UPPER CARBONIFEROUS CORALS FROM THE NAGAIWA SERIES, SOUTHERN KITAKAMI MOUNTAINS, N.E. JAPAN

by

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(With 7 Text-figures and 16 Plates)

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Introduction

In the southern Kitakami Mountains, N. E. Japan, rich limestone resources have been found to develop within Palaeozoic sequence ranging from Silurian to Permian. At present mainly Permian limestones are extensively quarried for cement industry.

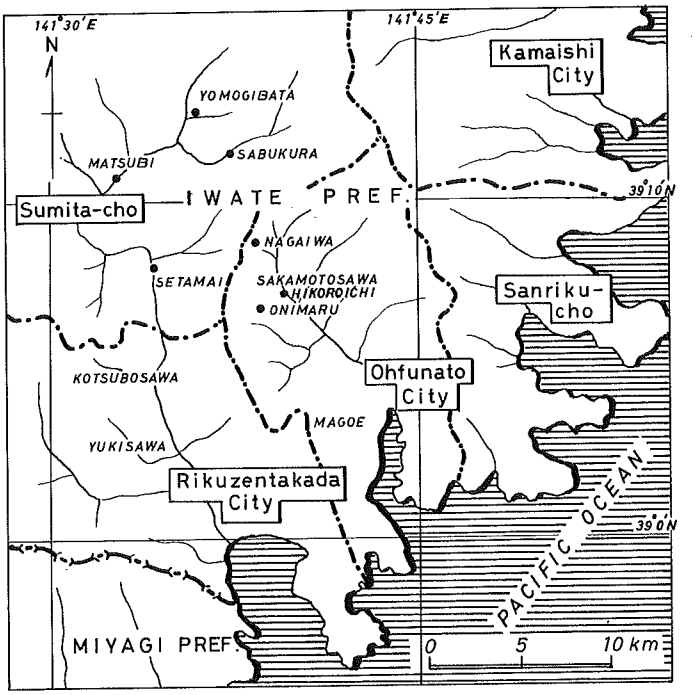

Fig. 1. The Southern Kitakami Mountains, showing chief localities wherein coral-bearing Nagaiwa series occurs.

In old days, Palaeozoic limestones in Japan were considered exclusively of Permian age, thus were assumed to bear fusulinids. However HAYASAKA (1922) first clarified the presence of marine Carboniferous in Japan. Following HAYASAKA, ENDO (1924) distinguished "Coral limestone" in field from "Fusulina limestone" in the southern Kitakami Mountains. The "Coral limestone" was later designated by ONUKI (1937) as the Onimaru series, which he further divided into two stages; namely the lower Kanenokura stage with *Kueichouphyllum* and the upper Nagaiwa stage with *Chaetetes* and *Fusulinella*. While the "Fusulina limestone" now belongs to the Sakamotosawa series of Lower Permian.

MINATO (1942) redefined the Onimaru series to the black limestone sequence bearing upper Viséan coral fauna, and he found a marked clino-unconformity at the base of the Onimaru series (MINATO, 1941; NAGAO & MINATO, 1943). And he raised the Nagaiwa stage to a series rank.

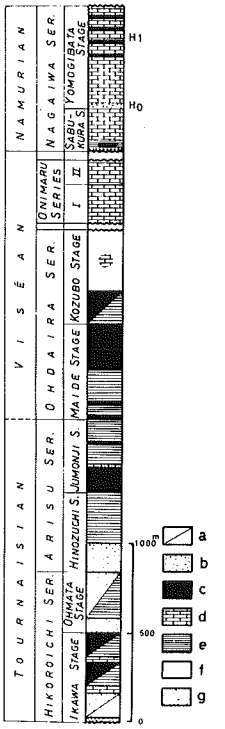

Fig. 2. Columnar section of the Carboniferous in the Southern Kitakami Mountains. a; alternation, b; porphyrite tuff, c; diabase tuff, d; limestone, e; slate, f; sandstone, g; conglomerate, I; Hotokezaka Stage, II; Hiishi Stage, H_0, H_1; fossil horizons. (As to tuffs of the upper part of the Yomogibata stage, Nagaiwa series, they appear to be diabasic in field. But true lithological nature of them has not been studied in detail yet.)

Detailed lithostratigraphy of the Nagaiwa series was made available by MINATO et al. (1953) as their VIII Group. Lithologically the series consists of white gray, massive limestones with the intercalations of porphyrite and diabase tuffs and siliceous nodule bands. MINATO et al (1953) recognized two major fossil horizons, H_0 and H_1, in the whole sequence of the series. YAMADA (1958) studied the distribution, lithology and biostratigraphy of the Nagaiwa series in the Hikoroichi region. The base of the series became clear by the finding of basal conglomerate in the Arisu region (TAKEDA in MINATO et al, 1959), whereas the top is marked by a clino-unconformity at the base of the Lower Permian Sakamotosawa series (MINATO, 1942; YAMADA, 1959).

Total thickness of the series may reach up to 700 m in the Arisu region, and to 600 m or more in the Hikoroichi region (MINATO et al., 1959).

More detailed lithological studies on Nagaiwan limestones were recently pursued by KOBAYASHI (1973a) and MUSASHINO (1973) in the Hikoroichi region. As a whole the series may have been deposited under shelf-margin environment.

Biostratigraphically the Nagaiwa series has been divided into the lower Sabukura Stage and the upper Yomogibata Stage (MINATO et al., 1959). The former corresponds to *Millerella* zone, while the latter to *Profusulinella* zone in fusulinid zonation. The H_0 horizon (MINATO et al., 1953) marks the boundary between the two stages. Thus the series, as we presently understand, may be correlatable to Bashkirian to lower Moscovian of Upper Carboniferous.

The series as a whole yields rather scanty fossils including fusulinids, ostracods, corals and brachiopods. Fusulinids have been described by CHOI (1973) and KOBAYASHI (1973b); smaller foraminifera by OKIMURA (1966); Ostracods by ISHIZAKI (1963, 1964). The occurrence of spiriferids has been noted in field, but none has been described yet.

As to corals, YABE & HAYASAKA (1915) described *Diphyphyllum equiseptatum,* which they thought to denote Permian. But the coral has been generally considered to have come from the Upper Carboniferous Nagaiwa series of the present day use, although the exact locality and horizon of this coral has not been clarified yet.

In 1949 MINATO described *Thysanophyllum aseptatum* which constituted the first illustration of Nagaiwa corals. MINATO in his monograph on the Japanese Carboniferous and Permian corals (1955) added *Chaetetes nagaiwaensis* and *Lithostrotionella kitakamiensis.* All the above mentioned forms were from the Hikoroichi region. Also from the same region MINATO & KATO (1957) described *Diphyphyllum delicatum* while MINATO & SAITO (1959) established *Sciophyllum japonicum* from the Setamai region. YAMADA (1958) introduced 3 manuscript names of corals; *Diphyphyllum digitiforme* EGUCHI & YAMADA,

Lithostrotionella nagaiwaensis EGUCHI & YAMADA and *Thysanophyllum yabei* EGUCHI & YAMADA. These have been, however, remained undescribed. KATO (1959) recorded and described *Dibunophyllum* cfr. *bipartitum konincki* from the Hikoroichi region. And these exhaust the all described forms of Nagaiwa corals.

Corals are by no means abundant in the Nagaiwa Series, yet they may be commonly found at places, particularly from a horizon called H_0 which is often rich in *Chaetetes* and *Lithostrotionella.*

Materials have been collected and accumulated at our disposal, and it is the purpose of the present article to describe them.

As a result of the present research, new distribution of the Nagaiwa Series became evident in the eastern wing of the N-S strectching Ohdaira anticlinorium, to the south of Setamai along the right bank of the Kesen river, where only the upper Viséan Onimaru Series was formerly thought to have distributed.

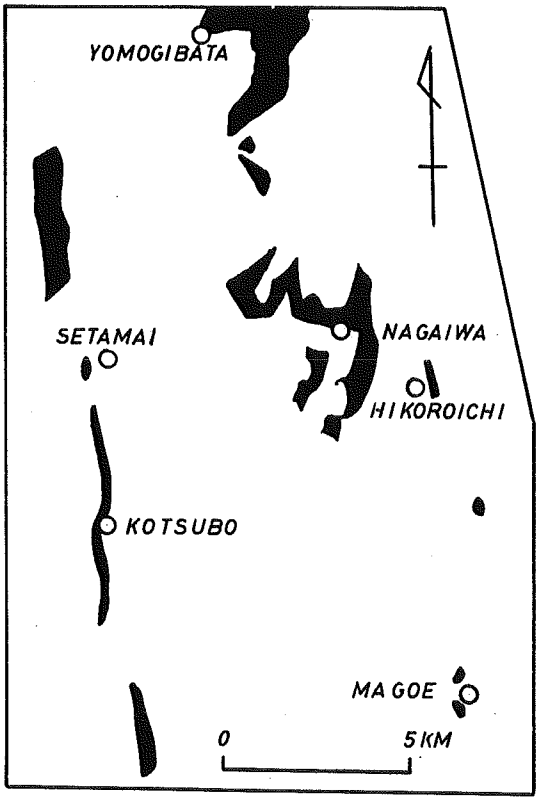

Fig. 3. Sketch map showing the known distribution of the Nagaiwa series in and around the Setamai – Hikoroichi region, Iwate Prefecture.

Specimens with UH Registration Nos. are deposited at the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University.

Acknowledgements

Dr. K. MORI of Tohoku University kindly took trouble to trace and locate the old materials described and figured by YABE and HAYASAKA. He provided us with photographs of *Diphyphyllum equiseptatum* and *Lithostrotionella unicum.*

Dr. E. W. BAMBER of Canadian Geological Survey supplied to us some Russian literatures translated into English.

D. W. SANDO of U.S. Geological Survey, through correspondence disscused with us the matter related to the *Lithostrotionella* problem.

Considerable portion of coralline materials were collected by ourselves. But Messrs. H. TAKEDA, T. KAKIMI, T. HASHIMOTO, S. YATO and D. R. CHOI formerly associated with Hokkaido University kindly donated their collections to the writers' study. Mr. S. KUMANO with the assistance of Dr. D. R. CHOI, photographed almost all specimens herein illustrated. He also prepared all text-figures. Miss E. MIMA typed the manuscript. To all these personal our cordial thanks are offered.

Systematic Description

Phylum COELENTERATA
Class ANTHOZOA
Order TABULATA EDWARDS & HAIME, 1850

Family **CHAETETIDAE** EDWARDS & HAIME, 1850

SOKOLOV (1950) discussed at length the systematic position of Chaetetids. He stressed the similarity between Stromatoporoids and Chaetetids, and the dissimilarity between Tabulata and Chaetetids. Thus he regarded Chaetetids as forming an independent group in Class Hydrozoa.

However, Tetradiids and Lichenariids, both have been unanimously treated as Tabulata, are all very similar to Chaetetids in having trabecular wall and cerioid coralla.

In Tabulata wall structure is the most important biocharacter, and there are two essential types recognized (KATO, 1968). Namely, they are fibro-normal type and trabecular type. Chaetetids are belonging to the latter category

together with Lichenariids, Heliolitids and Sarcinulids.

At present we follow the traditional classification in which Chaetetids are considered as representatives of Tabulata corals.

SOKOLOV (1962) divided the family Chaetetidae into three subfamilies, Chaetetinae, Chaetetiporinae and Moskoviinae respectively. But subfamily Chaetetiporinae may be better raised to a family rank in having distinct meandrine colonies. Moskoviinae is, of course, represented by *Moskovia* SOKOLOV, of which we doubt its validity. This genus is said to have a sort of double wall, but we suspect that *Moskovia* may well be a synonym of *Chaetetes* having relatively thick wall which, presumably due to fossilization, reveals splitting nature at the centre of wall structure. Therefore we restrict the family Chaetetidae to only Chaetetid colonies with fine, prismatic corallites.

Family Chaetetidae range from late Ordovician to Jurassic. Amongst cerioid Chaetetids SOKOLOV, (1939) distinguished four groups as tabulated below:

Corallum	Wall	Group
globular – hemispherical	thin	*Chaetetes* FISCHER
	thick	*Boswellia* SOKOLOV
tabular	thin	*Chaetetella* SOKOLOV
	thick	*Chaetetiporella* SOKOLOV

Further he (SOKOLOV, 1939) established *Moscovia,* also a cerioid form, but it might be a mere synonym of *Chaetetes* as above mentioned.

In 1955 SOKOLOV further introduced a new genus, *Cyclochaetetes* for those Chaetetids in which wall is so thick that it leaves round or subround configuration of the inner surface of each corallite.

This procedure in relatively fine splitting of the whole group of Chaetetids has not been followed closely outside the USSR. And the classification may be better tested widely in the other parts of the world before it is finally accepted.

In Japan so far, only *Chaetetes* has been known and described. Some forms, especially those from the southwest Japan, however have relatively thick wall, thus are close to *Boswellia* SOKOLOV.

Genus *Chaetetes* FISCHER, 1829

Chaetetes FISCHER in EICHWALD, 1829, p.197

Type species: (chosen by OAKLEY, 1936)
Chaetetes cylindraceous FISCHER, 1829

Remarks:

Colonies of *Chaetetes* are often to be encountered in "Middle" Carboniferous strata now known as the Nagaiwa Series in the Kitakami mountains. They are found in cherty nodules in limestone, conglomeratic limestone in porphyrite tuffs, and in limestone itself. The shape of *Chaetetes*, when visible on the weathered surface of limestone outcrop, is almost always showing hemi-globular outline, and corallite tubes are diverging outward towards the surface of the colony.

Until 1955 these *Chaetetes* specimens have been called as *Chaetetes asiaticus* YABE & HAYASAKA, a *nomen nudum*. MINATO (1955) therefore proposed a new species, *Chaetetes nagaiwaensis* to substitute this long used, yet obscure name, which was presumably originated from a manuscript on Asiatic corals studied a long time ago by YABE & HAYASAKA.

It is quite probable that Chaetetids also occur in the Lower Carboniferous Onimaru Series underlying below the Nagaiwa Series, but none has been reported to occur from that series up to present.

In Japan, outside the Kitakami mountains *Chaetetes* has been found and described from the Omi, Akiyoshi, South-west Hokkaido and the Kuma mountains. They are all Upper Carboniferous in age.

In short *Chaetetes* is very common and even characteristic in the Japanese Upper Carboniferous.

Chaetetes nagaiwaensis MINATO

pl.1, figs.1-2; pl.2, fig.1; pl.5, fig.1; pl.6, fig.1.

1955 *Chaetetes nagaiwaensis* MINATO, p.190, pl.19, fig.1; pl.38, fig.2.

Syntype: UHR 16432, 16464
Lectotype here chosen: UHR 16464, Nagaiwa, Hikoroichi machi, Ohfunato city, Iwate Prefecture. H_0 horizon. Collected by M. MINATO.

Description:

Corallum compound, massive and cerioid. Whole shape of colony in lectotype is not known, but it may be either hemispherical or somewhat elongated hemispherical as in other specimens. The size of corallum may reach 4x4x5 cm^3 or more.

Corallites are seen to arrange parallel with each other and they themselves diverge towards the external surface of corallum. Therefore often a single thin section reveals both transverse and longitudinal characters of the coral at the same time.

External features are unknown. Whether it has holotheca or not is not examined.

In transverse section corallites are polygonal, five to six sided in shape, but may be subround due probably to recrystallization.

The size of corallite is almost uniform throughout the corallum. Corallite diameter ranges from 0.5 to 0.7 mm, and is 0.6 mm in average. The thickness of corallite wall is somewhat variable, and is difficult to measure, due also probably to recrystallization. It varies from 0.05 to 0.17 mm, but 0.07 to 0.1 mm in average. A short pseudoseptal projection may be seen in some corallites which are in fact on the way of increase by fission. Fine structure of wall is very difficult to determine. It is assumed to have originally trabecular wall.

In longitudinal section corallites are arranged parallel. New corallite wall is seen to intercalate between the formerly existing walls of somewhat large corallites. This implies the increase by fission as above mentioned. Tabulae are complete and horizontal, counted 3 to 6 in the vertical distance of 1 mm. They are not evenly spaced but show a sort of grouping. No definite periodicity, however, is detectable in the tabular arrangement.

Remarks:

Chaetetes specimens from the Nagaiwa Series were previously assigned to *Chaetetes asiatica* YABE & HAYASAKA, a *nomen nudum.* In the lack of original specimen of this undescribed form at the Tohoku University, MINATO (1955) established a new species, *Chaetetes nagaiwaensis* for the Nagaiwan form. Further historical background on the taxonomy of the latter species may be referred to MINATO (1955, p.191).

Chaetetes nagaiwaensis resembles some previously described forms such as *radians, janischewskyi* and *septosus,* in the size of corallite, and in having numerous tabulae. Although specific characters of *Chaetetes radians* FISCHER, like other forms described by FISCHER, are still obscure. Specimens from Spitzbergen described by HERITSCH (1939) for example are similar to *Chaetetes nagaiwaensis* in characters appeared in transverse sections. Longitudinal characters of Spitzbergen material are, however, not precisely described. HERITSCH's form may be Upper Carboniferous in age.

Chaetetes septosus (FLEMING), of which the junior author examined the holotype at the Royal Scottish Museum (KATO, 1971) shows somewhat irregularly shaped corallites of different size.

Chaetetes janischewskyi SOKOLOV especially its "var." *major* from D_3 of Moscow basin reveals close similarity to the Japanese form. But the Russian form is provided with a little thin wall, more numerous pseudoseptal projections, comparatively sparse tabulae.

A specimen (UHR 18939) from Nagaiwa has rather uniform corallites of 0.35 to 0.5 mm in diameter. Although the size of corallite is smaller than the typical *Chaetetes nagaiwaensis* it may be referable to that species. In the lack of longitudinal section the final dentification is however retained at present.

Materials:

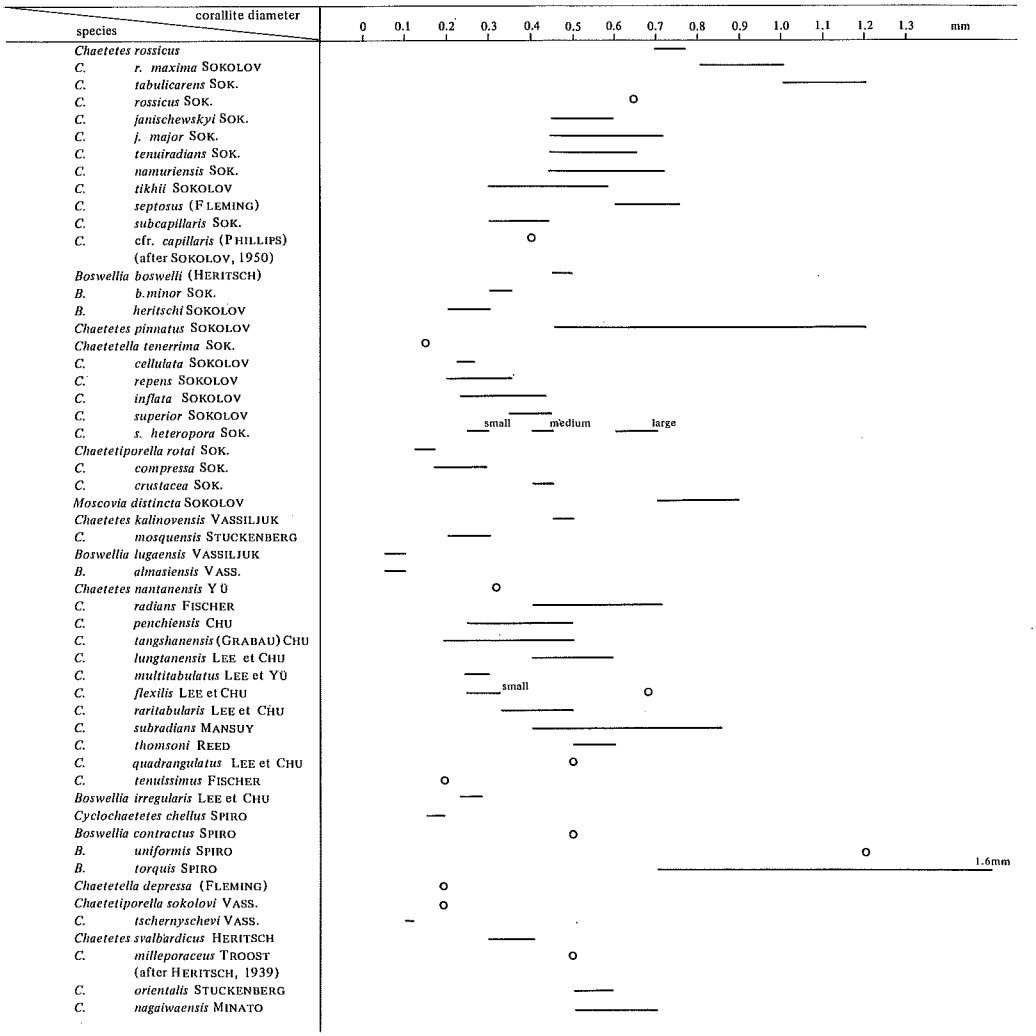

Fig. 4 Range of the size of corallite in some cerioid forms of Carboniferous Chaetetids.

