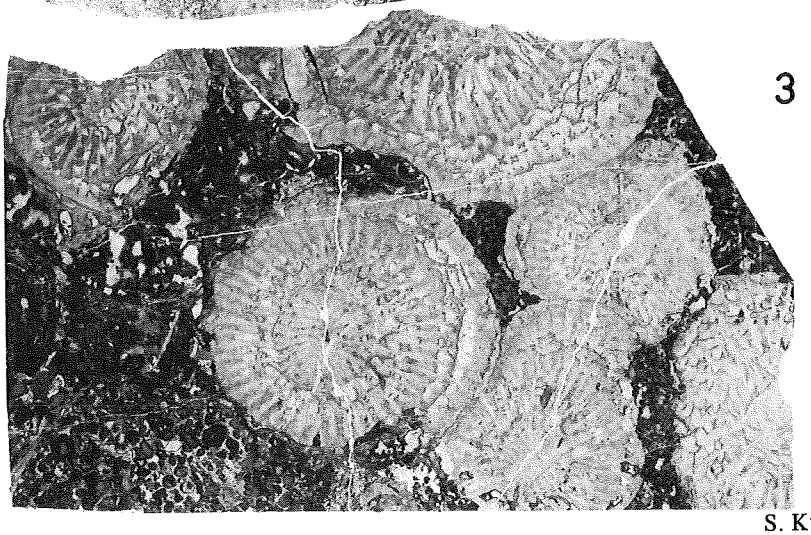
Explanation of plate 1
(All figures four times natural size)

Figs. 1,2 *Amygdalophyllidium naosoideum* (Minato)
1 – Transverse section showing Amygdalophylloid axial column, cavernous septa and naotic dissepiments. 2 – Longitudinal section. Holotype – Ozawa collection IV $_{1,2}$ from Ohkubo, Yamaguchi Prefecture.

Fig. 3 *Hiroshimaphyllum toriyamai* (Minato)
Transverse section. Holotype – UHR 12707 – ii, from Ohkubo, Yamaguchi Prefecture. Coll. by Toriyama.





