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The fossil on the cover is an adult example (T. TAKAHASHI coll.) of *Mikasaites orbicularis* MATSUMOTO (subfamily Marshallitinae, family Kossmaticeratidae) from the Lower Cenomanian (Cretaceous) of the Mikasa area, central Hokkaido. (photo by M. NODA, natural size)

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733. SILURIAN CORALS FROM THE YOKOKURAYAMA FORMATION IN THE MT. YOKOKURA REGION, KOCHI PREFECTURE, SOUTHWEST JAPAN —PART I. HALYSITIDAE—*

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Abstract. Eight species of halysitid corals, namely *Schedohalysites kitakamiensis* (SUGIYAMA), *Falsicatenipora shikokuensis* NODA and HAMADA, *Halysites catenularius* (LINNAEUS), *H. suessmilchi* ETHERIDGE, *H. kuraokensis* (HAMADA) and three indeterminable species, are described and figured from the Silurian deposits of Mt. Yokokura region in Kochi Prefecture, Southwest Japan. Among them, *Halysites* spp. A and B may represent new forms although they are imperfect in preservation. *Halysites catenularius* (LINNAEUS) and *H. kuraokensis* (HAMADA) are recorded from Mt. Yokokura region for the first time. Also Silurian geology in Mt. Yokokura region is briefly described.

Introduction

Since the discovery of "*Halysites*" by YABE and SUGIYAMA (1942) from the Silurian of Mt. Yokokura region in Shikoku, the area has been geologically investigated by a number of research workers.

Fossils are abundant at places within the Silurian there, and they include corals, molluscs, bryozoan fossils, brachiopods, trilobites, a graptolite and conodonts. As for corals, however, only two descriptive papers (HAMADA, 1956; 1958) are available, in which four species of halysitid corals are described; namely *Schedohalysites kitakamiensis* (SUGIYAMA), *Falsicatenipora japonica* (SUGIYAMA), *F. shikokuensis* NODA and HAMADA and *Halysites süssmilchi* ETHERIDGE. In fact, corals are the most common and conspicuous faunal elements in the Silurian of Mt. Yokokura. And not only halysitids, but also other tabulate corals, heliolitids and rugose corals are represented. Although, in general, the state of preservation of these corals is not favourable, their diverse feature is quite noteworthy, and they need description. Faunal aspects of corals of the Silurian of Mt. Yokokura have been briefly mentioned in KATO et al. (in press).

The author has been engaged in a stratigraphical and palaeontological study of the Silurian of Mt. Yokokura since 1976. He wishes to describe in a series of papers the Silurian coral faunas obtained from there, in order to grasp biostratigraphical distribution of various corals, and to make use of them as palaeoenvironmental indicators. In the present paper only halysitid corals are described to begin with. Two of them may be new species and two others are first described

* Received December 17, 1980.

from Mt. Yokokura region.

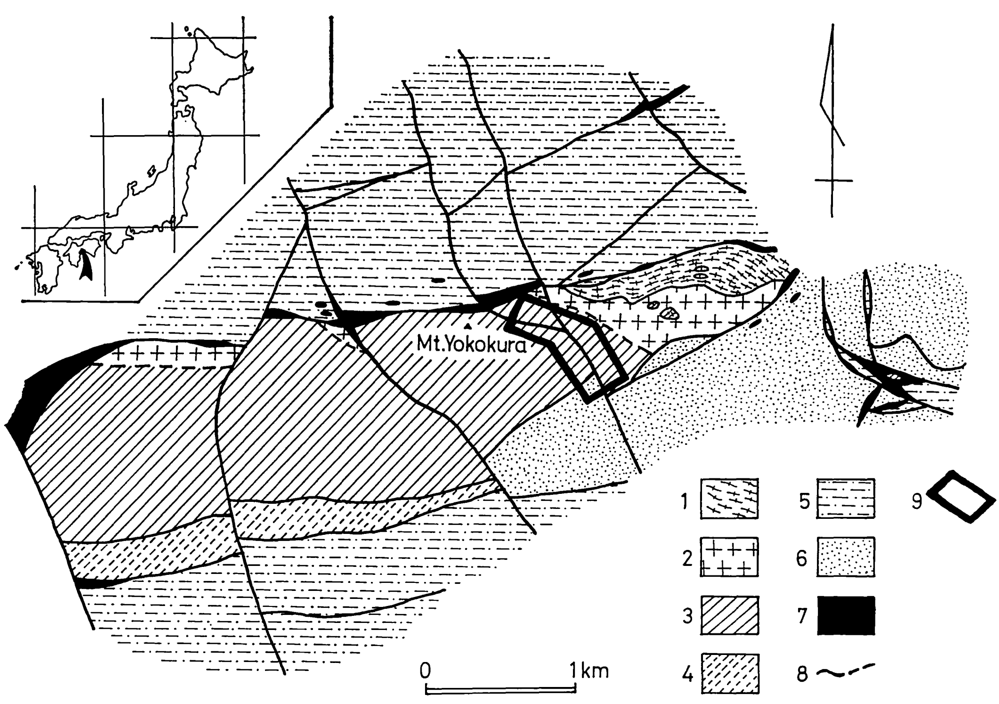
All the treated specimens are stored and registered at the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, Sapporo. They carry numbers with the prefix UHR.