UHR 16464 (Lectotype), 16432, coll. by M. MINATO; UHR 17626, 18939, Coll. by T. KAKIMI, from Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref.

UHR 12553, 12554, 12556, 12562 from Yomogibata 010; UHR 12569, from the entrance of Yomogibata valley; UHR 12563, 12557, from Yomogibata 042; UHR 12567, from Yomogibata 055; UHR 12558, from Yomogibata 075; Sumita-cho, Iwate Pref. Coll. by H. TAKEDA and T. KAKIMI.

UHR 18935, from west of Onimaru, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. HASHIMOTO.

UHR 18938, from Nagakurazawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by S. YATO.

Several other localities have been known for *Chaetetes,* as the entrance of Kotsubosawa, and the mouth of Yukisawa, in Yokota, Rikuzentakada city; west of Setamai, Sumita-cho, Iwate Prefecture etc.

Chaetetes tenuiradiatus SOKOLOV

pl.3, figs.1-2; pl.4; figs.1-2.

1950 *Chaetetes tenuiradiatus* SOKOLOV, p.51-52, pl.V, figs.5-6.

Description:

Corallum compound, cerioid, composed of numerous tubular corallites. External shape of whole colony is not known.

In transverse section corallites are small, polygonal and uniform in size. Corallite diameter appears to be rather consistent for colonies at a certain locality. Specimens from the entrance of Yomogibata (UHR 12559-12561) reveal 0.35 – 0.55 mm in corallite diameter, 0.4 to 0.45 mm on average. Another series of specimens from Magoe (UHR 18878) have corallites ranging from 0.4 to 0.6 mm, of which 0.4 to 0.5 mm are the mean value. Thus the size of corallite varies considerably.

The shape of corallite is mostly five to six sided. One or two pseudoseptal projections may be seen occasionally in some corallites. Wall is comparatively thin, being 0.05 to 0.1 mm. Fine structure of the wall cannot be ascertained under microscope because of recrystallization. In longitudinal section corallites are long, slender and arranged parallel with each other. Increase is by fission. Tabulae are extremely rare, seemingly non-existing in a narrow field of thin sections. When present tabulae are moderately spaced.

Remarks:

The present Japanese form is identifiable with the Russian *Chaetetes tenuiradiatus* from upper Viséan in Moscow Basin, the latter of which has

corallites of 0.4 to 0.66 mm diameter, very distant tabulae and thin wall. Russian form has, however, somewhat rounded internal corallite configuration, whereas in Japanese form it is polygonal.

Some specimens with smaller corallites show similarity also to Viséan *Chaetetes subcapillaris* SOKOLOV, in which tabulae are extremely rare, and to which rather imperfectly known *Chaetetes raritabularis* LEE et CHU from Chinese Upper Carboniferous stands very closely. We suspect that all the above mentioned forms are in fact belonging to the same species group.

Chaetetes namuriensis SOKOLOV resembles the present form, but has slightly larger corallites and more frequent tabulae.

In transverse section the present form quite resembles the above described *Chaetetes nagaiwaensis,* which possesses however, slightly larger corallites and more numerous tabulae. And thus both species are readily distinguishable with each other, even if they often occur together.

Materials:

UHR 12559, 12560, 12561, from the entrance of Yomogibata valley; UHR 12564, 12565, from Yomogibata 048, all in Sumita-cho, Iwate Pref. Coll. by H. TAKEDA and T. KAKIMI.

UHR 18866, 18878 (a,b), from north of Magoe, Ohfunato city. Coll. by M. MINATO.

UHR 18936, from west of Onimaru, Hikoroichi machi, Ohfunato city. Coll. by T. HASHIMOTO.

Family **SINOPORIDAE** SOKOLOV, 1955

Genus ***Sinopora*** SOKOLOV, 1955

Sinopora SOKOLOV, 1955, p.226.
Sinopora, SOKOLOV, 1962, p.247.
Sinopora, YÜ et al, 1963, p.282.
Sinopora, KLAAMANN, 1966, p.76.
Sinopora, ROWETT, 1969, p.77.

Type species: *Monilopora dendroidea* YOH, 1932

Generic diagnosis: Corallum compound, fasciculate and dendritic, Corallite small, curved cylindrical. Corallite wall thick, often composed of two layers. Tabulae rare, complete and concave upward if present. Septal spines rare. Increase by lateral.

Included Species:

Romingeria asiatica MANSUY, 1913. Upper Permian of Cambodgia.

Monilopora dendroidea YOH, 1932. Upper Carboniferous to Upper Permian

Yugoslavia, Iran, China, Donetz basin, Priural, Malaysia and Japan.
Sinopora operta KLAAMANN, 1966. L. Silurian of Esthonia.
Sinopora callosa KLAAMANN, 1966. L. Silurian of Esthonia.
Sinopora minatoi ROWETT, 1969. L. Permian of Alaska.

Geological range: Lower Silurian to Upper Permian
Geographical distribution:
Yugoslavia, Donetz basin, Esthonia, Priural, Iran, China, Malaysia, Japan and Alaska.

Remarks:
In Japan the genus *Sinopora* occurs from the *Yabeina* zone of the Taishaku limestone, Hiroshima Prefecture, the Handa limestone of Yamaguchi Prefecture. It occurs with *Parawentzelella* in Imo, Iwate Prefecture and Iwaizaki of Miyagi Prefecture. These horizons may be *Neoschwagerina* to *Yabeina* zone. From Lower Permian Sakamotosawa limestone *Sinopora* like form has been seen in the Hikoroichi region, Iwate Prefecture. The present record of *Sinopora* from the Upper Carboniferous Nagaiwa Series extends down the range of the genus in Japan.

Monilopora dendroidea Yoh, the type species has no septa and tabulae. But generic diagnosis has been somewhat amended to include such forms having sparse septal spines and tabulae. A number of Upper Carboniferous and Permian species treated as belonging to such genera as *Aulopora, Cladochonus, Monilopora, Multithecopora* and *Syringopora* need complete revision. Some of them may be better classified as species of *Sinopora.*

Pseudoromingeria YABE et SUGIYAMA resembles *Sinopora,* but the former is

genera / skeletal element	*Syringopora*	*Multithecopora*	*Sinopora*	*Aulopora*
corallum	mostly phaceloid, connecting tubes frequent	mostly phaceloid, connecting tubes present	mostly dendritic, connecting tubes absent	reptant
wall	thin to moderately thick	thick	moderately thick to thick	thin to moderately thick
septal spines	usually conspicuous	not conspicuous	may be present but rare	may be present
tabulae	funnel shaped, may be closely set	rather sparse, complete and concave	rare, complete	absent

said to have funnel shaped tabulae, though having no connecting tube as in *Syringopora.*

Principal genera are compared with *Sinopora* in a tabular form above.

Sinopora choiana MINATO and KATO, sp. nov.
pl.6, figs.2-3; pl.7, figs.1-2.

Type Materials: UHR 19806 (Holotype) (23 thin sections) from Yomogibata, Sumita-cho, Kesen-gun, Iwate Pref. Coll. by D. R. CHOI., UHR 19006 (paratype) (29 thin sections) from Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

Derivation of specific name: After Dr. D. R. CHOI, who greatly advanced our knowledge on the bio-and lithostratigraphy of Upper Carboniferous and Permian in the Southern Kitakami Mountains.

Description:

Corallum compound, dendritic, composed of numerous branching corallites which are rather closely spaced with each other. Size of corallum in the holotype attains more than 10 cm in diameter, but there seem to be much larger specimens present. External features of the corallum and corallites are unknown. But the colonies are embedded in micritic limestones, thus they might have been standing in sea water or possibly covered by lime muds in parts, and they are not reptant or creeping. No connecting processes are present. No particularly dichotomous arrangement of corallites is to be detected, although some corallites are seemingly arranged in a somewhat straight row. Otherwise corallites are arranged subparallel with each other or else they grow towards various directions. Many corallites are in lateral contact, but they usually apart from one another at the distance of about 3 mm or less.

Corallite is round or subround in cross section, measures 1.5 to 1.8 mm in diameter. Some large corallites attain as long as 2 mm in diameter. External surface of corallite wall is smooth in transverse section, while internally one or two septal spines are seen quite occasionally. Wall is very thick, of about 0.4 to 0.6 mm, but is less so near the calicular margin. Inside of corallite is commonly filled with dark limy matrix. Fine structure of wall is, when visible, double layered, each with fibres arranged radially from the centre of corallite. Sometimes boundary line between these two layers appear to be quite dark, and sometimes it is represented by a transparent layer after recrystallization.

Length of corallite is not exactly known, but it is 10 mm long as far as it is appeared in thin sections. Tabulae are commonly not seen, and thus corallites are like hollow tubes. But tabulae are definitely present in some corallites, because complete tabula is seen at places. Quite exceptionally in one corallite

of the holotype 5 horizontal tabulae are seen in the vertical distance of 1 mm.
Remarks:

The holotype is associated with *Lithostrotionella,* and the paratype is with *Pseudostaffella,* smaller foraminifers including textulariids and indeterminable corals. Another specimen probably identical with the present form has been found together with *Chaetetes* and *Sciophyllum* on the bank of Kesen river at a locality near the entrance of Kotsubo Creek. This specimen is a fragmental silicified colony, partially revealing weathered out corallites. Coarse transverse wrinkles are observed on the surface of corallites in this specimen.

Of the species hitherto housed in the genus *Sinopora,* Silurian forms have relatively large corallites (2.5 – 3.0 mm diameter), and henceforth they are easily distinguishable from the Nagaiwa specimens, which have corallites of 1.5 mm diameter.

Permian and Carboniferous forms reveal somewhat similar size of corallites with the present form. But *Sinopora asiatica* has faint septal ridges on the epitheca; *S. minatoi* has crowed corallites with the axial tube and rather frequent tabulae. The present form rather closely resembles *S. dendroidea,* but the former has distinct tabulae, septal spines and relatively crowded corallites in the corallum.

Order RUGOSA MILNE-EDWARDS & HAIME, 1850

Family **LITHOSTROTIONIDAE** d'ORBIGNY, 1851

Genus ***Diphyphyllum*** LONSDALE, 1845

Diphyphyllum LONSDALE, 1845, p.622.
Diphyphyllum, LO & ZHAO, 1962, p.174.
Diphyphyllum, BYKOVA, 1966, p.138.
Diphyphyllum, IVANOVSKY, 1967, p.78-79 (see for further synonymy).
Diphyphyllum, ARMSTRONG, 1970, p.23-24 (see for further synonymy).

Type species: *Diphyphyllum concinnum* LONSDALE, 1845.

Generic diagnosis: Fasciculate Lithostrotionidae, typically without axial structure and lonsdaleoid dissepiments. Tabulae domed and axially flattened. Septal fine structure diffusotrabecular.
Remarks: More than sixty nominal species have been proposed in *Diphyphyllum,* and majority of them is upper Lower Carboniferous in age. Devonian occurrence is doubtful unless they are disphyllids. Late Carboniferous and Permian forms may form another stock not necessarily related to true *Diphyphyllum* which is closely connected to *Siphonodendron.* Some "Middle"

Carboniferous forms are to be in the group of *Donophyllum* FOMITCHEV, which has long major septa to meet at the centre of corallite. Or else they may be related to *Tschussovskenia,* a member of Lithostrotionidae.

Species have been grouped into several types according to the shape and mode of tabulae. Particularly forms in which inner series of arched tabulae are resting one upon another, thus forming a sort of pile, have been often classified as *Depasophyllum.* But this procedure is no more tenable, because *Depasophyllum* is now interpreted as a Devonian genus without dissepiments. On the one hand representative forms of *Diphyphyllum* such as *D. lateseptatum* are often provided with a kind of piled tabulae above described.

Diphyphyllum equiseptatum YABE & HAYASAKA
pl.9, fig.1.

1915 *Diphyphyllum equiseptatum* YABE & HAYASAKA, p.137 (59) – 138 (60).
non *Diphyphyllum equiseptatum,* MINATO, 1955, p.81-82, pl.4, figs.3, 5 & 6.

Type specimen: Type locality of the present form was originally described as Nagaiwa, Hikoroichi-machi, Kesen-gori, Prov. Rikuzen.

At the Institute of Geology and Palaeontology, Tohoku University, only a single transverse section of a corallite has been registered as *Diphyphyllum equiseptatum* from Hikoroichi. YABE & HAYASAKA (1915) stated that they had a single transverse section of the coral now in question, which had no minor septa. Therefore it is quite probable that this specimen is the one that the original authors examined. It has about the size of corallite as YABE & HAYASAKA described, and no minor septa. However, it appears to have 28 or 29 major septa, which should be 26 according to YABE & HAYASAKA.

Although original article lacks any illustration of this species, the thin section above described should be chosen as the lectotype of the species, being the only specimen left at present. Most of its characters fits the original description except for the number of major septa.

Description of the lectotype:

Single transverse section of an imperfect corallite is available. Corallite may be round in original configuration, measures 11 mm across the corallite as far as it is preserved. Wall thin, mostly smooth but partially crenulated on its external surface. Septa are only in one order, thin, subequal in their length, and are arranged radially without any trace of fossula. Number of major septa is either 28 or 29. They are 1/2 the length of the half diameter of corallite. Two to three concentric dissepiments are seen between adjacent septa in the peripheral part of corallite. Dissepimentarium is narrow, 2 mm at its maximum width. No conspicuous inner wall is present. Central part of the corallite is left open having no axial structure, and is bounded by a ring like cut edges of a tabulae.

Remarks: As a *Diphyphyllum* the species is very unique in having relatively large corallite and no minor septa. YABE & HAYASAKA says that the coral is

"probably composite".

No additional specimen has been found to date for this species. Therefore full details are yet to be investigated as to the characters and systematic position of the present coral.

Since the original specimen was long believed to be lost and having no actual specimen to compare, MINATO (1955) ascribed several slides from Nagaiwa, the type locality, to *Diphyphyllum equiseptatum.* However they show slightly smaller corallites with fewer and shorter septa compared to the lectotype of this species. Beside minor septa are distinctly present in these specimens. Thus they are better removed from *D. equiseptatum.* In fact they are rather close to *D. delicatum* MINATO & KATO with which they may be referable.

Geological horizon of *D. equiseptatum* was said to be Permian (YABE & HAYASAKA, 1915). But it is almost certain that the actual age of this coral is Carboniferous, though from which horizon of Carboniferous the coral turned up we cannot be sure at present. The type locality, Nagaiwa, of the coral strongly implies its derivation from the Nagaiwa series of Upper Carboniferous.

Diphyphyllum delicatum MINATO & KATO

pl.9, figs.2-6; pl.10, figs.1-4; text-fig.5.

1957 *Diphyphyllum delicatum* MINATO & KATO, p.137-139. Text-figs. B, 1-6, C.
1955 *Diphyphyllum equiseptatum,* MINATO, p.81-82, pl.4, figs.3, 5, & 6.
1961 *Diphyphyllum* cfr. *delicatum,* IGO, p.171-172, Text-figs. A-E.

Holotype: UHR 12446 (9 thin sections) from the middle part of the Nagaiwa series, in Onimaru, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. HASHIMOTO.
Additional material: UHR 18868 (67 thin sections), from North of Magoe, Ohfunato city, Iwate Prefecture. Coll. by M. MINATO. Associated with *Profusulinella prisca* (DEPART) (CHOI, 1973). UHR 19703, from Loc. 072, Yomogibata, Sumita-cho, Iwate Pref. Coll. by H. TAKEDA. UHR 19801, 19802, Kotsubosawa, Rikuzentakada city, Iwate Pref. Coll. by D. R. CHOI.

Description:

Corallum compound, fasciculate, may be dendritic rather than phaceloid, because variously oriented corallites are seen together in a single thin section. Size and external features of the entire corallum are unknown. Corallites are closely situated with each other, and are often in contact. They are cylindrical, flexuous, and rond in cross section. Diameter of corallite ranges from 5 to 10 mm in mature stage after the introduction of dissepiments. It attains as long as 12 mm in a corallite showing lateral increase. Four offsets are seen "budding" at the same time in another corallite. Wall is generally thin and smooth, only weakly undulated suggesting the presence of faint septal ridges.

Septa are thin, fibronormal in fine structure, and in two orders. Major septa are short, subequal, and 1.5 to 2 mm in length. Number of major septa is 16 to 21. Holotype has less numerous septa (16 to 19) while the Magoe specimen reveals a little more numerous septa (16-21). (Figure 5)

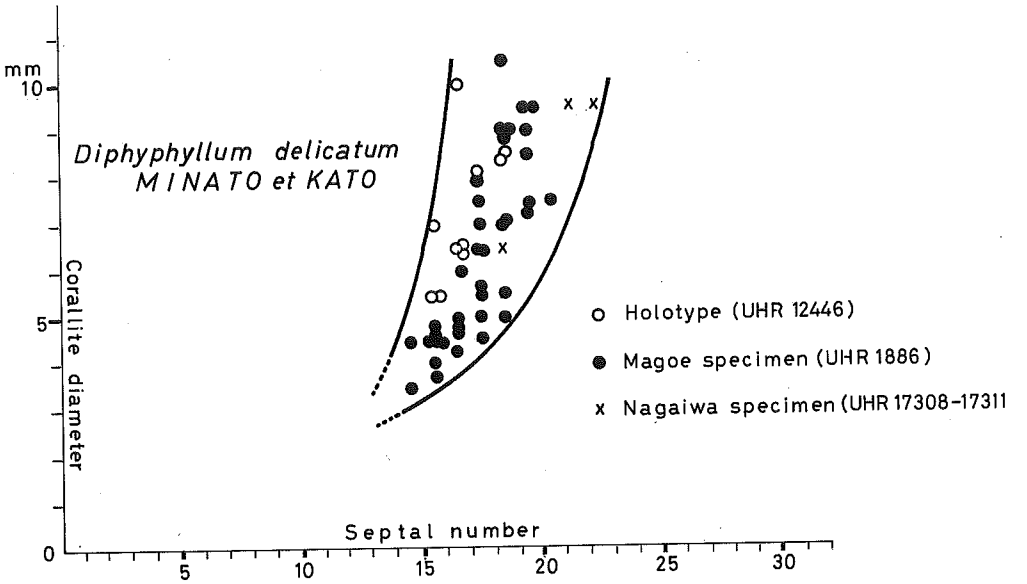

Fig. 5. Scatter diagram showing relation between diameter of corallite and number of major septa in *Diphyphyllum delicatum* MINATO et KATO.

Minor septa alternate with the major, very short, 0.5 mm in length. They are mostly confined to but sometimes extend a little beyond the dissepimentarium. Dissepimentarium is very narrow, normally consists of a single row of concentric dissepiments in cross section. Dissepiments are absent in young corallites, and they may be still partially absent even in some mature corallites.

Tabularium is wide, open, without any axial structure.

In longitudinal section axial portion of septa reveals amplexoid nature. Tabulae are nearly always complete, arched, and flat topped, numbering 3 to 8 in the vertical distance of 5 mm.

In case of lateral increase tabulae are common in both "mother" corallite and "daughter" one at the beginning. Dissepiments are somewhat elongated, only occasionally in double rows.

Remarks: General skeletal construction of the present species belongs to the type of *Diphyphyllum ingens* HILL (1940). According to MINATO's grouping this is termed as the 3rd type in which tabulae are complete, differentiating into flat inner part and concave outer part.

D. ingens, however, differs from the present form in having a little larger corallites with more numerous septa and dissepiments. Age of this British form is upper Viséan.

Some Upper Carboniferous and Permian *Tschussovskenia* are similar to the present form. Some corallites of *T. capitosa* DOBROLYUBOVA (1936) and *T. minor* FEDOROWSKI (1965) are quite comparable with the present form, yet they definitely possess axial structure in other parts of the same colony.

Only other *Diphyphyllum* from the Nagaiwa series, *D. equiseptatum* differs from *delicatum* in having larger corallite, long and numerous major septa, and no minor septa, in comparison with the latter.