S. Kumano photo.

Explanation of plate 2

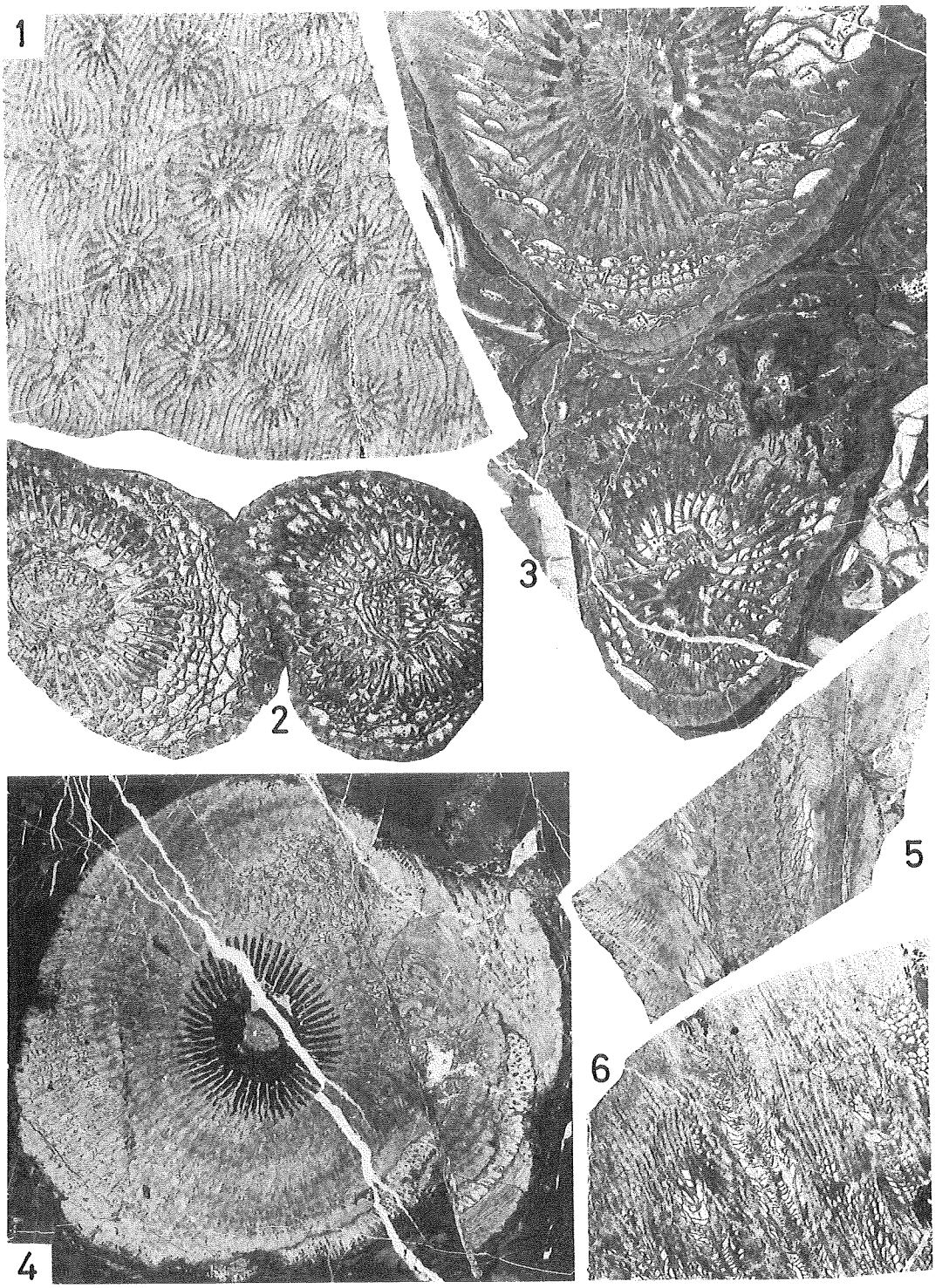
Fig. 1 *Pseudopavona taisyakuana* Yabe, Sugiyama & Eguchi. Transverse section showing thamnastreoid corallum with thick columella and septa. MK 268-i from Karamon, Taisyaku, Hiroshima Prefecture. Coll. by M. Kato. X 4

Fig. 2 *Hiroshimaphyllum toriyamai* (Minato). Transverse section. UHR 12708-ii from Ohkubo, Yamaguchi Prefecture. Coll. by E. Takahashi X 3

Fig. 3 *Hiroshimaphyllum toriyamai* (Minato). Transverse section. MK 177-ii from Uzura quarry, Ofukudai, Yamaguchi Prefecture. Coll. by M. Kato X 3

Figs. 4 & 5 *Taisyakuphyllum rostfer* Minato. 3-Transverse section. 4-Longitudinal section showing clinotabulae and elongate dissepiments. MK 182-i, ii from Isa no.4 quarry, Yamaguchi Prefecture. Coll. by M. Kato X 3