Outline of Geology

Almost vertically dipping Middle Palaeozoic strata are known to develop as a huge lenticular body within a tectonic zone called the Kurosegawa Structural Belt in Mt. Yokokura region (Text-fig. 1). A conformable succession from the Silurian to Devonian was termed as the Yokokurayama Formation by SUYARI (1961), in which HAMADA (1958) further recognized four beds (=members), namely G_1, G_2, G_3 and G_4 in ascending order (Text-fig. 3).

The G_1 member is about 250 m thick, consists of the alternation of acidic tuff, tuffaceous sandstone and slate. Two thick beds of welded tuff are intercalated in the member. Fossils occur in the middle part of G_1 member. Brachiopods, trilobites and some moulds of rugose corals have been obtained.

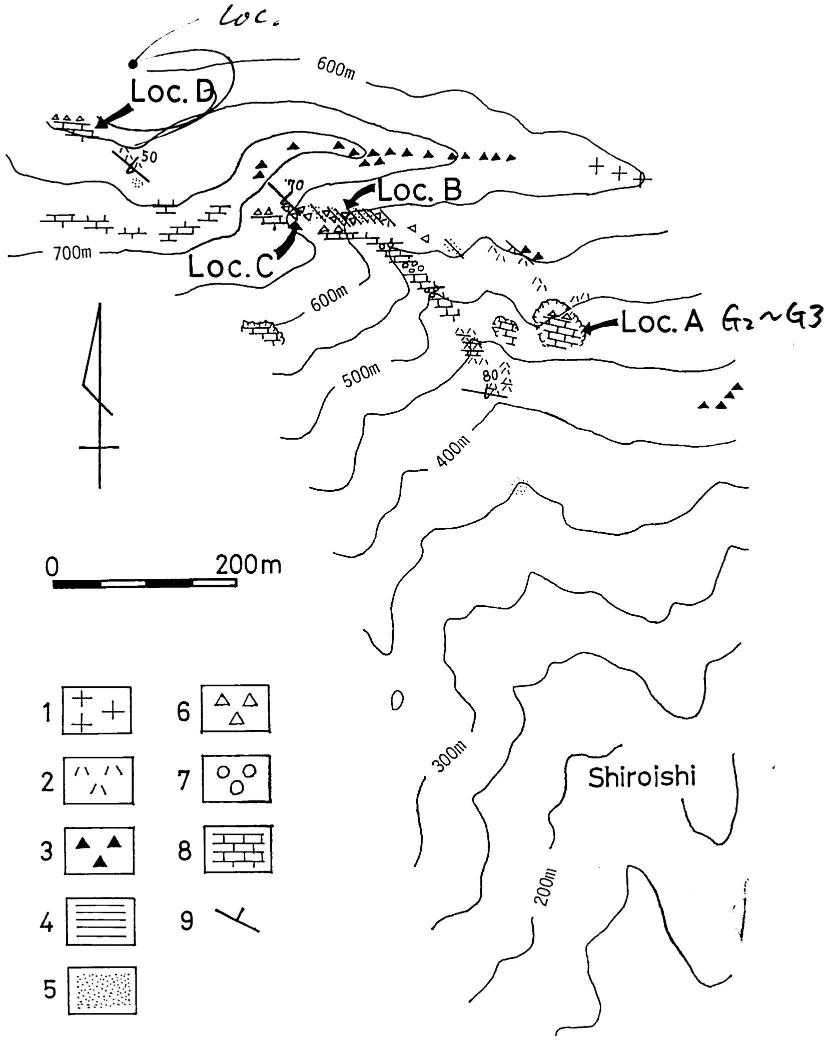
The G_2 member is only 90 m thick, consists mainly of the thin alternation of tuffaceous sandstone and slate. In the lower part of the member several thin beds of acidic tuff are intercalated. While the member becomes calcareous in the upper part where thin beds of impure limestone or sandy limestone are intercalated. Fos-



Text-fig. 1. Simplified geological map of Mt. Yokokura region and showing the mapped area (Text-fig. 2).
1: Terano Metamorphic Rocks, 2: Mitaki Granitic Rocks, 3: Yokokurayama Formation, 4: Ochi Formation, 5: Upper Palaeozoic Strata, 6: Cretaceous deposits, 7: serpentinite, 8: fault, 9: mapped area (see Text-fig. 2)

sils are abundantly found in these calcareous strata. Halysitids, other tabulate corals, heliolitids, rugose corals, stromatoporoids, brachiopods, trilobites and conodonts have been known to occur in the member.