IGO (1961) described a *Diphyphyllum* from *Fusulina* limestone in the Fukui Prefecture. His form seems identical with Kitakami species. *D. equiseptatum* of MINATO (1955) has a little larger corallites than the holotype of *D. delicatum,* but other essential characters are quite the same with those of the latter. This is here considered a large variety of *D. delicatum.*

A *"Disphyllum"* illustrated by Yabe & SUZUKI (1955) from the "Devonian" of Korea is now considered as a *Diphyphyllum* of Upper Carboniferous (KATO 1973). Judged from the illustration of a vertical section of this coral, it is not unlike *D. delicatum* now in question. The horizon of this Korean coral is from the Nanhang formation (CHEOUNG, 1971), which is a stratigraphical equivalent to the Japanese Nagaiwa series.

Family **LONSDALEIIDAE** CHAPMAN, 1893

Genus ***Sciophyllum*** HARKER & MCLAREN, 1950

Sciophyllum HARKER & MCLAREN, 1950, p.31
Sciophyllum, HILL, 1956, F.307
Sciophyllum, MINATO & SAITO, 1957, p.91
Sciophyllum, SANDO, 1965, E.29
Sciophyllum, ARMSTRONG, 1970 a, p.31
Sciophyllum, ARMSTRONG, 1970, b, p.38
Sciophyllum, COTTON, 1973, p.186.

Type species: *Sciophyllum lambarti* HARKER & MCLAREN, 1950.

Original generic diagnosis: Cerioid rugose corals of basaltiform habit, without columella; complete corallum unknown, dissepimentarium of one or more series of dissepiments, the inner margin forming a well marked inner wall; tabulae strong, well spaced and regular, flat or slightly arched, septa absent or reduced to fine vertical striations on the inner side of the epitheca or inside the inner wall; gemmation lateral.

Included species:

Acervularia adjunctiva WHITE, 1880 (fide SANDO, 1965).

Sciophyllum lambarti HARKER & MCLAREN, 1950, Meramecian, Canada.

Sciophyllum japonicum MINATO & SAITO, 1957, Nagaiwa Series, N. E. Japan.

Sciophyllum mulleri WILSON & LANGENHEIM, 1962, Wolfcampian, Nevada, U.S.A.

Sciophyllum alaskaensis ARMSTRONG, 1970, Meramecian, Alaska.

Sciophyllum sp. A. ARMSTRONG, 1970, Meramecian, Alaska.

Geological range: Late Lower Carboniferous to early Permian.

Discussion: Although the type species of the present genus is characteristic in having almost no vestige of septa, either short septal spines of the outer wall or septa on lonsdaleoid dissepiments may show various degree of development from species to species. Namely septal spines or septa are almost absent or only poorly developed in *lambarti, japonicum* and *adjunctiva,* while they are rather commonly found, though very short, in many corallites of such species as *alaskaensis, mulleri* and Alaskan from (Sp. A of ARMSTRONG).

However, all these species are common with each other in entirely lacking in axial structure. In this concern *Thysanophyllum aseptatum* DOBROLYUBOVA and *Thysanophyllum kendalense* (LANG & SMITH) may be akin to the present genus. These two species, however, definitely have well developed septa.

Further, tabulae are complete and well spaced in the type species, *japonicum, adjunctiva* and *mulleri,* but they are rather incomplete and a little densely arranged in *alaskaensis* and sp. A of ARMSTRONG. Also tabulae are almost horizontal or a little arched in most species, but concave only in *adjunctiva,* which may be worth while mentioned.

Lonsdaleoid disseipiments are large in general and arranged in only one row as usual in the type species, *japonicum, adjunctiva, alaskaensis* and *mulleri.* Single exception in this concern is *Sciophyllum* sp. A. (ARMSTRONG, 1970), in which lonsdaleoid dissepiments are small in size and arranged in a number of rows. Thus these features remind us pattern in certain species of *Thysanophyllum,* including its type species, *T. orientale* THOMSON. Therefore, this Alaskan form would be better transferred from *Sciophyllum* and placed under *Thysanophyllum.*

In short, generic diagnosis of *Sciophyllum* may be slightly modified in some points which will be given below: Corallum compound and cerioid. Corallites with large lonsdaleoid dissepiments, the inner margin of which marked distinct inner wall. Dissepiments arranged generally in one row in longitudinal section.

Septa are absent, or only represented by sporadical short septal ridges on the outer wall or very short septa developed on the inner wall. Tabulae are complete, nearly flat and well spaced, but may be variously inclined. No axial structure. Increase by peripheral.

Systematic position of the genus *Sciophyllum* has not been unamimously settled yet. IVANOVSKY (1967) doubtfully placed *Sciophyllum* under the synonymy of *Thysanophyllum,* which he thinks a member of the family Lonsdaleiidae. HILL (1956), WILSON & LANGENHEIM (1962), SANDO (1965) and ARMSTRONG (1970a,b) all consider *Sciophyllum* as valid, and that it belongs to Lonsdaleiidae. But in Osnovyi, SOSHKINA & DOBROLYUBOVA (1962) placed the genus under the family Lithostrotionidae. Fine structure of septa illustrated for *S. alskaensis* by ARMSTRONG (1970) appears to be minutely trabecular in type. And this is similar to that of *Lithostrotion.* But all other skeletal features, seem to us in favour of its assignment to Lonsdaleiidae.

In view of palaeobiogeography, *Sciophyllum* appears to be restricted to the "boreal" province. It has been found only from North America and Japan, but it will turn up from Urals in future, for instance.

Sciophyllum japonicum MINATO & SAITO
pl.11, figs.1-3.

1957 *Sciophyllum japonicum* MINATO & SAITO, p.92, 94, pl.V, figs.1-5.

Type materials: Holotype: UHR 12465 (i-vi) thin sections from a corallum embedded in limestone.
Paratype: UHR 12466 (i-vii), all thin sections prepared from another corallum from the same locality with Holotype.
Type locality: At the top of ridge, about 1 km S. E. of Matsubi, Sumita-cho, Kesen-gun, Iwate Pref.
Horizon: *Profusulinella* zone of the Nagaiwa Series, in association with *Chaetetes.*
New Materials:

: A specimen from Sakamotosawa, Hikoroichi-machi, Ohfunato city, in association with *Lithostrotionella.* Coll. by M. MINATO.
: A specimen from about 200 m north of the type locality, in association with *Chaetetes.* Coll. by M. MINATO.
: A specimen. Locality is about 200 m north from the entrance of Kotsubo valley, on the west bank of the Kesen river, Sumita-cho, Kesen-gun, Iwate Pref. Coll. by M. KATO.

Remarks: MINATO & SAITO originally described lonsdaleoid dissepiments of the present species to be unequal in size and arranged in one to three rows. This statement is true to some extent in cross section, but these dissepiments are, in fact, large and arranged in only one row in longitudinal section, as in other forms of the genus. Tabulae are counted 6 to 10 in the vertical distance of

5 mm.

The present Japanese species is closely akin to the type species of *Sciophyllum* in having almost no trace of septal development, but the former is still distinct from the latter in possessing slightly thick wall and narrow tabularium. Geological horizon is also different between them.

Genus ***Thysanophyllum*** NICHOLSON & THOMSON, 1876

Thysanophyllum NICHOLSON & THOMSON, 1876, p.150.
Thysanophyllum, YABE & HAYASAKA, 1915, p.98.
Thysanophyllum, HUDSON, 1926, p.148.
? *Sublonsdalia* LISSITZIN, 1925, p.128.
Thysanophyllum, DOBROLYUBOVA, 1936.
Thysanophyllum, HERITSCH, 1937.
Thysanophyllum, YÜ, 1937, p.49.
Thysanophyllum, HILL, 1940, p.160-162.
Thysanophyllum, McLAREN & SUTHERLAND, 1949.
Thysanophyllum, MINATO, 1949, p.31.
Thysanophyllum, SOSHKINA, DOBROLYUBOVA & PORFIRIEV, 1941, p.255.
Thysanophyllum, WANG, 1950.
Thysanophyllum, GORSKY, 1951, p.65-67.
Thysanophyllum, MINATO, 1955, p.84-85.
Thysanophyllum, WANG et al, 1955, p.42.
Thysanophyllum, HILL, 1956, F.306.
Thysanophyllum, YÜ, 1962, p.3.
Thysanophyllum, SOSHKINA & DOBROLYUBOVA, 1962, p.339.
Thysanophyllum, YÜ et al, 1963, p.87.
Thysanophyllum, YOH & WU, 1964, p.105.
Thysanophyllum, IVANOVSKY, 1967, p.80.
Thysanophyllum, ARMSTRONG, 1970, p.36 (see for earlier synonymy)
Thysanophyllum, COTTON, 1973, p.211.

Type species (chosen by GREGORY, 1917): *Thysanophyllum orientale* NICHOLSON & THOMSON, 1876.

Generic diagnosis: Cerioid rugose corals with peripheral area occupied by lonsdaleoid dissepiments, with relatively short septa except for cardinal septum, the distal end of which extends sometimes to the axial area, especially in young stage. Tabulae are complete or incomplete, horizontal, slightly arched or concave.

Included species:

The following cerioid species known to us are to be included in *Thysanophyllum* herein defined.

Thysanophyllum orientale NICHOLSON & THOMSON, 1876.
T. minus Nicholson & THOMSON, 1876.
Diphyphyllum argylli THOMSON, 1888.

?*Sublonsdalia intermedia* LISSITZIN, 1925.
Thysanophyllum praedictum HUDSON, 1926.
Diphyphyllum astraeiforme WARREN, 1927.
Diphystrotion kendalense LANG & SMITH, 1930.
Diphystrotion mutabile HILL, 1934.
?*Lithostrotionella simplex* HAYASAKA, 1936.
Thysanophyllum perpastum DOBROLYUBOVA, 1936.
T. aseptatum DOBROLYUBOVA, 1936.
Thysanophyllum cystosum DOBROLYUBOVA, 1936.
T. major DOBROLYUBOVA, 1936.
T. cystoides PORFIRIEV, 1941.
Diphystrotion hyporiphaeum PORFIRIEV, 1941.
D. mirabile PORFIRIEV, 1941.
D. vesiculosa PORFIRIEV, 1941.
Thysanophyllum princeps EASTON, 1960.
T. arcticum FEDOROWSKI, 1965.
T. regressum FEDOROWSKI, 1965.
T. giganteum FEDOROWSKI, 1965.
T. dubiosum FEDOROWSKI, 1965.
T. vermiculare DEGTJAREV, 1973 (=*T. vermiformae* DEG.)
T. druzhininae DEGTJAREV, 1973.

Geological range of the genus: Lower Carboniferous to Lower Permian.

Remarks: Many authors have interpreted the genus *Thysanophyllum* rather broadly to include both cerioid and fasciculate forms in it. MINATO (1949) however, proposed to distinguish them and to restrict the genus to cerioid forms only. As has been repeatedly remarked by authors, the genus *Thysanophyllum* here defined is still seemingly a polyphyletic one. Although no reliable criteria or biocharacters have been devised in order to clearly differentiate various stocks in the genus concerned.

Therefore some authors place the genus under the Family Lonsdaleiidae (e.g. HILL, 1956; WILSON & LANGENHEIM, 1962, FEDOROWSKI, 1965, 1967; IVANOVSKIY, 1967; ARMSTRONG, 1970), whereas others consider it is a representative of Lithostrotionidae (e.g. MINATO, 1955; FONTAINE, 1961; LO & ZHAO, 1962; SOSHKINA & DOBROLYUBOVA, 1962; DEGROOT, 1963).

Junior author once examined four British Lower Carboniferous forms, and he found that they were considerably different from each other. Lectotype of the type species, *T. orientale* (KMT 1095, Glasgow Museum & Art Gallery) is provided with large corallites with long septa, numerous dissepiments and flat topped, arched tabulae. Fine septal structure of *T. orientale* is doubtfully assignable to trabecular type. Holotype of *T. argylli* (BMR 4278, British

Museum of Natural History) has small corallites, ill developed lonsdaleoid dissepiments, and horizontal tabulae. Columella is only rarely present. Holotype of *T. praedictum* (BMR 25244-9, British Museum of Natural History) has corallites of intermediate size. Fine structure of septa is diffuso-trabecular. Minor septa are only rudimentary developed. Tabulae are essentially sagging, except for the axial region where they are a little arched towards columella. No type material is traceable for *T. minus,* but a specimen described by Hill (1940) (GSE, JS 2972, Geological Survey & Museum) shows sagging tabulae.

Thus *orientale* is close to *Lithostrotion; argylli* has similarity to *T. aseptatum; praedictum* and *minus* to *Lithostrotionella.*

JULL (1967), from a study on the ontogeny of *Thysanophyllum orientale,* conclude that the species was related to cerioid *"Lonsdaleia", Actionocyathus.*

A number of Permian forms described from "Boreal province" on the other hand, reveal morphological affinity to Permian *"Orionastraea", "Diphystrotion"* and *"Cystophora".* They might be forming a separate stock in *Thysanophyllum.*

As yet, no conclusive and satisfactory classification has been achieved as to *Thysanophyllum.* But, in view of its general resemblance to *Sciophyllum, T. aseptatum,* which will be treated below, may be a member of Lonsdaleiidae. So, here we tentatively place the genus *Thysanophyllum* in this family of Lonsdaleiidae.

Thysanophyllum differs from *Sciophyllum* in having distinct columella and numerous comparatively long septa.

Thysanophyllum aseptatum DOBROLYUBOVA
pl.12, figs.1-6; fig.6.

1936 *Thysanophyllum aseptatum* DOBROLYUBOVA, p.31, pl.14, figs.40-41; pl.15, figs.42-43.
1941 *Thysanophyllum aseptatum,* SOSHKINA, DOBROLYUBOVA and PORFIRIEV, p.255-256, pl.XIX, figs.1a-b; pl.XX, figs.1a-c.
1949 *Thysanophyllum aseptatum,* MINATO, p.31, fig.1.
1955 *Thysanophyllum aseptatum,* MINATO, p.87, pl.35, fig.2.

Holotype: No. 1944765, Verkhnetschussovskye Gorodky. Upper Carboniferous.
Japanese Material: UHR 16433 from Nagaiwa, Ohfunato city, Iwate Pref. Coll. by M. MINATO. UHR 12468, 12469-9, ii from Usagisawa, Sumita-cho, Iwate Pref. Coll. by M. MINATO. UHR 12536, 12538, from Yomogibata, Sumita-cho, Iwate Pref. Coll. by H. TAKEDA. A specimen from 200 m N. of the entrance of Kotsubo valley, alongside the Kesen river. Coll. by M. KATO.

Description: Corallum compound, cerioid. Corallites are polygonal, six to eight sided in cross section. The diameter of corallite ranges from 5 to 8 mm in mature corallites. Wall is thin to moderately thick, weakly crenulated with dark

line in the middle. Dissepimentarium is narrow, 1 mm in width, and consists of large lonsdaleoid dissepiments which are arranged vertically in a single row. Tabularium is wide, open, bounded by well marked inner wall, the diameter of which measures 4 to 5 mm. Septa are present on the inner wall as thin, short, spiny projections except for one which extends near but not quite to the centre of corallite. Presumably this elongated septum represents cardinal one. In one corallite 16 septa are counted. No minor septa are discernible.

In vertical section, tabulae are complete, well spaced. They are mostly horizontal or gently sagging. But they may be axially elevated towards the columella, if it is present. Six to eight tabulae are to be seen in the vertical distance of 5 mm.

Remarks:

Specimens from the Nagaiwa Series are quite identical with Russian form from Ural Mountains.

Presence of columella and septa allows to place the present species in the category of *Thysanophyllum*. In fact type specimens of *Thysanophyllum aseptatum* described by DOBROLYUBOVA (1936) lacks any longer septa indicating the presence of columella. Thus it shows close affinity to *Sciophyllum*. However, septa in *T. aseptatum* are definitely present.

Fig. 6. *Thysanophyllum aseptatum* DOBROLYUBOVA
Transverse section showing a corallite in which one of the major septa is elongated towards the centre of the corallite. UHR 16433 from Nagaiwa, Ohfunato city. X10

HILL (1940) placed *"Diphystrotion" kendalense* LANG & SMITH into the genus *Thysanophyllum*, in spite of that it lacks axial structure, though septa are

well developed in it. Likewise *aseptatum* can stay in *Thysanophyllum.* Also Japanese form actually has an elongated septum in corallite as above described.

Compared to *Sciophyllum japonicum,* with which the present form has resemblance at a glance, *T. aseptatum* possesses distinct and numerous septa, one of which is axially elongated. Tabularium of *T. aseptatum* is comparatively wide.

The present species is somewhat allied to *Thysanophyllum astraeiforme* (WARREN) described by ARMSTRONG (1970), BAMBER (1966) and NELSON (1960), although the last named author placed the species in the genus *Lithostrotionella.* But this North American form is specifically distinct from the present form in having more pronounced columella.

Thysanophyllum aseptatum has a range from Upper Carboniferous to Lower Permian in the USSR. The present Japanese specimens may represent old representative of the species, which might have been distributed in "Boreal Province" in those days.

Genus ***Lithostrotionella*** YABE & HAYASAKA, 1915

Petalaxis EDWARDS & HAIME, 1852, p.204 (partim)
Lithostrotion (Lithostrotionella) YABE & HAYASAKA, 1915, p.94(32)
Stelechophyllum, DOBROLYUBOVA, KABAKOVITSCH & SAYUTINA, 1966, p.130.
Acrocyathus, EASTON, 1973, p.128 (partim) (for extensive synonymy of *Lithostrotionella* see).
Lithostrotionella, COTTON, 1973, p.116.
Eolithostrotionella auctt.

Type species (by monotypy): *Lithostrotion (Lithostrotionella) unicum* YABE & HAYASAKA, 1915.

Original diagnosis (YABE & HAYASAKA, 1915): Corallum composite, massive, composed of prismatic corallites with lamellar columella; distinguished from *Lithostrotion* by having a vesiculated peripheral zone, well bounded by an inner wall, the inside of which has essentially the same structure which soon disappear in the vesiculated zone, without extending to the external wall.

Discussion: Quite recently EASTON (1973) gave a detailed and thorough review on the *Lithostrotionella* group, and he revived an old genus, *Acrocyathus,* with which he showed *Lithostrotionella* was synonymous.

As EASTON clearly remarked, present day taxonomic confusion in this group of corals was partly due to the lack of precise knowledge on type materials of related forms, and partly rooted in the different taxonomic weight of each morphological feature put by various authors.

In other words, it is the matter of phylogenetical, hence systematic

understanding of the large groups of corals, Lithostrotionids and Lonsdaleiids.

In many ways, *Lithostrotionella* stands morphologically in between *Lithostrotion* and *Actinocyathus* (=cerioid *"Lonsdaleia"*), as YABE & HAYASAKA originally considered. For that matter, therefore, a number of genera, such as *Nemaphyllum, Stylaxis, Petalaxis, Acrocyathus, Actinocyathus, Lonsdaleia, Thysanophyllum, Lithostrotionella, Stelechophyllum, Eolithostrotionella* and *Cystolonsdaleia* are involved in the problem here considered.

The problem is, in short, what is *Lithostrotionella*? Is it a member of either Lithostrotionidae or Lonsdaleiidae? Is it a genuine, cognate group? Does the name stand valid and available against old generic names?

When YABE & HAYASAKA first established *Lithostrotionella* they compared this "subgenus" with *Petalaxis* EDWARDS & HAIME. They knew that *Lithostrotionella* should be replaced by *Patalaxis,* only if the latter was to develop definitely lonsdaleoid dissepiments.

So, let us consider the status of *Patalaxis* first. EDWARDS & HAIME (1852), in establishing *Patalaxis,* indicated that they misunderstood as to the nature of *Stylaxis,* and *Nemaphyllum* of McCoy to have such lonsdaleoid dissepiments. EDWARDS & HAIME (1850) thought *Nemaphyllum* and *Stylaxis* synonymous, both differing from *Lithostrotion* in having exterior, "vesicular area". Having realized the synonymity between these three genera, they (1852) newly proposed *Petalaxis* for the conception they had earlier for *Nemaphyllum (=Nematophyllum).* Thus original generic contention for *Petalaxis* is nothing but that of *Lithostrotionella.*

LANG, SMITH & THOMAS (1940, April) says *Petalaxis* is another name of *Nematophyllum* MCCOY, and that they are objective synonyms. This way of treatment has been followed by some authors (FLÜGEL, 1970; COTTON, 1973). But we think it is not the right procedure.

EDWARDS & HAIME (1952) described clearly that *Petalaxis* contained *Stylaxis Portlocki* Edwards & Haime, 1851, and *Stylaxis M'Coyana* EDWARDS & HAIME, 1851 (non *Lithostrotion Portlocki* or *Lithostrotion maccoyanum*).