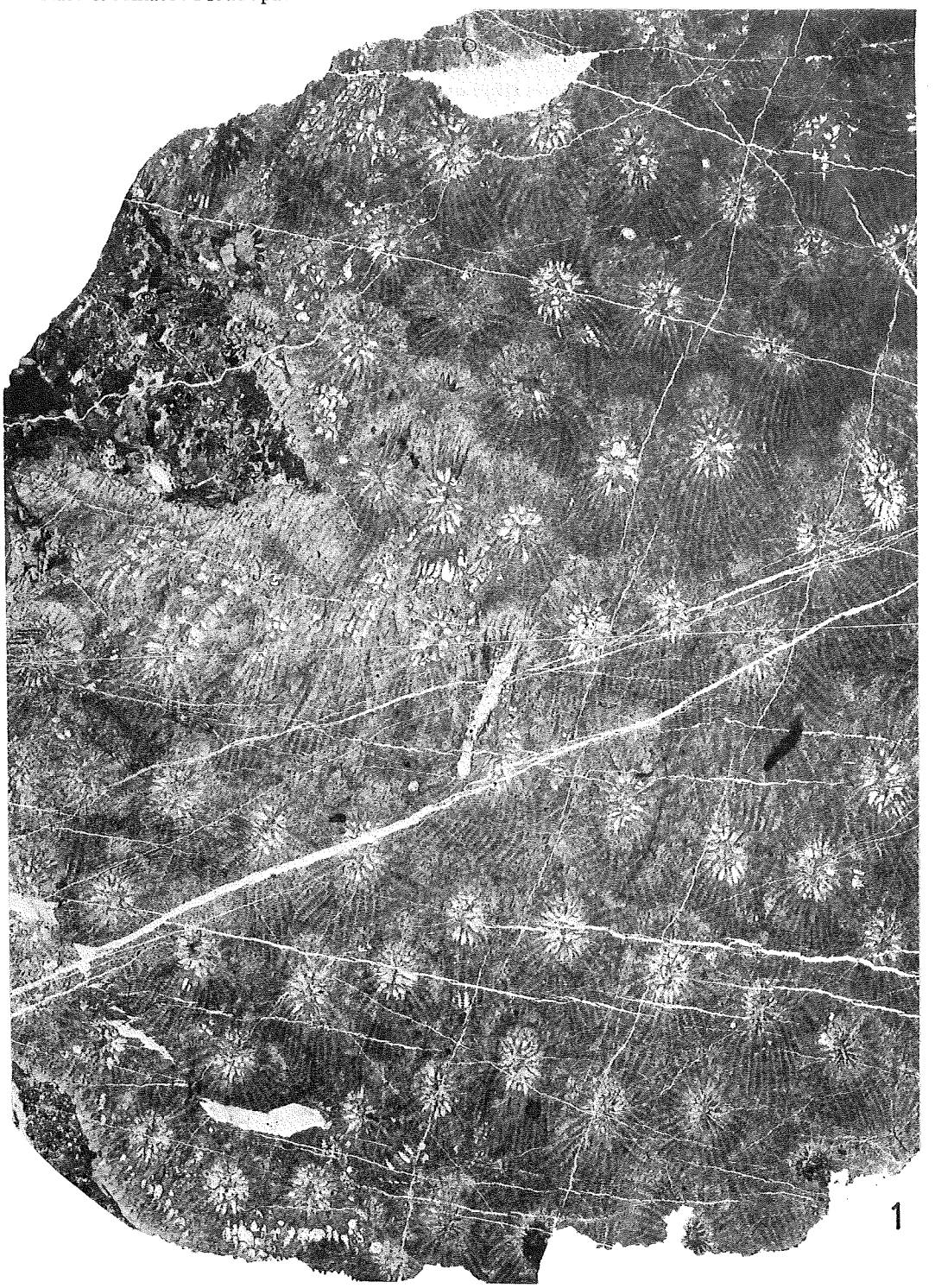
Fig. 6 *Pseudopavona taisyakuana* Yabe, Sugiyama & Eguchi. Longitudinal section of a less dilated corallum in which clinotabulae are clearly seen. MK 200-i from Shiraiwa, Yamaguchi Prefecture. Coll. by M. Kato X 4



M. Kato photo.

Explanation of plate 3

Fig. 1 *Pseudopavona taisyakuana* Yabe, Sugiyama & Eguchi. Transverse section. MK 225-1 from Daiyama loc. 42411, Akiyoshi, Yamaguchi Prefecture. Coll. by M. Kato X 4