Junior author once cursory examined the figured specimen of *Stylaxis M'Coyana,* borrowed by Prof. D. HILL from the Ecolé de Mines, Paris. This specimen is a broken corallum free from matrix, obtained by VERNEULI from Oka section in Russia. It has distinct, large, lonsdaleoid dissepiments, styliform columella and subhorizontal tabulae. Therefore it clearly belongs to the type of corals now known as *Lithostrotionella,* commonly found from the Russian "Middle" Carboniferous.

HILL (1940, June) however selected *Stylaxis Portlocki* as the "genolectotype" of *Petalaxis,* of which no type material has been studied to date. Yet, illustration for this coral (EDWARDS & HAIME, 1852, pl.38, figs.4, 4a) shows a

detached prismatic corallite probably assignable to *Lithostrotion maccoyanum.* No particularly vesicular peripheral area is indicated in this coral, but expanded portion of a corallite probably is indicative of a stage of peripheral budding. Hill (1940) merges *Petalaxis* with *Lithostrotion* FLEMING, and we follow her in this connection. So, *Petalaxis* is no more available for Lithostrotionellid corals.

HERITSCH (1939) employed *Petalaxis* as well as *Lithostrotionella* in the description of corals from Spitzbergen.

FOMITCHEV (1953) revived *Petalaxis* in choosing *"Stylaxis" maccoyana* as the type species. This was followed by SOSHKINA et al (1962). But this is apparently erroneous procedure, although FOMITCHEV was absolutely right to consider his corals of *"Petalaxis"* to be congeneric with *"Stylaxis" M'Coyana* EDWARDS & HAIME.

Next, genus *Eolithostrotionella* ZHIZHINA creates another nomenclatorial problem.

Presumably this genus was introduced in an unpublished dissertation on Donetz corals by ZHIZHINA. The generic name, to our knowledge, first appeared in FOMITCHEV (1953) in his discussion on the phylogeny of corals of *Lithostrotion – Eolithostrotionella* lineage in the western slope of Urals, together with some other new genera. He meant *Eolithostrotionella* to house corals previously described as *Thysanophyllum.* FOMITCHEV (1953) did not designate type species for any of these new genera, though brief diagnoses were given to them, HILL(1957) claims they should be treated as *nomina nuda.*

Subsequently FOMITCHEV (1953) in the Atlas of fossils from west Siberia edited by KHALFINA described *Petalaxis sibiricus* GABUNIA as a *Eolithostrotionella.*

In 1956 ZHIZHINA gave for the first time the generic diagnosis of *Eolithostrotionella,* for which English translation is available in EASTON (1973). Type species is *Lonsdaleia longiseptata* LISSITZIN, 1925 (non *Lonsdaleia longiseptata* GORSKY, 1935). LISSITZIN's original description and illustration of this coral are, however, not at all adequate for understanding its precise characteristics. But VASSILYUK (1960) redescribed and figured *Lonsdaleia longiseptata* LISSITZIN, which has cerioid corallum and axial column nearly differentiated from centrally elevated tabulae. VASSILYUK also employed *Eolithostrotionella,* and cited its type species as *Lonsdaleia longiseptata,* but she actually described the latter species in the section of cerioid *Lonsdaleia.*

The name *Eolithostrotionella* has been in use by authors (ZHIZHINA, 1960; DEGTJAREV, 1973).

DOBROLYUBOVA, KABAKOVITCH and SAYUTINA (1966), however, demonstrated that *Eolithostrotionella* was a synonym of *Stelechophyllum* TOLMATCHEV, 1933, a *nom. nov.* for *Stylophyllum* TOLMATCHEV, 1924 (non

Stylophyllum REUSS, 1854). This Tournaisian genus of *Stelochophyllum* is provided with cerioid coralla, lonsdaleoid dissepiments, axially elevated tabulae and columella. These authors suggest its systematic relationship to the Devonian *Tabulophyllum,* although this seems still questionable. Probably *Stelechophyllum* shows diphymorphic modification, which will bring Tabulophylloid morphology as a whole. We agree with DOBROLYUBOVA, KABAKOVITCH & SAYUTINA (1966) in that *Stelechophyllum* and *Eolithostrotionella* are synonymous, unless the latter should be distinguished by the possession of comparatively stout axial column, as exemplified by *Lonsdaleia longiseptata.*

Now the problem is manifest whether *Stelechophyllum* (=*Eolithostrotionella*) has any connection with *Lithostrotionella.* DOBROLYUBOVA, KABAKOVITCH & SAYUTINA (1966) suggest, in fact, a possible relationship between these genera. Truly many American forms of *Lithostrotionella* are generically inseparable from Russian species of *Stelechophyllum.* These two genera are difficult to distinguish from each other. Thus we are in favour of treating them synonymous. *Lithostrotionella,* is of course, available as a senior synonym for all these corals above mentioned.

Quite recently EASTON (1973) redescribed the type specimen of *Acrocyathus floriformis* d'ORBIGNY, type species of *Acrocyathus,* and thus made the genus available in taxonomy.

According to EASTON *Acrocyathus* is synonymous with *Lithostrotionella.* His lengthy discussion on the morphological features and their evaluation in the group of *Lithostrotion* and *Lonsdaleia* is quite thorough and convincing. It demonstrates no single character is to be fully considered as reliable criterion in these corals as yet.

We are, however, inclined to separate *Acrocyathus* from *Lithostrotionella,* because the former has, at least its type species is concerned, weakly differentiated axial structure with septal lamellae, which is nothing like the simple lathlike columella found in many forms of *Lithostrotionella,* including the type species. (see, for example EASTON, 1973, Fig.1f, pl.1.) In this connection *Eolithostrotionella* may be better placed under the synonymy of *Acrocyathus.*

FOMITCHEV (1953) erected a new subgenus of *Petalaxis sensu* Fomitchev, *Cystolonsdaleia,* which in Russian Upper Carboniferous seems to occupy the middle portion of a seemingly genetical series from *"Petalaxis"* to *"Polythecalis".* It possesses cerioid coralla, lonsdaleoid dissepiments, axial column and sagging tabulae. But morphologically, it is very difficult or even impossible to generically distinguish *Cystolonsdaleia* from *Actinocyathus* (cerioid *Lonsdaleia).* Therefore *Cystolonsdaleia,* for the time being, considered as a synonym of the latter chiefly lower Carboniferous genus. DEGROOT (1963) expressed the

same sort of opinion in this concern.

The following table will summarize the above discussion.

Lithostrotion	=*Nemaphyllum* =*Nematophyllum* =*Stylaxis* =*Petalaxis*
Lithostrotionella	=*Petalaxis auctt.* =*Stylophyllum* TOLMATCHEV =*Stelechophyllum* =*Eolithostrotionella auctt.*
Acrocyathus	=*Eolithostrotionella* =*Lithostrotionella auctt.* =*Lonsdaleia auctt.*
Actinocyathus	=*Lonsdaleia auctt.* =*Cystolonsdaleia*

Above delimited group of *Lithostrotionella* still contains two major morphological types in it.

The first type is provided with relatively large corallites, thin wall, long major septa which often unite with columella, arched, often incomplete tabuale. Inner wall is not very conspicuous, and lonsdaleoid dissepiments are many but small and flattened. Septal fine structure may be trabecular (?).

This form group is found abundantly in North America and Kuznetzk basin, geologically ranges from Tournaisian to Viséan. *Stelechophyllum* and *"Eolithostrotionella"* of authors are belonging to this category.

The second type, on the other hand, reveals comparatively small corallites, with very thick, bead shaped wall. Columella is originated from the axial prolongation of cardinal septum, but is normally separated from the rest of major septa. Lonsdaleoid dissepiments are large but less numerous. Tabulae are usually complete, sagging or subhorizontal. Inner wall is prominent. Septa are fibro-normal in fine structure.

This latter group is well exemplified by "Middle" Carboniferous *"Petalaxis"*, and has the range from upper Viséan to Lower Permian.

Both groups may reveal diphymorphic tendency or a trend to build up axial column.

Lithostrotionella unicum the type species of genus *Lithostrotionella,* as will be redescribed below, shows intermediate features between these two major

types above described. And further, there are some more forms which also do not definitely fall in any of these group categories.

Inability of delimiting morphological characteristics within many species of *Lithostrotionella,* we have to adopt rather broad interpretation of the genus.

Inadequacy of the type material also made th problem much difficult.

Phylogenetically, or morphologically to be precise, the first type of group is close to genuine *Lithostrotion,* while the second one to *Lonsdaleia.* Thus *Lithostrotionella* has to be remained as polyphyletic at present. The situation is quite the same as in *Thysanophyllum* or in *Sciophyllum* in that, in theory they may have been derived from or may have given rise to either Lithostrotionids or Lonsdaleiids.

In view of the general origin of Lonsdaleiids from Lithostrotionids, we tentatively place all Lithostrotionellids with distinct lonsdaleoid dissepiments in the family Lonsdaleiidae, not employing Lithostrotionellidae STUMN in SHROCK & TWENHOFEL, 1953, Petalaxidae FOMITCHEV, 1953, or Thysanophyllidae YÜ, 1960. The last named family was introduced without any discussion in YÜ, LIN & FAN (1962) dated as for 1960, of which we are unable to trace the literature.

Lithostrotionella differs from both *Hillia* DEGROOT, 1963 and *Eastonoides* WILSON & LANGENHEIM, 1962 in having much well developed lonsdaleoid dissepiments.

So far, 40 forms of *Lithostrotionella* (*Eastonoides* and *Acrocyathus* incl.) have been proposed from North America.

There are two species from Japan, four from China, eleven from Spain (*Lithostrotionella* & *Hillia*). From Soviet Union about 30 forms of *Lithostrotionella, Eolithostrotionella* and *Stelechophyllum* have been described. A complete revision and reassignment of these species to genera are beyond the scope of the present study.

Lithostrotionella unicum YABE & HAYASAKA
pl.15, fig.1.

1915 *Lithostrotion (Lithostrotionella) unicum* YABE & HAYASAKA, p.133(55) – 134(56).
1920 *Lithostrotion (Lithostrotionella) unicum,* YABE & HAYASAKA, pl.IX, figs.12a-b.
1963 *Lithostrotionella unica,* YÜ et al, p.86, pl.24, figs.7a-b.

Lectotype (here chosen): No.29a, Institute of Geology & Palaeontology, Tohoku University, Sendai, Japan.

YABE & HAYASAKA illustrated (1920) two somewhat oblique thin sections of the species. But only a thin section (YABE & HAYASAKA, 1920, pl.IX, fig.12a) has been turned up inspite of the careful search of Dr. K. MORI. Being one of illustrated specimens, and only preserved specimen we select this thin section, No. 29a as the lectotype of *Lithostrotionella*

unicum. Type locality of this coral was originally described as from Kung-shan, Hui-tso-hsien, Prov. Yun-nan. And it was said to have been associated with *Tetrapora* (=*Hayasakaia*) and *Polythecalis.* The association denotes Lower Permian age.

But this was altered later, when the coral was first illustrated, to Hon-shan, Ton-chuan-hsien (Fui-tse), Prov. Yun-nan. The age of the coral was definitely described this time as Carboniferous.

Since the label attached to the lectotype indicates the latter locality is the correct one, the former description was an error caused by confusion.

Description of the lectotype:

Corallum compound, cerioid. Ten prismatic corallites are present in the oblique section (Lectotype), the largest one of them being 8.5 mm in shorter diameter. Wall is thin, straight. Dissepimentarium wide, consists of one to three series of large lonsdaleoid dissepiments which interrupt the continuation of peripheral parts of septa, leaving only spiny projections on vesicles. Tabularium is wide, 6 mm across, well differentiated from dissepimentarium. Tabulae are usually complete, well spaced, uparched, but with down bent peripheral margin. Six to seven tabulae are counted in a corallite in the vertical distance of 2 mm.

Septa are in two orders. Major septa start from dissepiment near the inner wall, and mostly fall short to the center of corallite. Minor septa alternate with the major, short, and confined in the region near the inner wall. Number of major septa is not counted with certainty, but may reach up to 22. Columella present, platy, often quite sinuous, unite with a major septum or two opposite major septa. Columella has dark line at the certer.

Tabulae are ascending towards the columella, and in one corallite they incorporate with a sinuous columellar plate to form an axial column like construction, though any particular axial tabellae and septal lamelae are differentiated.

Lithostrotionella kitakamiensis MINATO

pl.14, figs.1-5; pl.15, fig.2; pl.16, fig.1; Text-fig.7

1955 *Lithostrotionella kitakamiensis* MINATO, p.88, pl.4, figs.2,7,8, & 10; pl.34 figs.2,3.

Syntype: UHR 17608, 17609, 17611, 17612, 17613, 17224.

Lectotype (here chosen): UHR 17609, Sakamotosawa, Hikoroichi, Ohfunato city, Iwate Pref. Coll. by T. KAKIMI.

Paratypes are all from the type locality (50605 of KAKIMI), (UHR 17608, 17611, 17612, 17613). except for UHR 17224, which is from Loc. 501, 102 (KAKIMI),

Additional material

: UHR 17616, Shiratorizawa, Sakamotosawa, Hikoroichi. Coll. by T. KAKIMI.

: UHR 17617, Nagaiwa, Hikoroichi. Coll. by T. KAKIMI. (identification doubtful because of crushed nature of the corallum).

: UHR 18876, 18877, 18870, Magoe. Coll. by M. MINATO. All specimens come from Ohfunato city, Iwate Prefecture. There are some other coralla probably identical to the present species from Magoe collected by M. KATO, but they have not been sectioned.

Description: Corallum compound, cerioid.

In transverse section, corallites are polygonal. Diameter of corallite is 4 to 6 mm in general, but may reach as long as 13 mm in some corallites.

Wall is thin, with a translucent layer in the middle in lectotype, but with median dark line in a specimen from Magoe. Wall is only weakly undulated, not forming a distinct bead shaped wall.

Dissepimentarium is wide, occupies about a half the half diameter of corallite, composed of a single or less commonly two and even more rows of large lonsdaleoid dissepiments, which completely interrupt the peripheral elongation of septa. Inner wall is well marked.

Tabularium is wide, 2.5 to 3 mm and sometimes 4 mm in diameter. Septa are in two orders. But minor septa are only rudimentary, and they are often absent. Major septa number 10 to 17 in mature corallites, and 14 to 16 septa are common. They are fibronormal in fine structure in Magoe specimens. Majors are thin, short. One septum only unites with the axial columella which is a thin plate, but may be flexuous, thickened, and having divarication in it in some corallites.

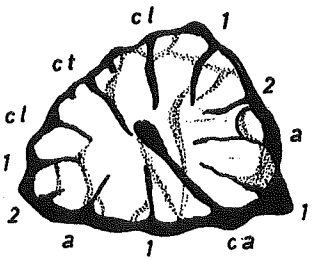

Fig. 7. Transverse section of a young corallite of *Lithostrotionella kitakamiensis* MINATO. X10
Loc. N. of Magoe, Ohfunato city. UHR 18877
Showing columella unites with the cardinal septum and short minor septa are introduced by the counter septum.

In an immature corallite lacking in peripheral area occupied by lonsdaleoid dissepiments, septal arrangement is clearly observable (UHR 18877). In that corallite septal formula is as shown in text-fig.7. So it is the cardinal septum which unites the columella.

In many corallites, however, a septum opposite to the elongated columella

is usually shorter than the other majors, and it looks as if it is the cardinal. However this is not the case, as is described above.

In longitudinal section tabulae are subhorizontal or slightly arched towards columella in a gentle tent like fashion, and they are mostly complete. Four to six tabulae are counted in the vertical distance of 2 mm.

In a corallite there are two series of tabulae, (UHR 18876) outer and inner respectively. Outer tabulae are almost horizontal and complete. Inner tabulae are domed and superimposed one upon another. Thus the structure is quite like that found in some forms of *Diphyphyllum.*

Columella is either straight or flexuous vertically.

Remarks: The present species is characteristic in having ill developed minor septa, simple columella and thin skeletal construction.

Specimens from Magoe show a little thick skeletal construction, including wall, septa and columella. Otherwise general skeletal pattern is identical with specimens from Hikoroichi.

It is very closely related to *Lithostrotionella stylaxis* (TRAUTSCHOLD) described by DOBROLYUBOVA(1935a, b) from Myachkovo horizon of Moscovian in Moscow basin. But the present form is provided with thinner wall, only rudimentary minor septa, and thus is distinguishable from Russian form.

Lithostrotionella unicum, type species, has large corallites, numerous septa and dissepiments, and prominent minor septa. So, it is clearly distinguishable from the present form.

Lithostrotionella taishakuensis YOKOYAMA (1957), the only other species of the genus described from the Upper Carboniferous of Japan, has bead shaped wall, distinct minor septa, and somewhat flexuous columella. It is very close to *Lithostrotionella maccoyana* (DEGROOT, 1963) and is different from the present species, though the size of corallites, septal numbers are similar with each officer.

Lithostrotionella sp.

pl.13, fig.1-4; pl.16, fig.2.

Compare with:

Lithostrotionella monocyclica DEGROOT,1963, p.85, pl.17, figs.1a-c.

Material: UHR 19798, Sakamotosawa, Hikoroichi. Coll. by T. KAKIMI.

UHR 19796, north of Nakajuku. Coll. by S. YATO.

UHR 18784 (a-b), Higuchizawa. Coll. by M. MINATO.

All specimens are from Ohfunato city, Iwate Prefecture. Occurrence of the first and the second specimens are from the Nagaiwa series. But the derivation of the last specimen is a little doubtful, because no deposits of the Nagaiwa series have been ascertained in the tributary of Higuchizawa. The specimen was obtained as a float.

Description: Corallum compound, cerioid. In transverse section corallite polygonal, large, being 8 to 10 mm in diameter. Wall is thick and crenulated. Dissepimentarium is wide, consisting of one to several rows of lonsdaleoid dissepiments of various size. Tabularium is wide, well bounded from dissepimentarium by an inner wall. Its diameter is 5 to 6 mm. Septa are in one order, of which cardinal septum unites with columella. Number of major septa is 23 at maximum. Minor septa are lacking, and septa are almost entirely confined in the tabularium. Columella is moderately thick, straight, incorporated with ring like cut edges of probably uparched tabulae towards the columella. Increase by peripheral. In an available longitudinal section, lonsdaleoid dissepiments are flattened and steeply inclined, in a fashion of much elongated dissepiments. Tabulae are concave and in deep saucer shape, yet they may be uparched towards the columella, near the columella which is straight. Tabulae are rather sparsely distributed, being 2 to 3 in a vertical distance of 2 mm.

Remarks: Three available coralla somewhat differ from each other. UHR 19798 has a little larger corallites with numerous lonsdaleoid dissepiments. UHR 18784 shows some diphymorphic corallites in which lonsdaleoid dissepiments are large. UHR 19796 has very stout and even a little thickened columella.

Yet they are in common, compared to *Lithostrotionella kitakamiensis,* in having larger corallites, thicker wall, somewhat numerous lonsdaleoid dissepiments, numerous septa and no minor septa.

That the form is still in the variation of *Lithostrotionella stylaxis-kitakamiensis* species group remains to be seen. Since Russian *Lithostrotionella stylaxis* appears to be variable in morphology, and some corallites of *L. kitakamiensis* may be quite large to be comparable the size of the present form.

At present we consider this form as distinct from both *L. stylaxis* and *kitakamiensis* from reasons above enumerated.

There are quite few species of *Lithostrotionella* which entirely lack in minor septa. Among them *Lithostrotionella monocyclica* DeGroot (1963) described from Spanish Bashkirian closely resembles the present form in the size of corallite, number of major septa, in having no minor septa and steeply inclined dissepiments. Columella in both forms are very simple as well.

These two forms are probably identical with each other. But we reserve the specific identification until more well preserved material is available for making firm comparison.

Genus *Acrocyathus* d' ORBIGNY, 1849

1849 *Acrocyathus* d'ORBIGNY, p.12.
1850 *Acrocyathus,* d'ORBIGNY, p.160.
1973 *Acrocyathus,* EASTON, p.128.

Type species (original designation):
G. (sic) *floriformis* d'ORBIGNY, 1849 (see THEVENIN in BAULE, 1906)

Generic diagnosis: Corallum compound, cerioid. Internal characters similar to *Lithostrotionella,* but differ from the latter in having septal lamellae differentiated from median plate to form an axial column. Tabulae are arched upward as in typical *Lithostrotion.*
Discussion: See under the genus *Lithostrotionella.*
Majority of North American *"Lithostrotionella"* may be classified in the present genus.

Actinocyathus (cerioid *Lonsdaleia*), d'ORBIGNY'S another genus, apparently resembles *Acrocyathus* in various skeletal elements except for tabulae. In *Actinocyathus* tabulae are saucer shaped, encircling axial column, while they are ascending along columella or axial column and descending at the outer edge of tabularium in *Acrocyathus.*

***Acrocyathus*? sp.**
pl. 15, figs. 3-5.

Material: UHR 19797 (a-b), upper course of Yomogibata valley, Sumita-cho, Kesen-gun, Iwate Prefecture. Coll. by D. R. CHOI. Occurrence from tuffaceous limestone, with *Chaetetes.*

Description: Whole colony is entirely embedded in matrix, of cobble size, massive but a little flattened. External portion is recrystallized, completely filled with the aggregate of calcite crystals leaving any discernible skeletal elements. Inside of the colony is also recrystallized, but reveals skeletal construction rather clearly. Only two oblique thin sections are available for study.

Corallum compound, cerioid. Corallites are prismatic, having maximum diagonal of 16 mm.

Wall is thick, bead shaped. Dissepimentarium is wide, consists of several rows of flattened, lonsdaleoid dissepiments of irregular size.

Tabularium is wide, 6–7 mm in diameter, composed by gently arched, complete and imcomplete tabulae. They number 7 to 10 in a vertical distance of 2 mm. Septa are only in one order, numbering 21 to 22. They are not as long as to reach the columella. Columella thick, spindle shaped. Presence of septal lamellae is not observed with certainty.

Remarks: Although the presence of septal lamellae in axial structure is not certain, this form has thick columella which incorporate with elevated and a little differentiated tabulae near the columella forming a prominent axial column like structure at the centre of corallite. Therefore it is better to be

placed in the genus *Acrocyathus* rather than in *Lithostrotionella*. Mode of tabular elevation is also much the same with that we see in *Acrocyathus*.

Certain American species resemble the present form in having large corallites and stout columella. We need more materials of the present form under good preservation. For example, *Lithostrotionella banffensis* (WARREN) described by ARMSTRONG (1970) from Mississipian of Alaska shows similarity with the present form. But it has minor septa, rather thin skeletal elements including wall. At present we are unable to find any precisely identical forms hitherto established with the present form.

Family **LOPHOPHYLLIDAE** GRABAU, 1928

Although the generic characters of *Lophophyllum* have not been fully elucidated, dissepimented solitary corals with diffuso-trabecular septa and axial structure are provisionally included in the present family. Thus *Koninckophyllum, Arachnolasma, Dibunophyllum, Turbinatocaninia* etc. are herein included in this family.

The group differs from Aulophyllids or Clisiophyllids, and Amygdalophyllids in the construction of septal fine structure. These latter groups all have trabecular or pseudotrabecular septa. Amygdalophyllids differ from the present family in the construction of large, solid axial structure.

Actually *Dibunophyllum,* typically having axial column, has been often grouped with Clisiophyllids. But since the differentiation of axial column from the rest of tabularium is quite gradational in Dibunophyllid corals, it is often difficult to distinguish forms with columella from forms with axial column.

If a separate group name is necessary for Dibunophyllids, Dibunophyllidae (pro Dibunophyllinae) WANG, 1950 is available. But here, the authors wish not to employ this procedure.

Genus ***Dibunophyllum*** THOMSON & NICHOLSON, 1876

Dibunophyllum THOMSON & NICHOLSON, 1876, p.457.
Dibunophyllum, HILL, 1938, p.65 (for discussion and early synonymy).
Dibunophyllum, COCKE, 1970, p.17.
Dibunophyllum, FEDOROWSKI, 1971, p.55 (for further synonymy see)
Dibunophyllum, SAYUTINA, 1973, p.75 (see for further synonymy)
Dibunophyllum, COTTON, 1973, p.58.

Type species (subsequent designation by GREGORY, 1917):
Dibunophyllum muirheadi NICHOLSON & THOMSON, 1876.

Remarks: From the bulk of about 110 literatures dealing with *Dibunophyllum,* only recent and important works are cited in the above list of synonymy. A

great many species of *Dibunophyllum* have been proposed until present. Even quite recently several new species were added by DOBROLYUBOVA (1970), COCKE (1970) and FEDOROWSKI (1971). The genus probably contain different morphological and truly phylogenetical groups altogether. Therefore a thorough revision of the genus is really much desired, though already some of the species have been proven to be of such different stock as Permian *Verbeekiella.*

Also a number of Upper Carboniferous species, sometimes classified as belonging to *Dibunophylloides,* may in fact form a cognate group by themselves.

Occurrence of true *Dibunophyllum* from the Nagaiwa Series was clarified by KATO (1959). Newly found materials from Magoe, Ohfunato city, Iwate Prefecture, are associated with *Profusulinella, Pseudostaffella, Chaetetes, Lithostrotionella* and *Choristites,* all denoting the Lower Moscovian age. And since "Middle" Carboniferous Dibunophylla are rare throughout the world the present Japanese occurrence is worthy of note.

Dibunophyllum is, of course, abundant in upper Lower Carboniferous, and it continues to the Lower Namurian. There are not many forms recorded from "Middle" Carboniferous later than Lower Namurian.

The following is a list of Dibunophylla from "Middle" Carboniferous (Namurian included) and Lower Pennsylvanian.

Dibunophyllum arachnoformis VASSILYUK, 1960.
Clisiophyllum bipartitum MC COY, 1851.
Rhodophyllum craigianum THOMSON, 1874.
Dibunophyllum chui LEE & YU, 1934.
Dibunophyllum derbiensiformis VASSILYUK, 1960.
Dibunophyllum dobrolyubovae VASSILYUK, 1960.
Dibunophyllum finalis VASSILYUK, 1960.
Dibunophyllum grandicolumnatum DOBROLYUBOVA, 1970.
Dibunophyllum ? inauditum MOORE & JEFFERDS, 1945.
Clisiophyllum konincki EDWARDS & HAIME, 1851.
Dibunophyllum longiseptata VASSILYUK, 1960.
Dibunophyllum moorei JEFFORDS, 1948.
Dibunophyllum missouriense FRAUNFELTER, 1965.
Dibunophyllum lonsdaleioides VASSILYUK, 1960.
Dibunophyllum insolitum DEGTJAREV, 1968.

Geological range: Lower to Upper Carboniferous.

No genuine *Dibunophyllum* occurs from Permian.

Dibunophyllum bipartitum (M'COY)
pl.8, figs.1-15.

1851 *Clisiophyllum bipartitum* M'COY, p.93, pl.3c, figs.6, 6a.
1938 *Dibunophyllum bipartitum*, HILL, p.67, pls.I-III. (for extensive synonymy see)
1959 *Dibunophyllum* cfr. *bipartitum konincki*, KATO, p.39, text-fig.7.
1970 *Dibunophyllum bipartitum*, DOBROLYUBOVA, p.123, pls.44-45.
1971 *Dibunophyllum bipartitum*, FEDOROWSKI, p.57. pls.III-V.
1973 *Dibunophyllum bipartitum*, SAYUTINA, p.78, pls.VII-IX.
Compare with *Dibunophyllum lonsdaleioides* VASSILYUK, 1960, p.143, pl.35, figs.3-3b.
Compare with *Dibunophyllum grandicolumnatum* DOBROLYUBOVA, p.129, pl.45, fig.4.

Lectotype (chosen by HILL, 1938): A 1971, Sedgwick Museum, Cambridge.
Materials: Several ill preserved, fragmental corallites which were firmly embedded in limestone matrix are at our disposal. UHR 17621-17623 from west of Tashiroyashiki. (Loc. 513181): UHR 17624 from the entrance of Shiratorizawa valley, Sakamotosawa. (Loc. 50605): UHR 12627 from w. of Ishibashi: UHR 17648 & 17649 from N. E. of Nagaiwa: UHR 17650, 17652, 17653 (with *Sinopora*) from Nagaiwa. Above listed specimens were all from Hikoroichi machi, Ohfunato city, Iwate Prefecture, collected by T. KAKIMI.

Specimens UHR 18940, 18941 and 18942 were collected by M. KATO, from a locality N. of Magoe, Ohfunato city, Iwate Prefecture. They were found in association with *Staffella, Chaetetes, Lithostrotionella* and *Sinopora*.

Description: Corallum simple, but external characters are unknown.

The largest corallite attains 23 mm in diameter. Wall is thin or moderately thick, consists of light coloured fibres arranged perpendicular to the outer surface represented by a dark line. Outer configuration of wall is smooth, and no trace for the presence of ridges or grooves is detectable in thin sections. Major septa are straight or flexuous, moderately thick, numbering as much as 48 in one corallite. Some major septa extend into the axial region where they form a weak axial structure. Minor septa are absent or only rudimentarily developed. Dissepimentarium occupies the width of 1/3 to 2/5 the half diameter. Dissepiments are small and numerous, inosculating between septa in transverse section. In one corallite UHR 18942 lonsdaleoid dissepiments are seen to develop. These lonsdaleoid dissepiments are flat and narrow in cross section, while they are steep and elongated in vertical section. The presence of such dissepiments in this case may represent a stage of rejuvenation. In general, inner wall is not conspicuous. Tabularium is wide. Tabulae are incomplete and gently domed. Only slight amount of intrathecal dilation is present in major septa of some corallites. Axial structure is broad, but is not well differentiated from tabularium. It occupies nearly 1/3 the diameter of corallite. Axial construction is quite loose.

Only a few, somewhat rotated septal lamellae which are axial elongation of some major septa take part in the construction of axial structure. A median

plate is discernible in some corallites, but Koninckophylloid or Rhodophylloid trend appears in other corallites, in which flattened axial tabellae are in no way distinguishable from incomplete tabulae (tabellae).

Remarks: Only recent works are quoted in the above synonymy. Further literatures are to be indicated in them.

HILL (1938) demonstrated extreme variability present in *Dibunophyllum bipartitum*. She recognized three subspecies within this mutable species. Later authors have been mostly following HILL in this concern. However, as these "subspecies" occur together in the same horizon at each locality (JOHNSON, 1956), they cannot be treated as true subspecies, unless they represent either independent species or mere varieties of *bipartitum*.

Here the present authors interpret the species rather broadly, and merge all "varietal" forms together in view of very mutable characters exemplified in this group of corals.

Specimens from the Nagaiwa series are identical with *Dibunophyllum bipartitum*, especially its "subspecies" *konincki*. But some of them are also close to another "subspecies" *craigianum* (HILL, 1938). Especially *D. bipartitum konincki* described by Vassilyuk (1964) from the Upper Carboniferous of Donetz basin has close similarity to the present Japanese form. Also Polish upper Viséan forms of *D. bipartitum konincki* (Fig.19, A-9) and *D. bipartitum craigianum* (Fig.20, A_2) illustrated by FEDOROWSKI (1971) very much resemble the Japanese form.

Dibunophyllum lonsdaleioides VASSILYUK (1960) from the Namurian of Donetz basin is not unlike *D. bipartitum*, except for the weak development of lonsdaleoid dissepiments in the former. In this connection it has morphological connection with *Dibunophyllum* from the Nagaiwa Series. Also *Dibunophyllum grandicolumnatum* DOBROLYUBOVA (1970) from the Namurian of Moscow basin shows large axial structure which is not well differentiated from tabularium and has a little twisted axial lamellae. As a whole this russian form has Rhodophylloid tendency in axial structure, and resembles the Japanese form.

In short, *Dibunophyllum* from the Nagaiwa Series has similarity to Namurian representatives of *Dibunophyllum bipartitum* species group, which were relicts from the Viséan form.

Concluding remarks

The following corals are now known to occur from the Nagaiwa Series in the Northeast Japan.

* *Chaetetes nagaiwaensis* MINATO

+ *Chaetetes tenuiradiatus* SOKOLOV
* *Sinopora choiana* MINATO et KATO
Diphyphyllum equiseptatum YABE et HAYASAKA
* *Diphyphyllum delicatum* MINATO et KATO
* *Sciophyllum japonicum* MINATO et SAITO
* *Thysanophyllum aseptatum* DOBROLYUBOVA
* *Lithostrotionella kitakamiensis* MINATO
* *Lithostrotionella* sp.
+ *Acrocyathus* ? sp.
+ *Dibunophyllum bipartitum* (EDWARDS et HAIME)

Among them, those marked with * are of typical "Middle" Carboniferous forms, while those with + sign are probable relicts from Viséan fauna. Thus the fauna, as a whole, is a mixture of both types, although the geological age of it is definitely Bashkirian to lower Moscovian (=Namurian).

Affinity of Nagaiwa corals with other faunas is worth while mentioned.

Diphyphyllum of the Nagaiwa Series shows similarity to a form from Korea. *Lithostrotionella kitakamiensis* is an ally to *Lithostrotionella stylaxis* of the Moscow basin. *Thysanophyllum aseptatum* was originally described from Urals. *Sciophyllum japonicum* resembles Alaskan forms. These as a whole reveal the character of northern elements, and they are further faunistically belong to the "Boreal Province"

We can find such "Boreal" corals also in Korea and North China. However, Upper Carboniferous corals of the Southwest Japan are quite different in assemblage from the above mentioned "Boreal" fauna, including the present Nagaiwa corals, but have more similarity to corals from the South China (MINATO, 1949).

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(Manuscript received on March 1, 1974)

PLATES 1 ~ 16 AND EXPLANATION

Explanation of Plate 1

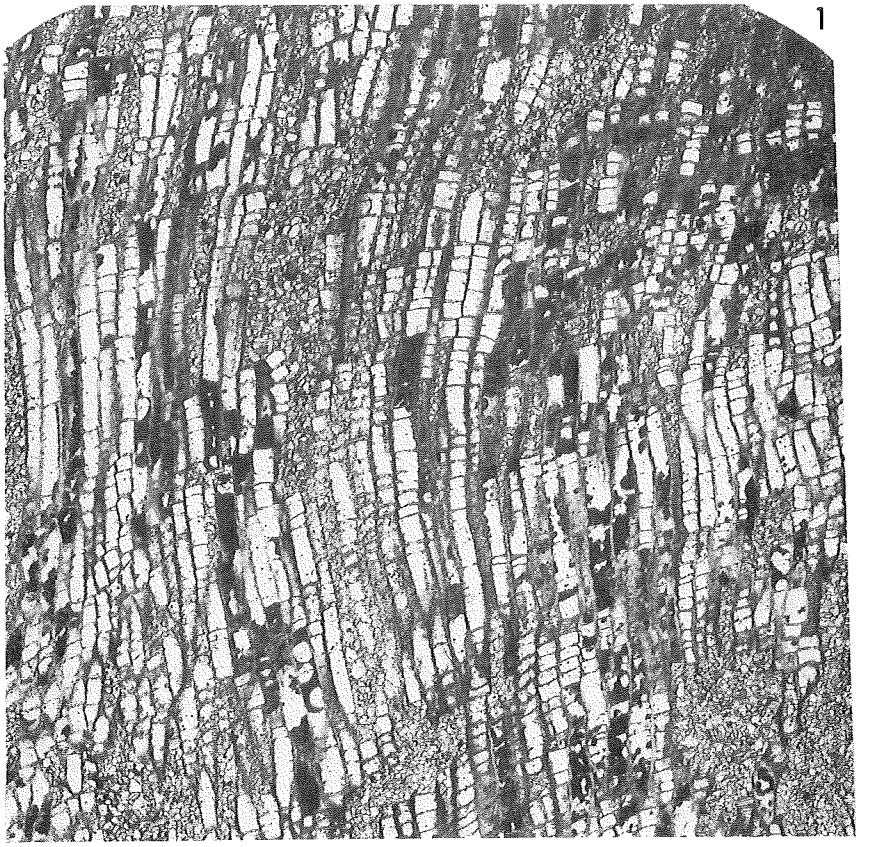
(All figures five times natural size)

Figs. 1-2: *Chaetetes nagaiwaensis* MINATO

UHR 12563, Loc.042, Yomogibata, Sumita-cho, Kesen-gun, Iwate Pref. (MINATO et al., 1959) Coll. by H. TAKEDA & H. KAKIMI

1: Longitudinal section showing closely but unevenly set, horizontal tabulae.

2. Transverse section showing subround internal configuration of corallites and sporadical pseudoseptal projections in them. The specimen is partially recrystalized.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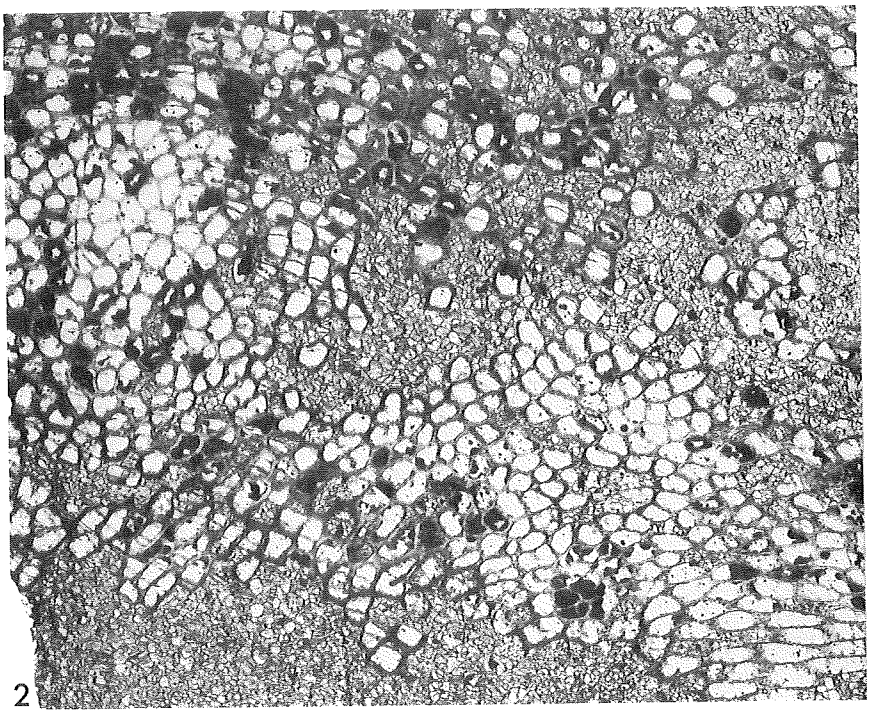
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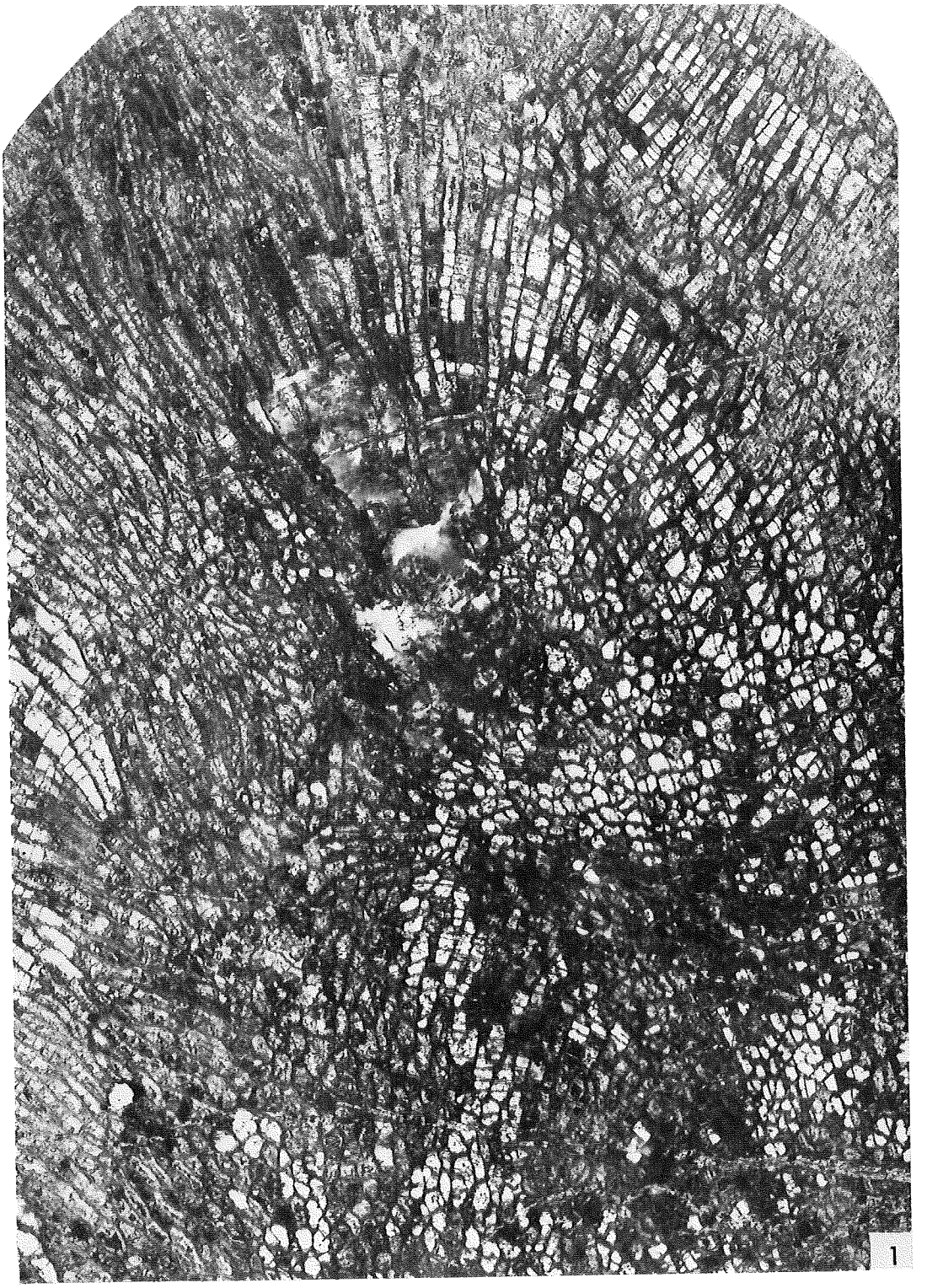
Explanation of Plate 2