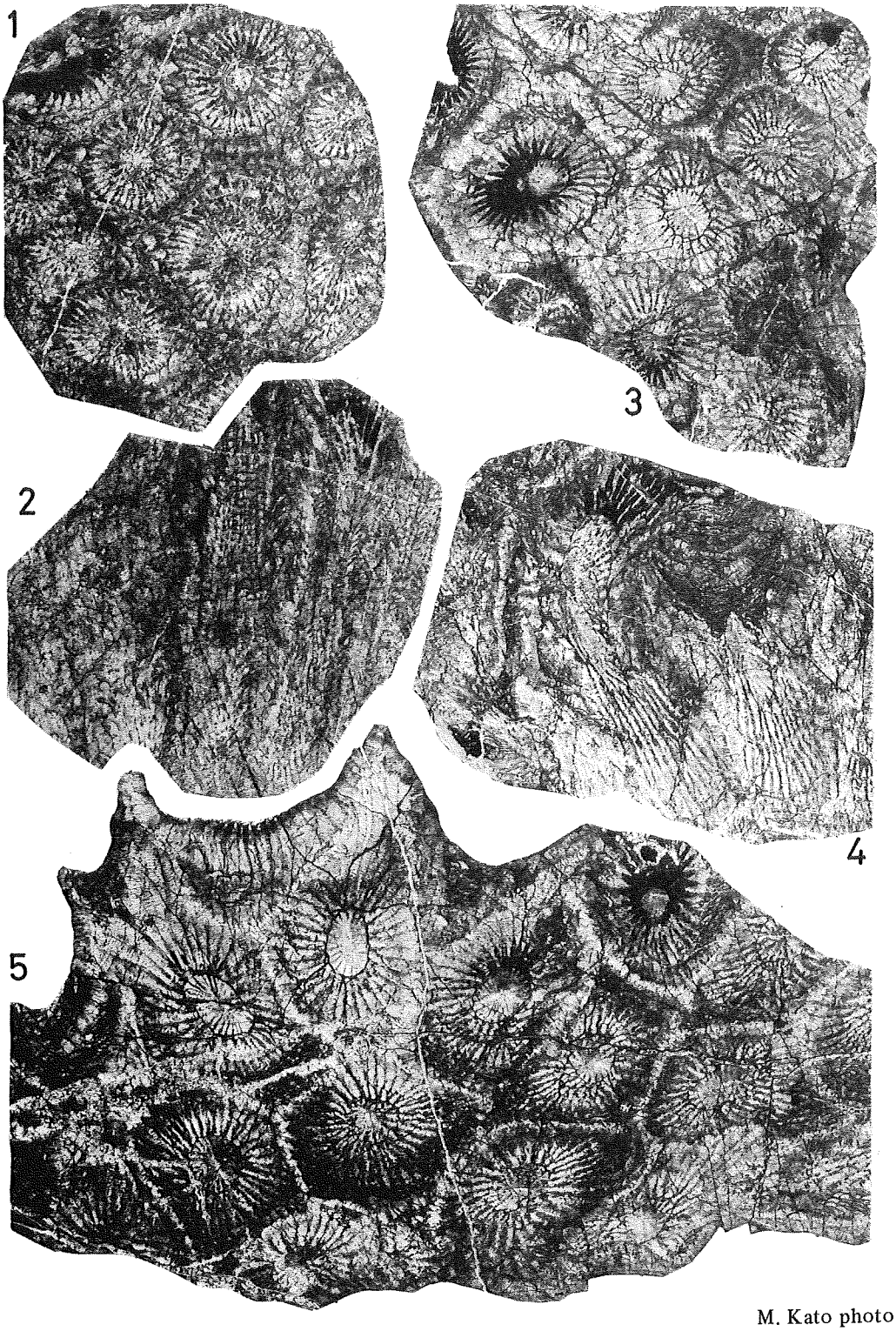


M. Kato photo.

Explanation of plate 4

Fig. 1,2 *Ozakiphyllum hayasakai* Kato & Minato, n.sp. 1-Transverse section. 2-Longitudinal section. Holotype – Ozawa collection III97,98 from Edo, Yamaguchi Prefecture. X 4