(Five times natural size)

Fig. 1: *Chaetetes nagaiwaensis* MINATO
UHR 18935, West of Onimaru, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. HASHIMOTO. Oblique section showing divergent arrangement of corallites which are somewhat irregular in size and shape. The specimen is partially silicified.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Explanation of Plate 3

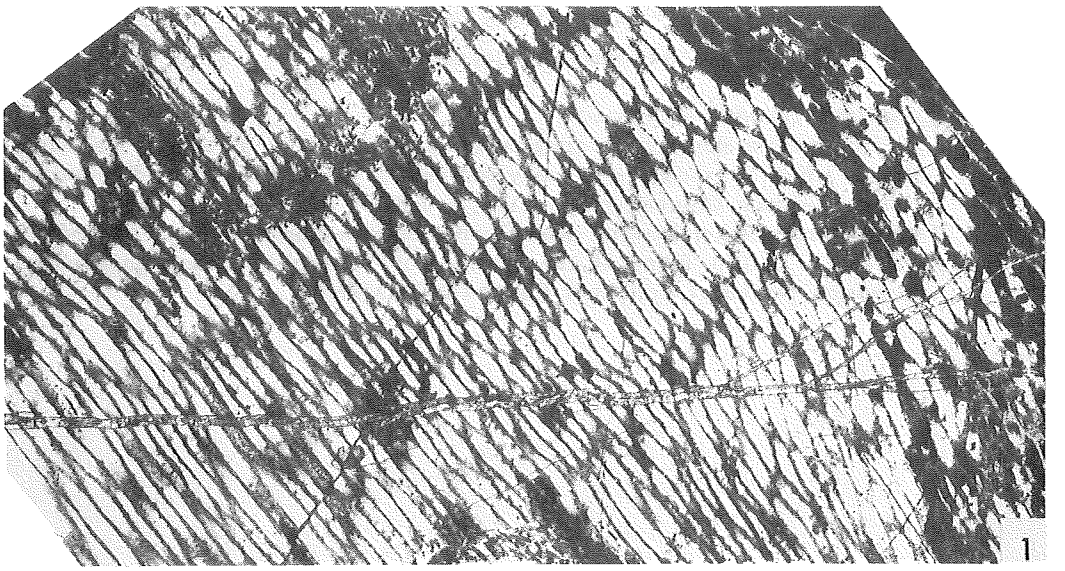
(All figures five times natural size)

Figs. 1-2: *Chaetetes tenuiradiatus* SOKOLOV

1: Longitudinal section with almost no trace of tabulae. UHR 12564

2: Transverse and partially oblique section of the same colony.

The specimen was collected from Loc.048, Yomogibata, Sumita-cho, Kesen-gun, Iwate Pref. (MINATO et al., 1959). Coll. by H. TAKEDA & H. KAKIMI.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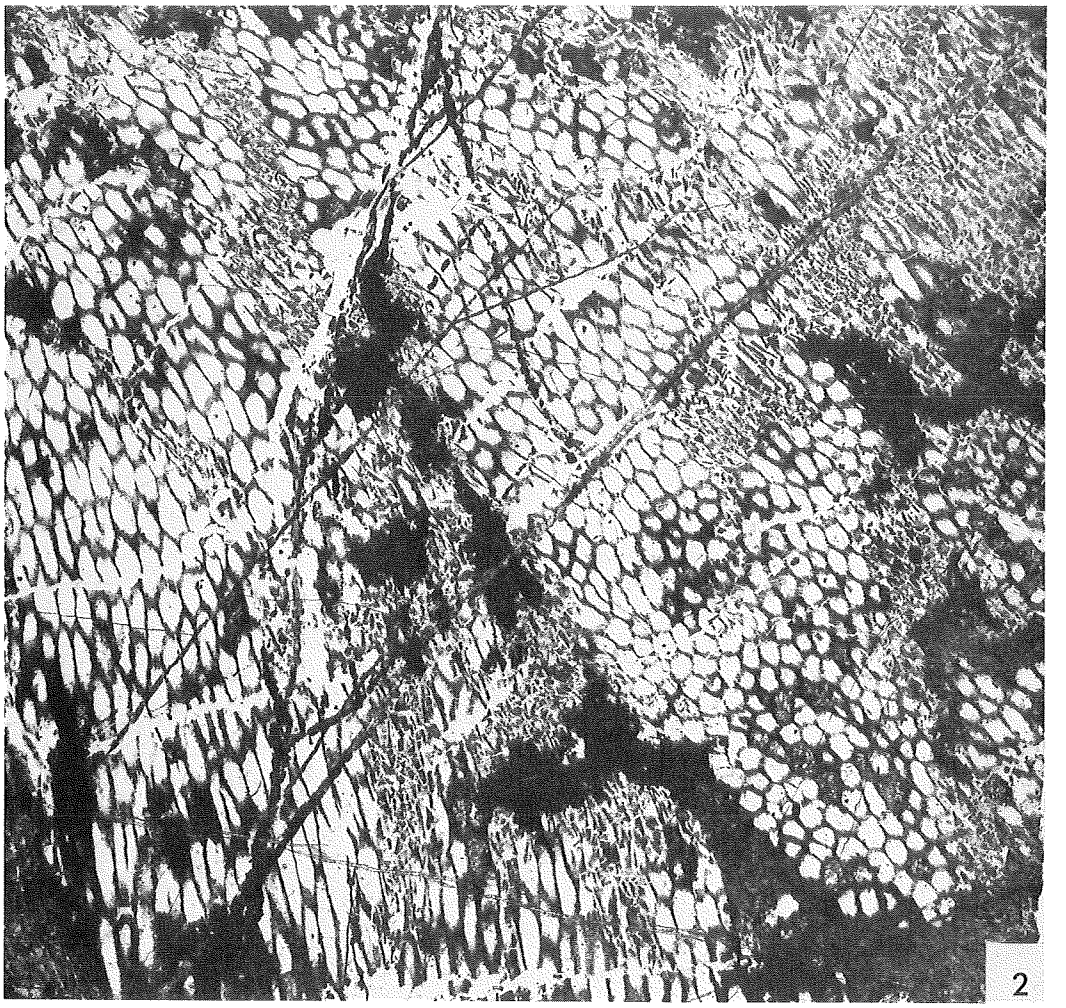
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Explanation of Plate 4

(All figures five times natural size)

Figs. 1-2: *Chaetetes tenuiradiatus* SOKOLOV

1: Oblique section showing diverging corallites and partially developed horizontal tabulae which are somewhat laterally continuous. UHR 18936, west of Onimaru, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. HASHIMOTO

2: Longitudinal section showing slender corallites with almost no trace of tabulae. UHR 18937, float found at the entrance of Yomogibata valley, Sumita-cho, Kesen-gun, Iwate Pref. Coll. by H. TAKEDA & T. KAKIMI.

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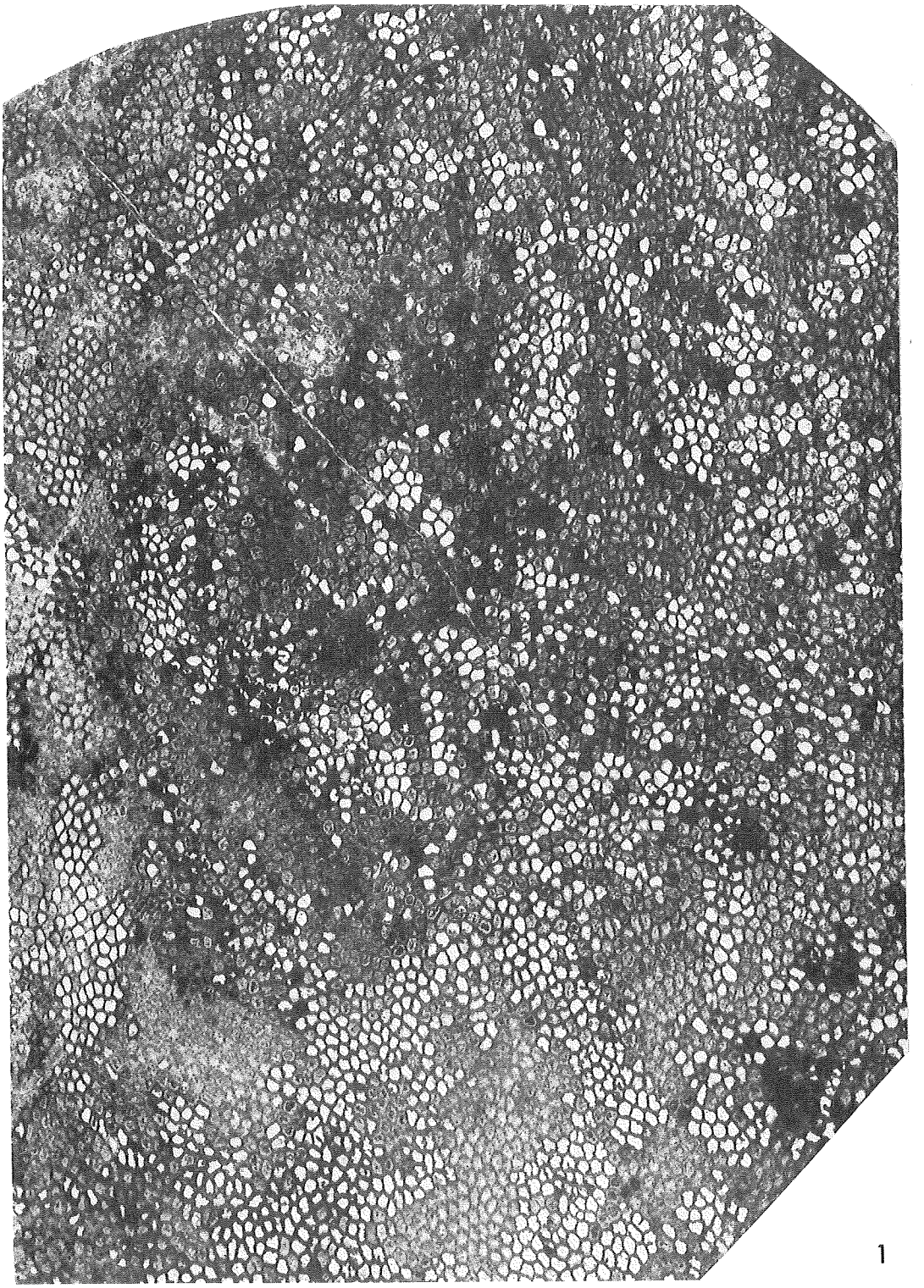
Explanation of Plate 5

(Five times natural size)

Fig. 1: *Chaetetes nagaiwaensis* MINATO?
Transverse section showing small corallites with rather frequent pseudoseptal projections. This probably represents a variety of *Chaetetes nagaiwaensis* MINATO.
UHR 18939, Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. KAKIMI



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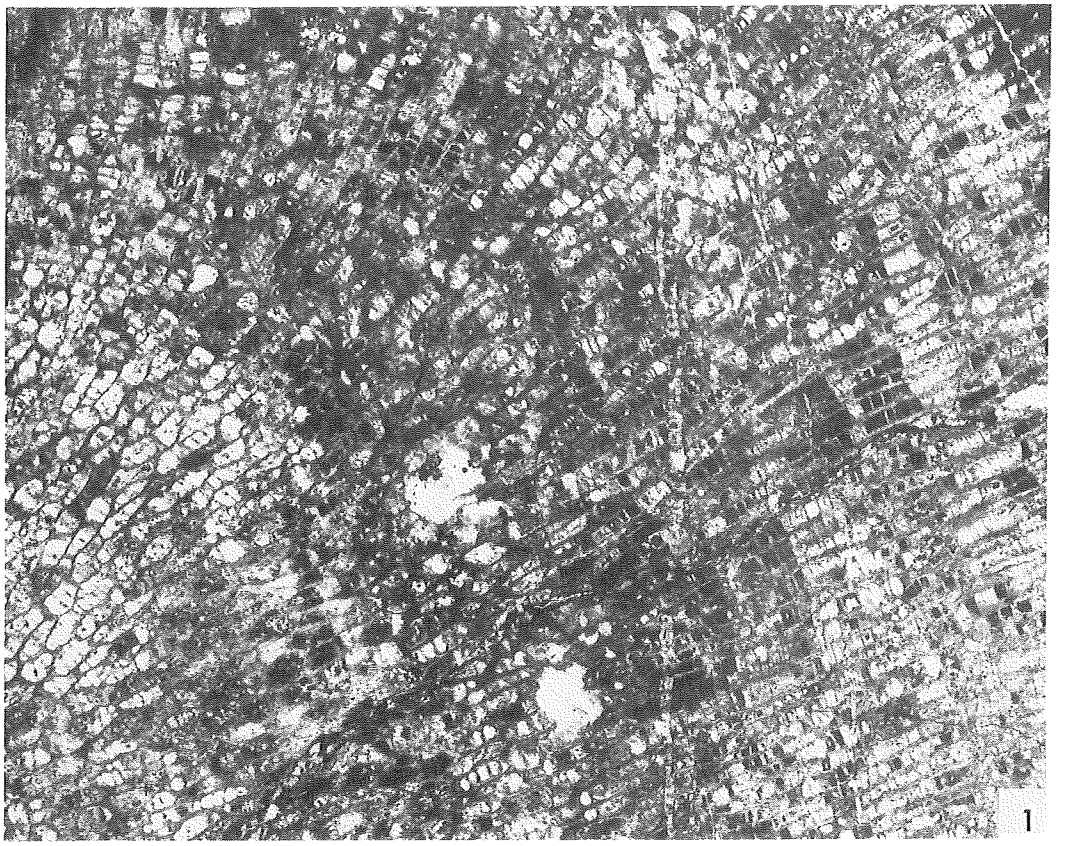
Explanation of Plate 6

Fig. 1: *Chaetetes nagaiwaensis* MINATO. X5
Longitudinal, but partially oblique section showing closely and evenly set tabulae. Lectotype, UHR 16464, Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

Figs. 2,3: *Sinopora choiana* MINATO & KATO: X4
2: Longitudinal section showing branching of hollow corallites. UHR 19806, Holotype –15.
3: Oblique section showing multilayered corallite wall. UHR 19806-9

Both from Yomogibata valley Loc. No. –3, Sumita-cho, Kesen-gun, Iwate Pref. Coll. by D. R. CHOI.



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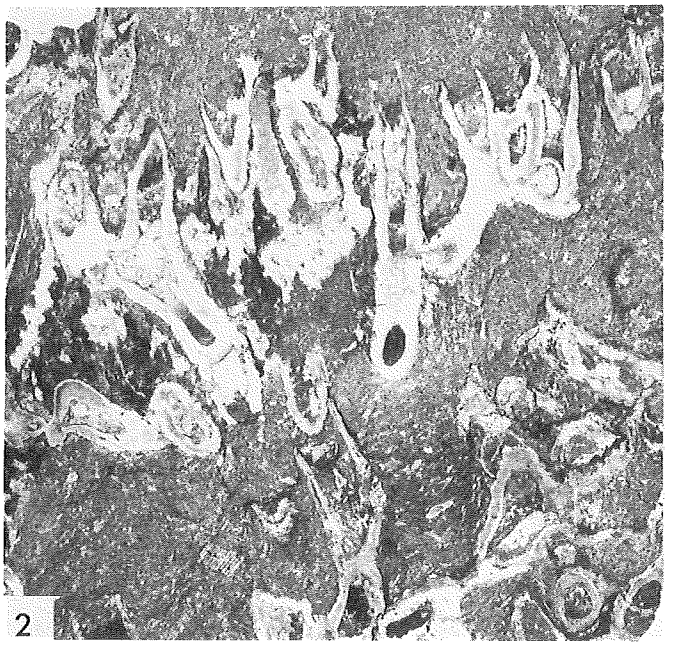

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Explanation of Plate 7

Figs. 1-2: *Sinopora choiana* MINATO & KATO

1: Oblique section of the holotype showing the presence of tabulae and wall structure UHR 19806-10. X10

2: Oblique section of the same colony, showing closely disposed corallites UHR 19806-2. X3

Both from Yomogibata Loc. no. 3, Sumita-cho, Kesen-gun, Iwate Pref. Coll. by D. R. CHOI.


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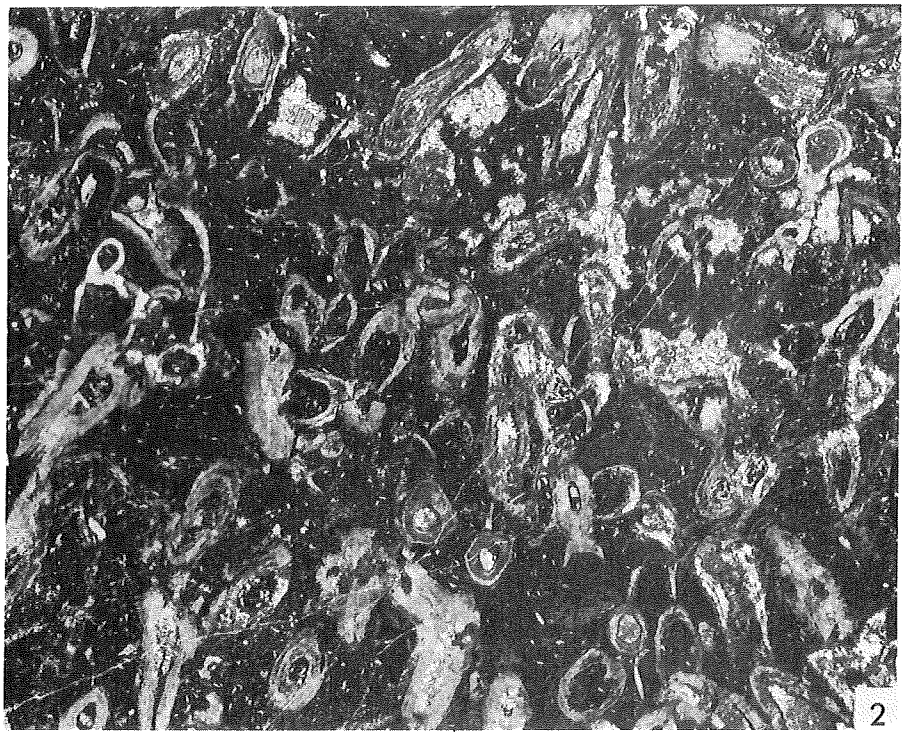
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Explanation of Plate 8

(All figures twice natural size)

Figs. 1-15: *Dibunophyllum bipartitum* (McCoy).

1. Somewhat oblique section, showing elongated and a little rotated septal lamellae, with Koninckophylloid degeneration in axial structure. UHR 17648, from N. E. of Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Hor. C-L zone or a little higher. Coll. T. KAKIMI.

2. Transverse section of calicular part of a corallite. UHR 17624, Entrance of Shiratorizawa, Sakamotozawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

3. Transverse section, showing typical Dibunophylloid axial structure. UHR 18940 – i, N. of Magoe, Ohfunato city, Iwate Pref. Coll. M. KATO.

4. Transverse section of a peripheral part of corallite revealing clear inner wall and no minor septa. Same corallite as fig. 3.

5. Oblique section UHR 17652, from Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

6. Transverse section of a young corallite. Axial structure is only weakly constructed. UHR 17650, Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

7. Transverse section axial structure is weak and loose. UHR 17653, Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

8. Transverse section of a fragmental corallite. UHR 17622, W. of Tahiroyahiki, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

9. Transverse section of a young corallite. Peripheral parts are eroded. Axial structure is weak and loose, and is not well differentiated from tabularium. UHR 18941 – ii, N. of Magoe, Hikoroichi-machi, Ohfunato city, Iwate Pref.

10. Longitudinal section of a corallite figured as 9. Axial tabellae are flat domed and like in *Koninckophyllum*.

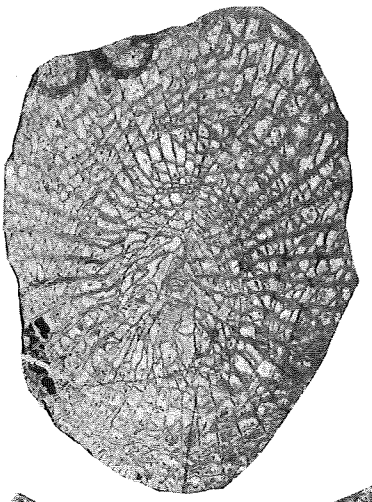
11. Transverse section of a fragmental corallite with seak axial structure. UHR 17623, W. of Tashiroyashiki, Hikoroichi-machi, Ohfunato city, Iwate Pref.

12. Transverse section showing broad axial structure which is loosely constructed peripheral portion are largely eroded. Septal dilation is a little conspicuous. UHR 17649, N. E. of Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.

13. Oblique section of UHR 18942 – i. Koninckophylloid tendency is strongly revealed. Dissepiments become lonsdaleoid in parts. Locality N. of Magoe, Ohfunato city, Iwate Pref.

14. Somewhat oblique longitudinal section of UHR 18942 – ii. Tabellae are flat domed and are crowded. Dissepiments are rather steeply inclined.

15. Obliquely cut longitudinal section. UHR 17621, W. of Tashiroyashiki, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. T. KAKIMI.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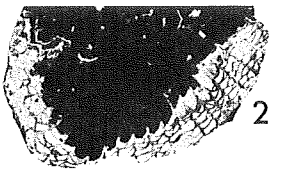
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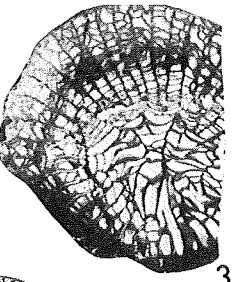
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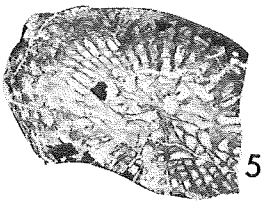
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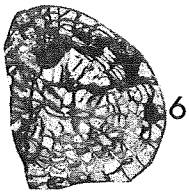
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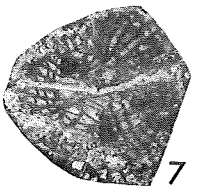
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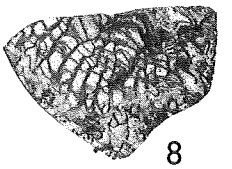
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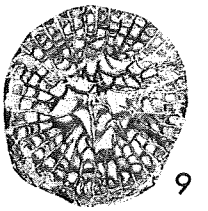
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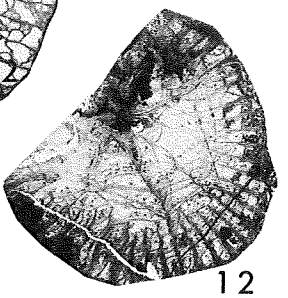
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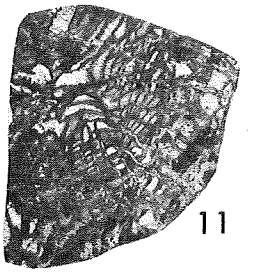
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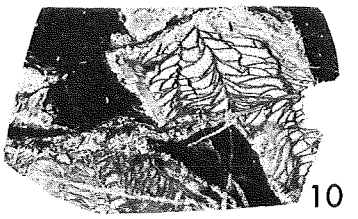
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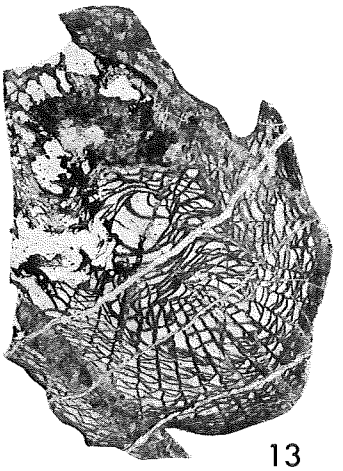
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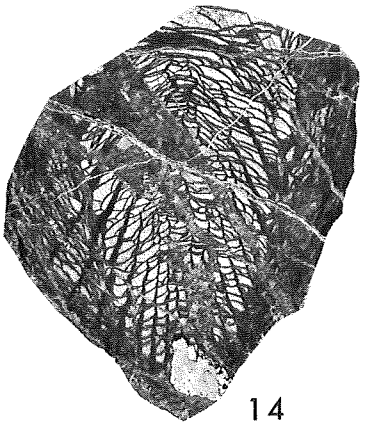
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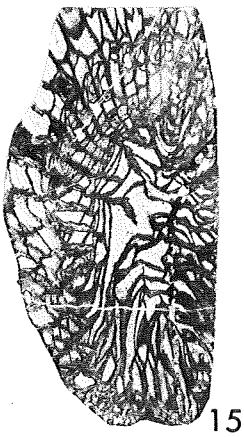
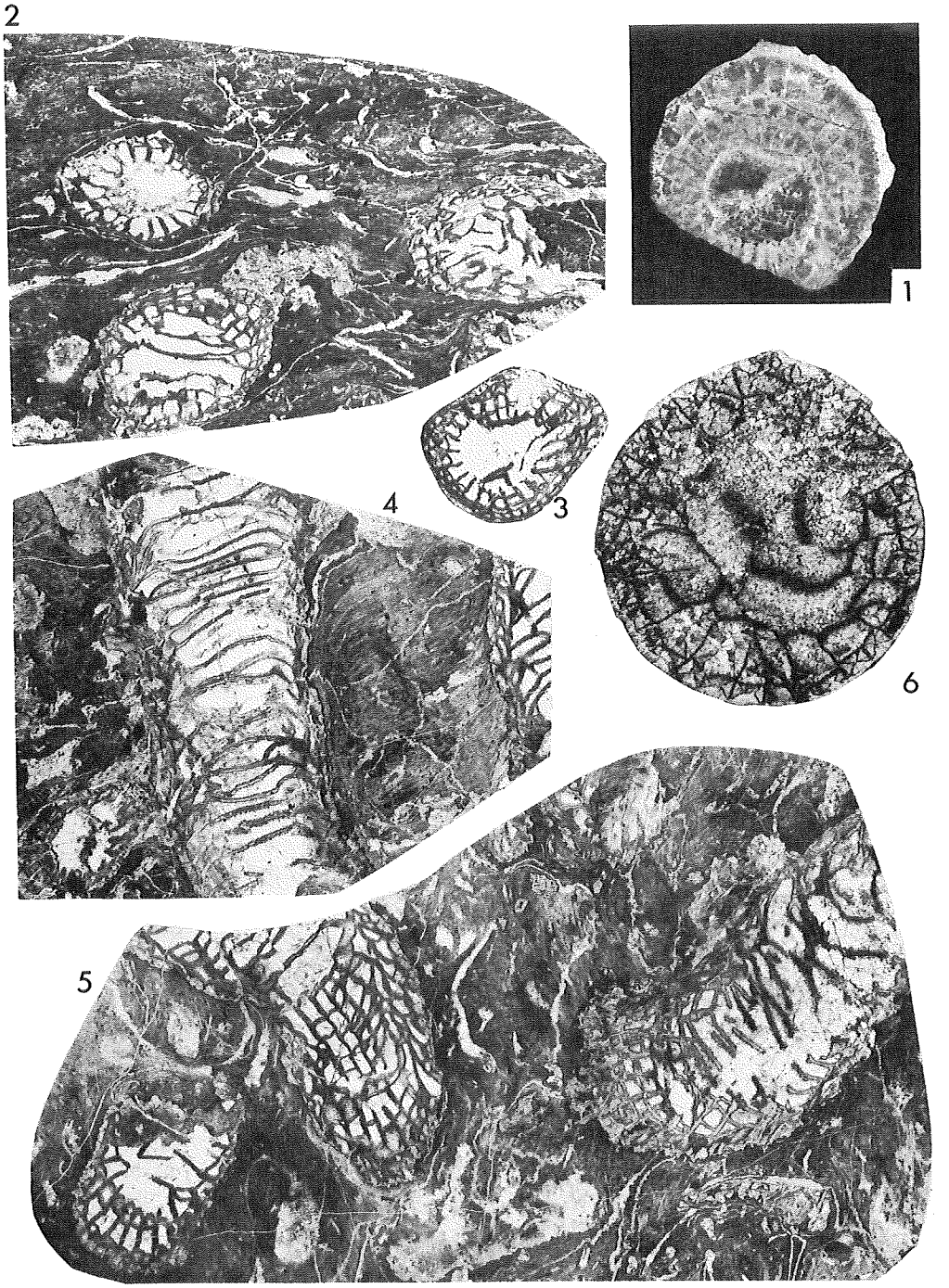

15

Explanation of Plate 9

Fig. 1: *Diphyphyllum equiseptatum* YABE et HAYASAKA X3.
Lectotype, Tohoku Univ. Locality: Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Photo. by K. MORI.

Fig. 2-6: *Diphyphyllum delicatum* MINATO et KATO
2: Transverse section UHR 17311
3: Transverse section UHR 17308
4: Longitudinal section UHR 17310
5: Oblique section UHR 17309
All specimens are twice natural size. Loc. Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by M. MINATO.
6: Transverse section UHR 18868-c X10.
Loc. North of Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.
Photographs of figures 2-6 are by S. KUMANO.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Explanation of Plate 10

Figs. 1-4: *Diphyphyllum delicatum* MINATO et KATO

1: Longitudinal section UHR 12446-v (Holotype) X4.

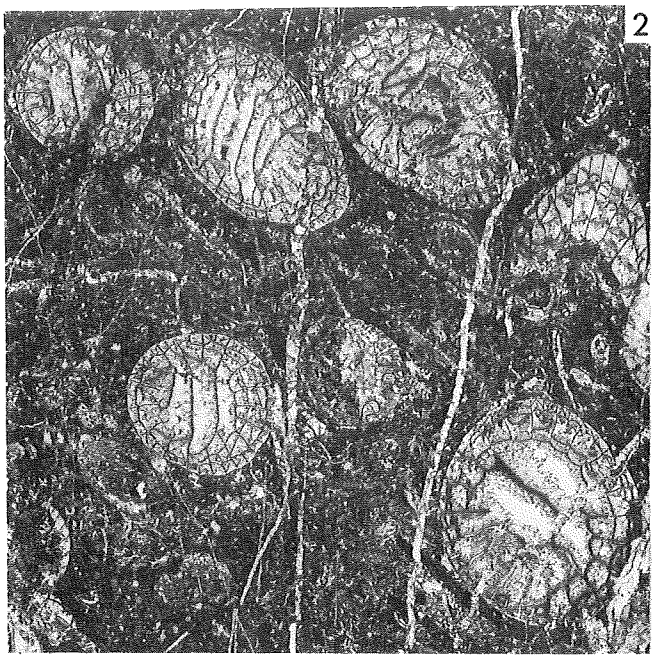
2: Transverse section UHR 18868-b X3.

3: A section revealing both transverse and longitudinal characters of the coral. UHR 18868-c X3.

4: Transverse section showing "budding". UHR 12446-viii (Holotype) X4.

1 & 4 are from a locality west of Onimaru, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. HASHIMOTO.

2 & 3 are from a locality north of Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.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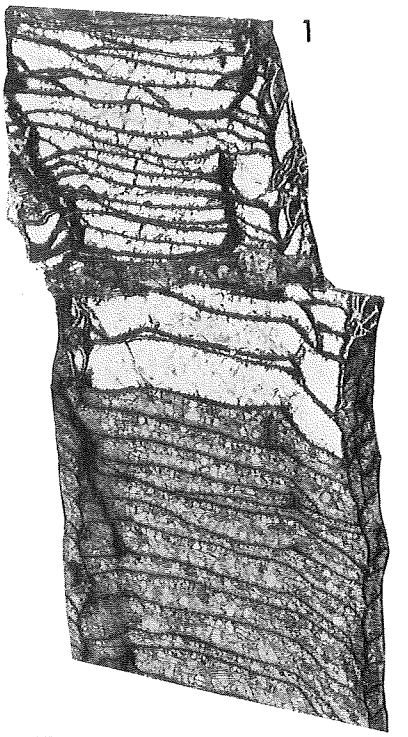
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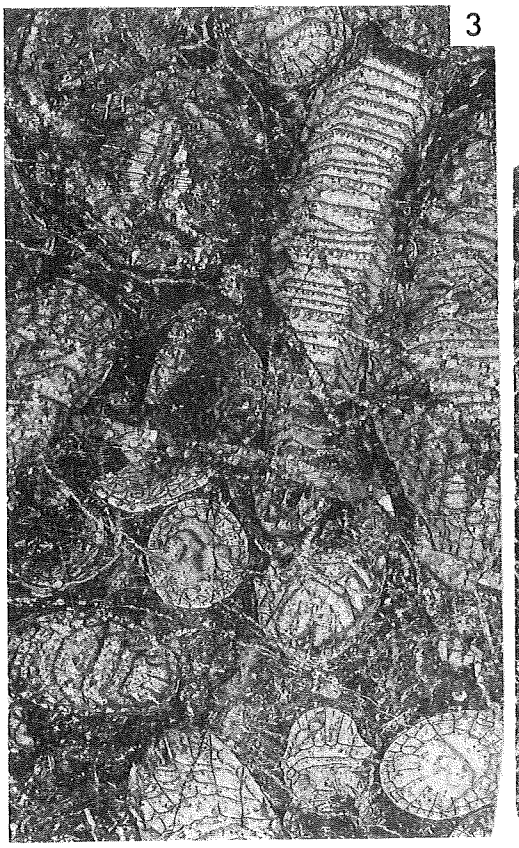
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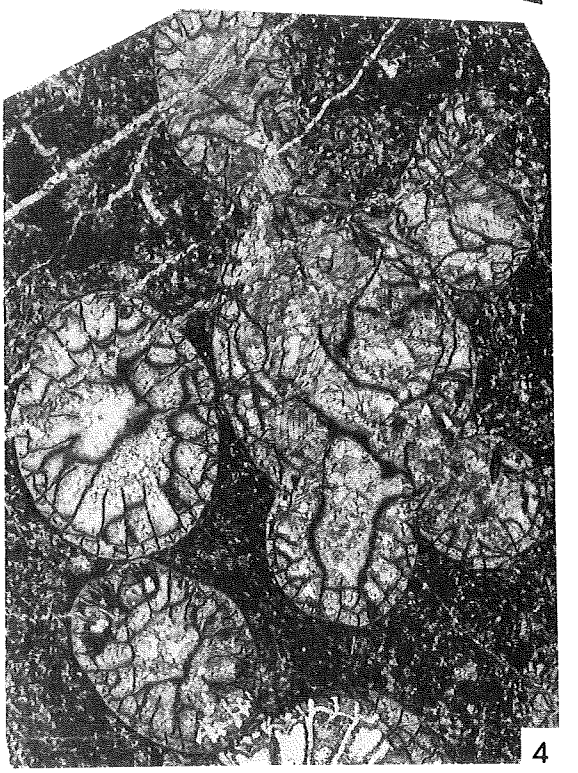
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Explanation of Plate 11

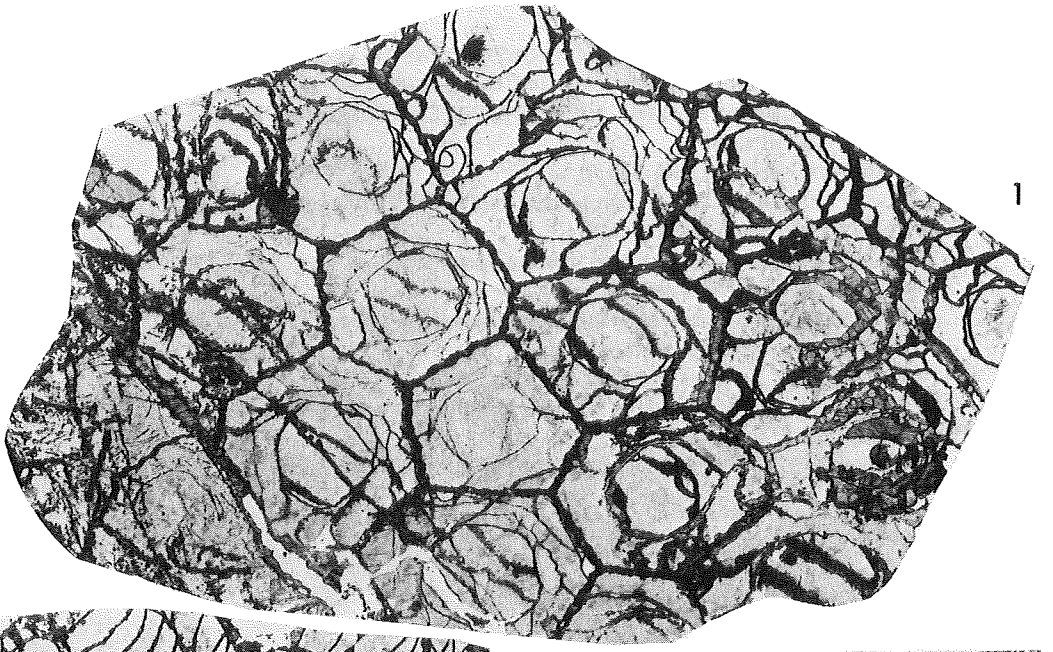
Figs. 1-3: *Sciophyllum japonicum* MINATO et SAITO.

1: Transverse section showing no trace of septa and axial structure. UHR 12465-iii (Holotype) X4

2: Longitudinal section. UHR 12466-iii (Paratype) X4

3: Transverse section. UHR 12465-iii (Holotype) X10

All specimens are from S. E. of Matsubi, Sumita-cho, Iwate Pref. Coll. by M.MINATO.



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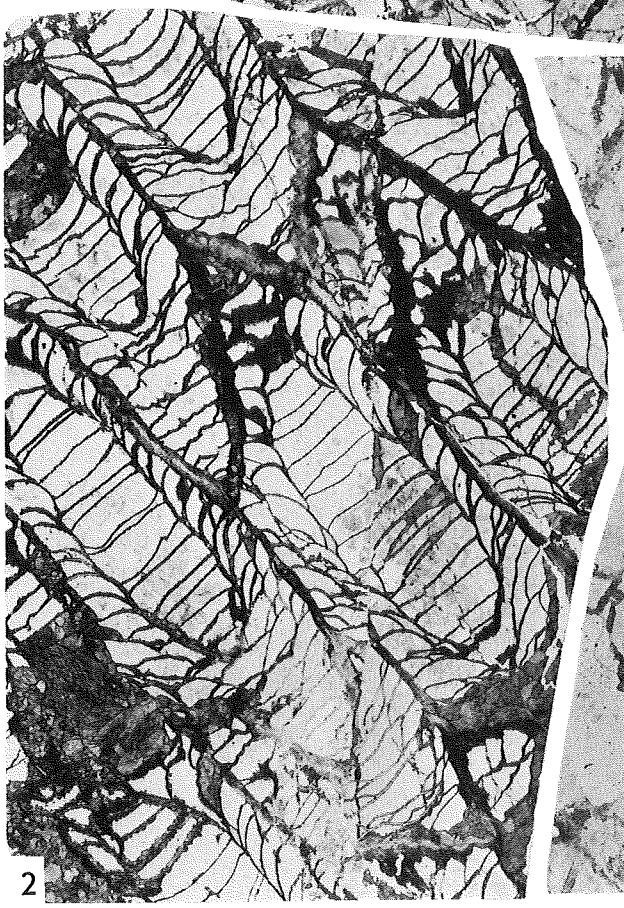

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Explanation of Plate 12

(All figures three times natural size)

Figs.1-6: *Thysanophyllum aseptatum* DOBROLYUBOVA

1: Somewhat oblique section showing the presence of septa and a long septum to which tabulae are elevated. UHR 12469-i. Loc. Usagizawa, Sumita-cho, Iwate Pref. Coll. by M. MINATO.