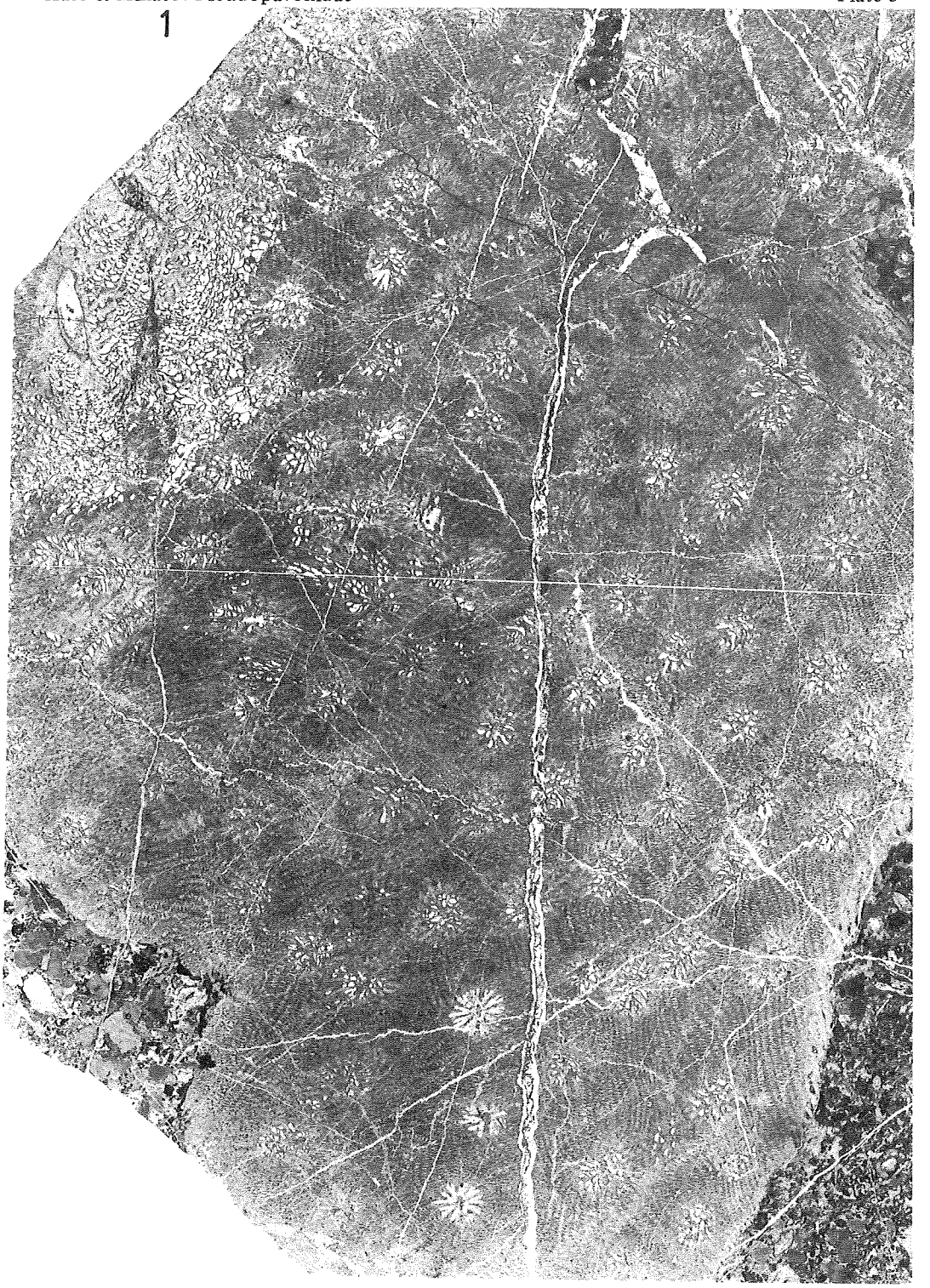
Fig. 3,4 & 5 *Ozakiphyllum compactum* Kato & Minato, n.sp. 3 & 5 – Transverse section. 4 – Obliquely cut longitudinal section. Holotype – MK 136 from Yakusen quarry, Isa-maruyama, Yamaguchi Prefecture Coll. by M. Kato. X 3



M. Kato photo.

Explanation of plate 5

Fig. 1 *Pseudopavona taisyakuana* Yabe, Sugiyama & Eguchi. Transverse section. Note the presence of non dilated portion of the corallum on the upper left. MH 14 from Nakanodai, Akiyoshi, Yamaguchi Prefecture. Coll. by Y. Hasegawa X 4



M. Kato photo.

Explanation of plate 6

Fig. 1 *Ibukiphyllum densum* Kato & Minato, n.sp. Transverse section. Holotype – Omi 572 from a glory hole of the Shinetsu Chemicals Co., Ltd. Omi. Niigata Prefecture. *Fusulinella* zone. X 7 Coll. by M. Kato.

S. Kumano photo.