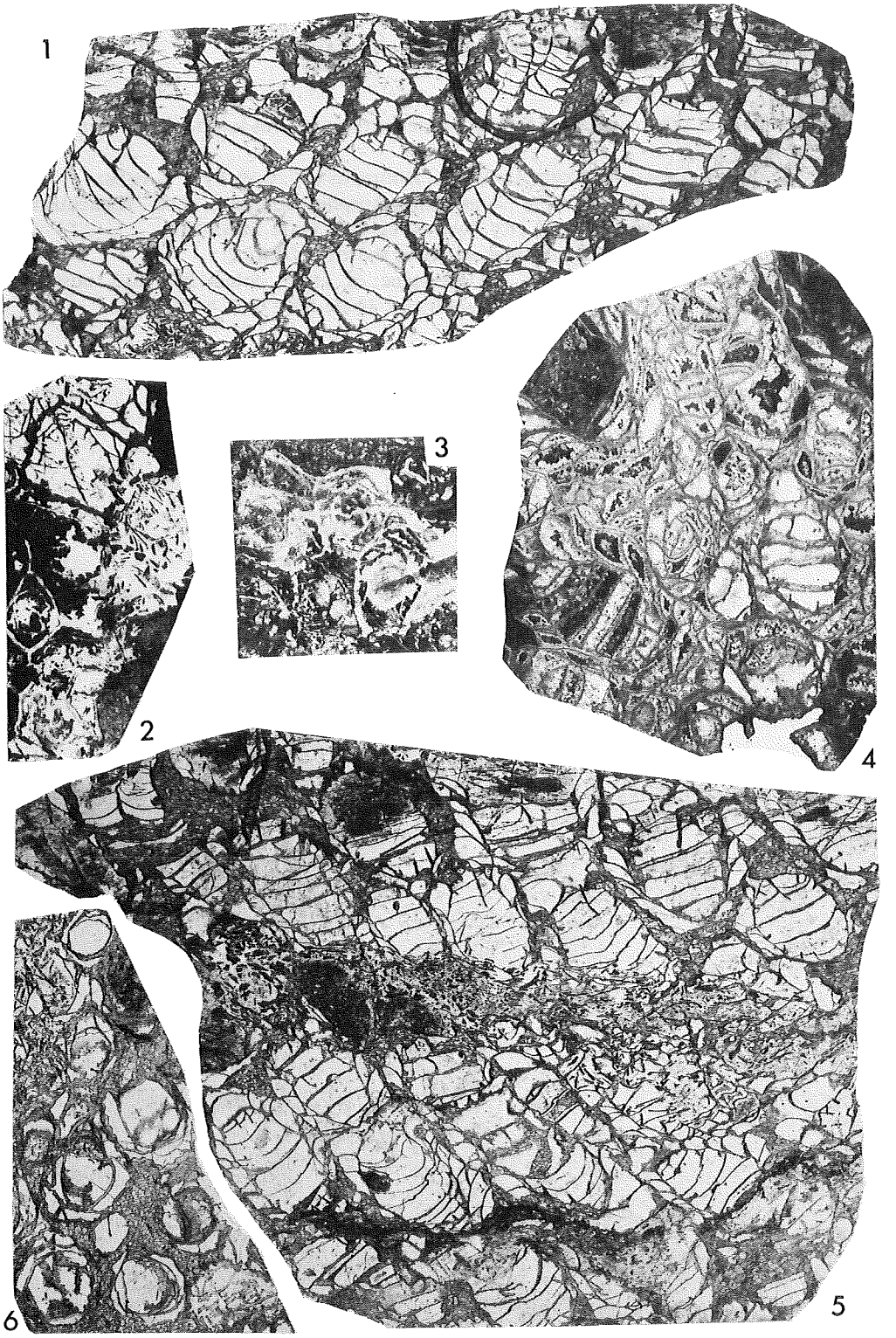
2: Transverse section UHR 12538
Loc. Yomogibata (048), Sumita-cho, Iwate Pref. Coll. by H.TAKEDA.

3: Transverse section UHR 12536
Loc. and Coll.: Same as the preceding specimen.

4: Oblique section UHR 16433
Loc. Nagaiwa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

5: Oblique section UHR 12469-ii
Loc. & Coll.: Same as the preceding fig. 1.

6: Transverse section, showing almost no septa but a long septum is definitely present. UHR 12468
Loc. and Coll.: Same as the preceding specimen show as figs. 1 & 5.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Explanation of Plate 13

(All figures three times natural size)

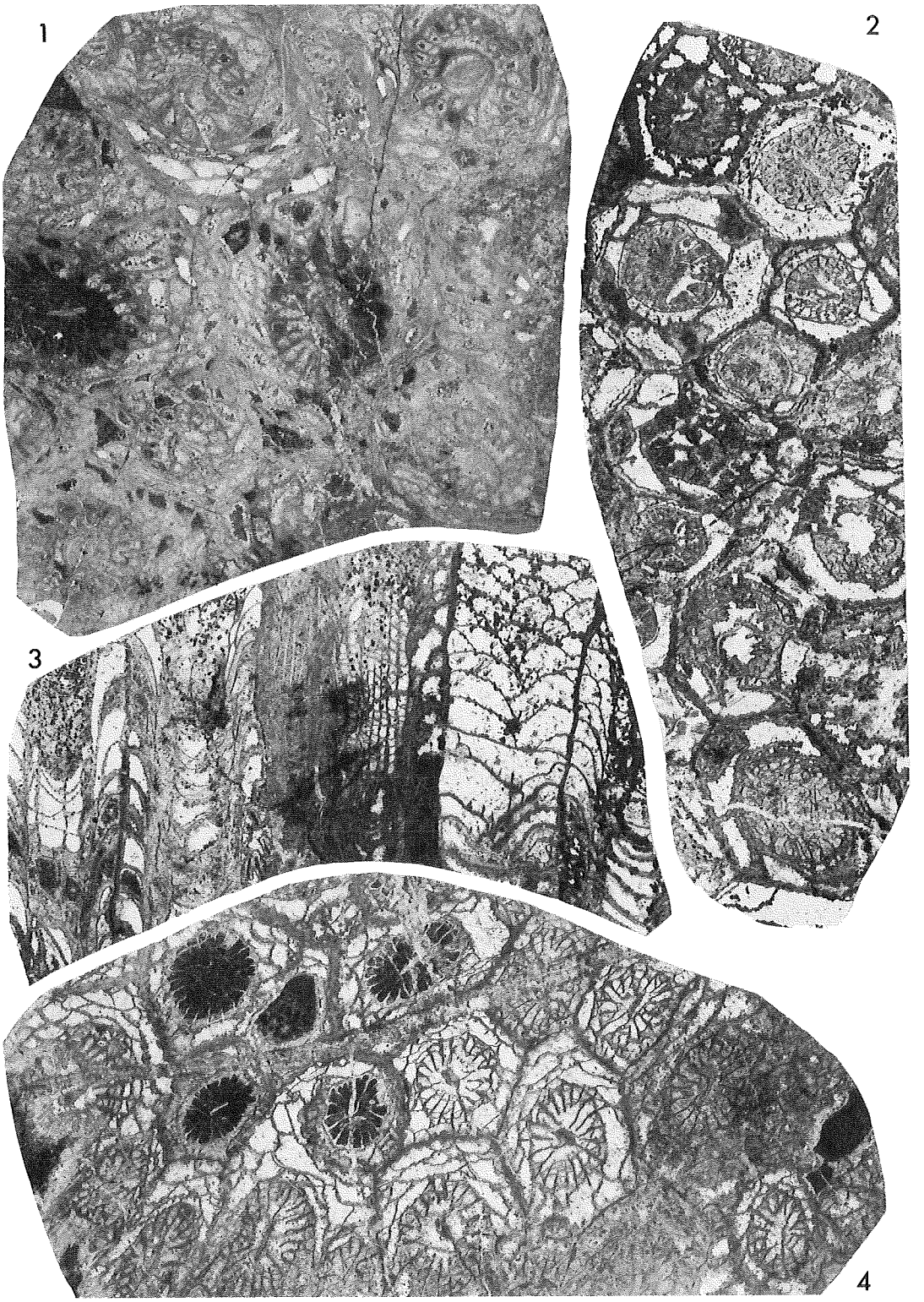
Figs. 1-4: *Lithostrotionella* sp.

1: Transverse section showing large corallites with numerous lonsdaleoid dissepiments. UHR 19798
Loc. Sakamotozawa, Hikoroichi-machi, Ohfunato city, Coll. by T. KAKIMI.

2. Transverse section showing some diphymorphic corallites. Loc. Higuchizawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

3. Longitudinal section of the same colony as shown in figure 2.

4. Transverse section showing the presence of stout columella. Loc. north of Nakajuku, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by S. YATO.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Explanation of Plate 14

(All figures three times natural size)

Figs. 1-5: *Lithostrotionella kitakamiensis* MINATO.

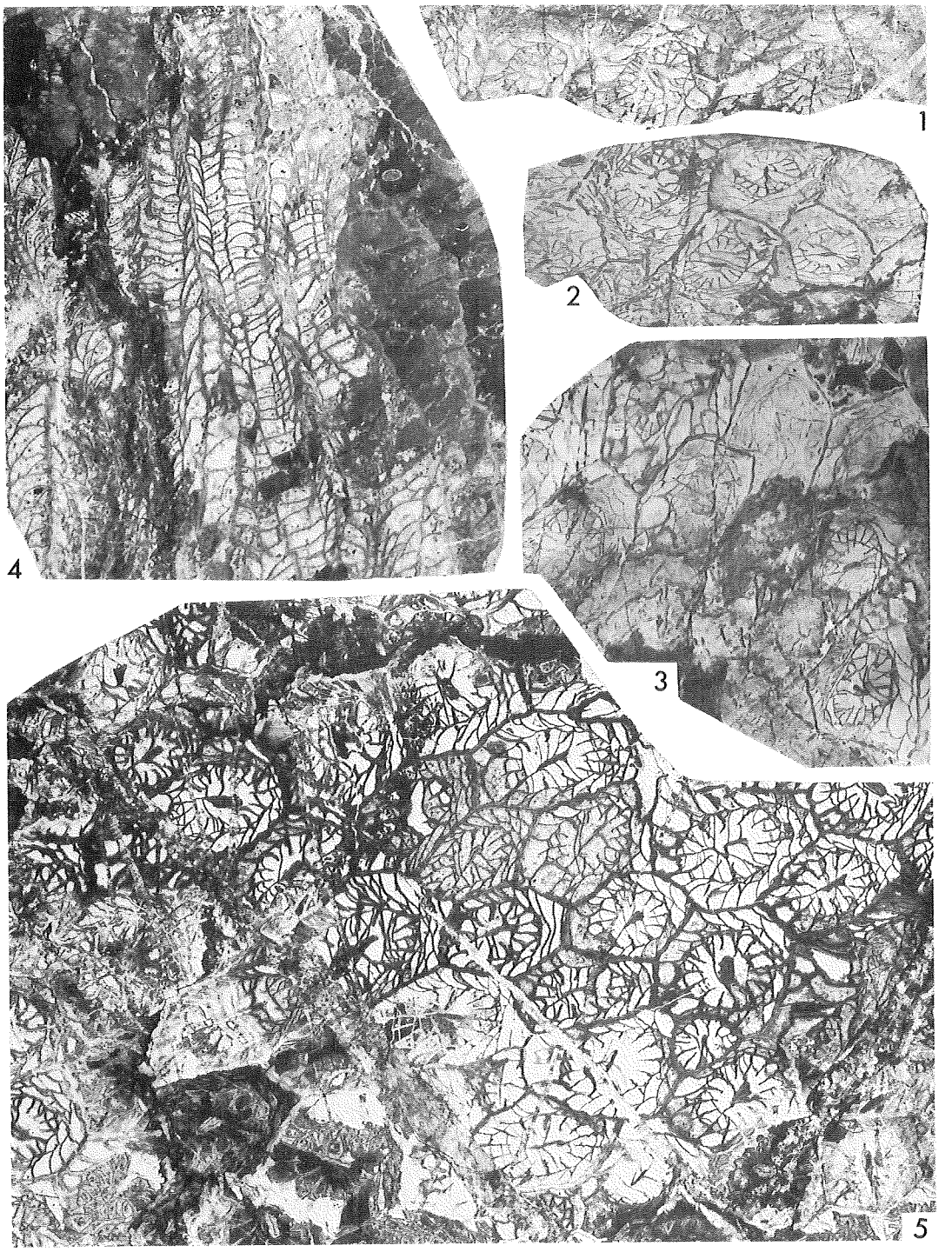
1: Transverse section UHR 17616
Loc. Shiratorizawa, Sakamotozawa, Hikoroichi-machi, Ohfunato city; Iwate Pref. Coll. by T. KAKIMI.

2: Transverse section UHR 17609 (Lectotype).
Loc. Mouth of Shiratorizawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. KAKIMI.

3: Transverse section UHR 17224
Loc. Sakamotosawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. KAKIMI.

4: Longitudinal section UHR 17613
Loc. Shiratorizawa, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by T. KAKIMI.
specimens 1 to 4 are syntypes.

5: Oblique section UHR 18877
Loc. North of Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.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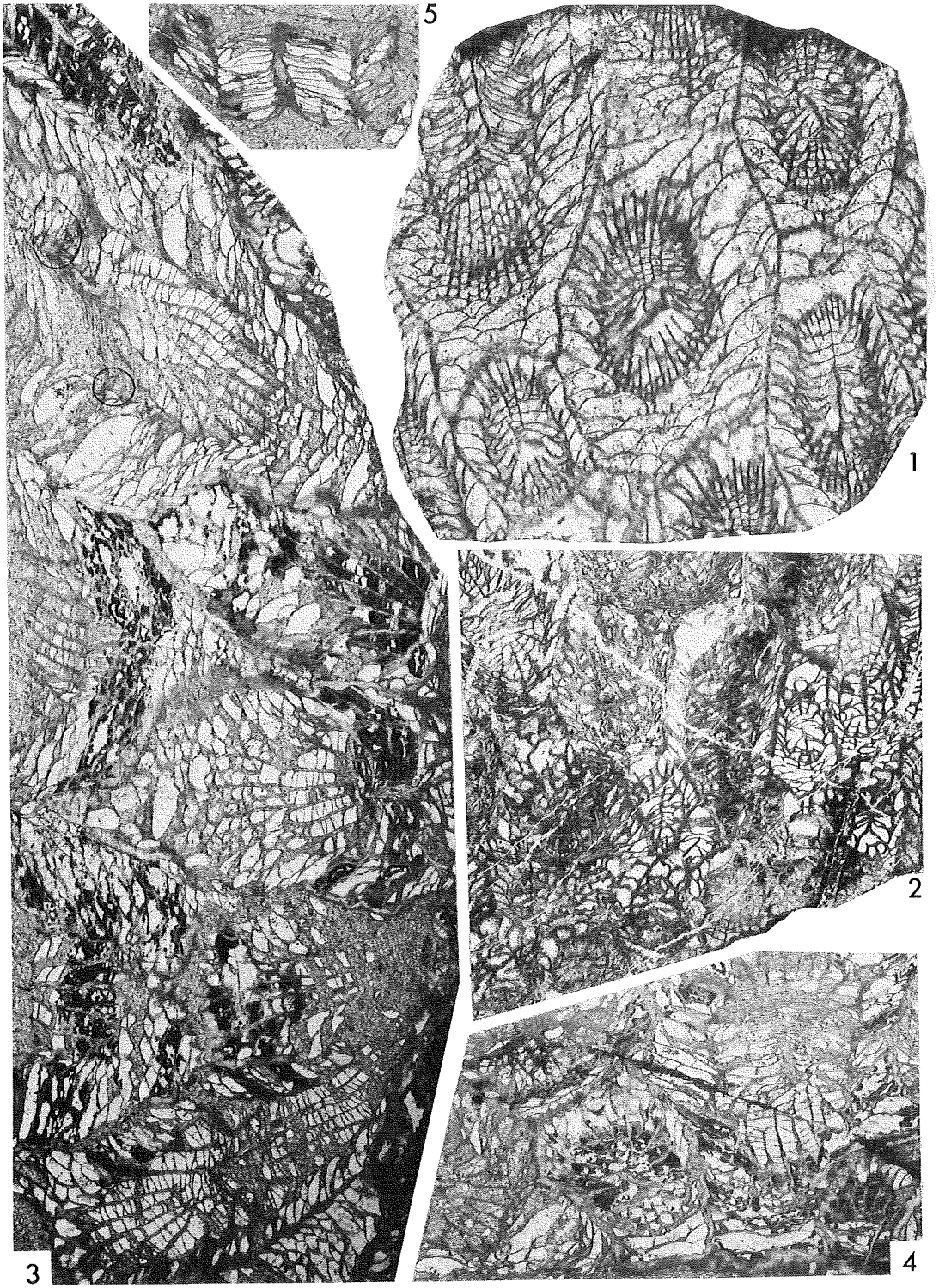
Explanation of Plate 15

Fig. 1: *Lithostrotionella unicum* YABE et HAYASAKA
Oblique section X4
Lectotype, N. 29a, Tohoku Univ. Loc. Hon-shan, Ton-Chuan-hsien, Prov. Yun-nan, China.

Fig. 2: *Lithostrotinella kitakamiensis* MINATO
Oblique section X3 UHR 18876
Loc. North of Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

Fig. 3-5: *Acrocyathus* ? sp.
3: Oblique section X3 UHR 19797b
4: Oblique section X3 UHR 19797a
5: Longitudinal section X3 UHR 19797a
Loc. Yomogibata, no. 2, Sumita-cho, Iwate Pref. Coll. by D. R. CHOI.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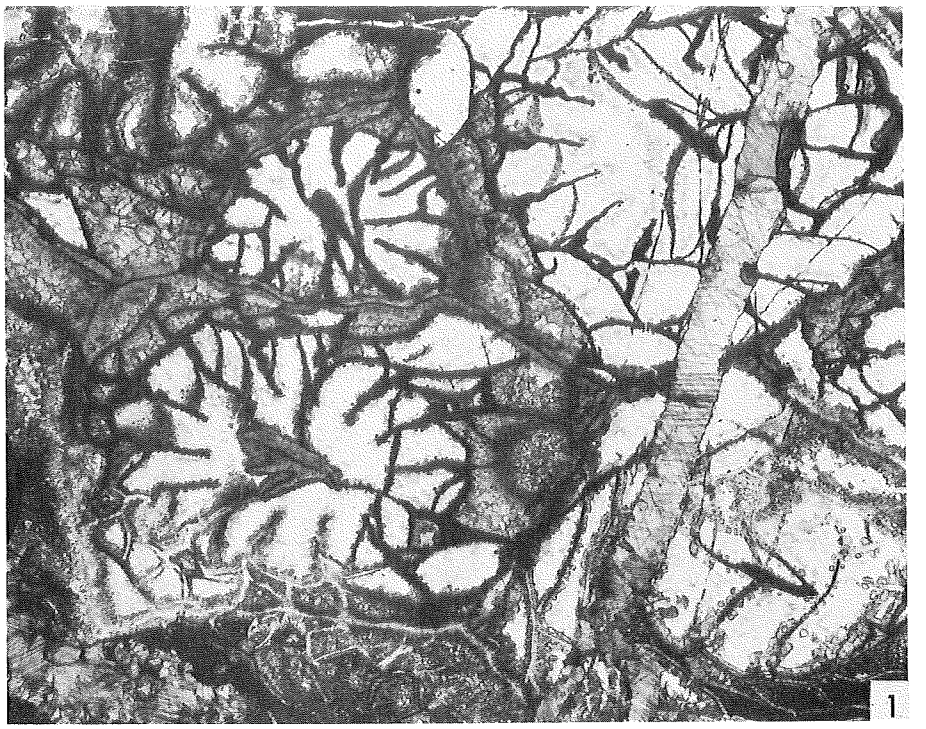
Explanation of Plate 16

(All figures ten times natural size)

Fig. 1: *Lithostrotionella kitakamiensis* MINATO.
Tangential section showing an younger corallite in which columella is originated from the cardinal septum, and the divaricating columella in another corallite. UHR 18877 Loc. North of Magoe, Ohfunato city, Iwate Pref. Coll. by M. MINATO.

Fig. 2: *Lithostrotionella* sp.
Tangential section showing columella uniting the cardinal septum. Counter septum is a little shorter than the counter laterals. One of alars is conspicuous, and a new septum is inserted on the left side of the cardinal one.
UHR 19796 Loc. Nakajuku, Hikoroichi-machi, Ohfunato city, Iwate Pref. Coll. by S. YATO.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