The G_3 member is 200 m thick at most, consists almost entirely of gray or pinkish gray, massive limestone partly conglomeratic. Thin beds of fine-grained, red tuff are known to intercalate at places. Fossils of halysitids, other tabulate corals, heliolitids, rugose corals, stromatoporoids, brachiopods, molluscs, a graptolite, trilo-

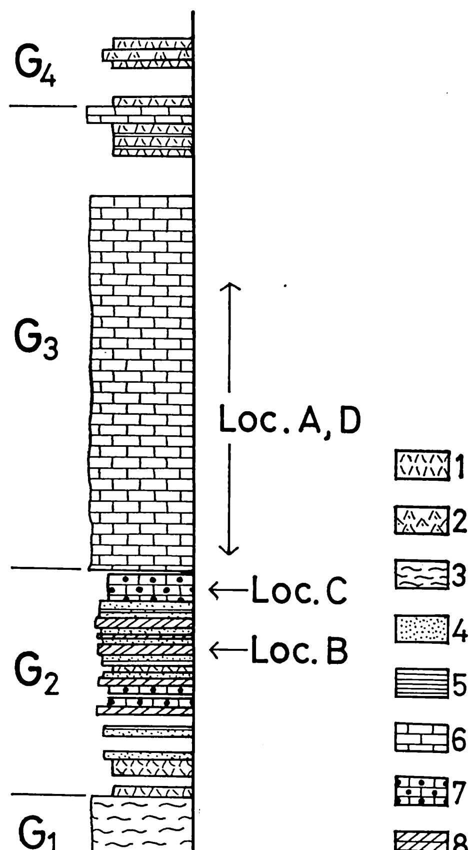


Text-fig. 2. Geological sketch map of the eastern part of Mt. Yokokura showing fossil localities.

1 : Mitaki Granitic Rocks, 2-8 : Yokokurayama Formation (2 : Acidic tuff, 3 : Welded tuff, 4 : Tuffaceous slate, 5 : Tuffaceous sandstone, 6 : Impure limestone, 7 : Limestone conglomerate, 8 : Massive limestone) 9 : Strike and dip

bites and conodonts are commonly found.

The G_4 member is more than 900 m thick, consists of fine acidic tuff, lapilli tuff and tuff breccia in alternation. Rhyolite lavas and beds of sandstone and slate are occasionally intercalated in the sequence. No fossils have been obtained.



Text-fig. 3. Composite geological columnar section of the Yokokurayama Formation showing fossil horizons in the eastern part of Mt. Yokokura (Text-fig. 2).
1: Fine acidic tuff, 2: Coarse acidic tuff, 3: Welded tuff, 4: Tuffaceous sandstone, 5: Tuffaceous slate, 6: Pinkish gray, massive limestone, partly conglomeratic, 7: Dark gray, conglomeratic, impure limestone, 8: Greenish gray, sandy, impure limestone or limy sandstone

KUWANO (1976) suggested by his conodont research that the lower part of G_2 is Llandoverian, the upper part of G_2 and the lower part of G_3 belong to Wenlockian, while the rest of G_3 member would be Ludlovian in age.

The Silurian corals treated in the present study were collected from the four localities, A, B, C and D in Mt. Yokokura region (Text-fig. 2).

Locality A is a quarry called the Gomi where the top G_2 member and the lower and middle part of G_3 member are exposed (Text-figs. 2, 3). Fossils were mostly collected as scree specimens derived from the G_3 member. *Schedohalysites kitakamiensis* (SUGIYAMA), *S.* sp., *Halysites suessmilchi* ETHERIDGE, *H.* sp. A and *H.* sp. B were collected together with other tabulate corals, heliolitids, rugose corals, stromatoporoids, molluscs, brachiopods, trilobites and conodonts.

Locality B is an outcrop along the upper tributary of Shiroishisawa valley where the middle part of G_2 member is exposed. *Falsicatenipora shikokuensis* NODA and HAMADA, *Halysites catenularius* (LINNAEUS), *H. kuraokensis* (HAMADA) and *H. kuraokensis* (HAMADA) variety were collected together with other tabulate corals, heliolitids and rugose corals. Fossils are mostly found abraded within limestone matrix which is sandy.

Locality C is a small outcrop also in the upper stream of the Shiroishisawa valley, where the top part of G_2 member is exposed. Impure limestone is conglomeratic in parts. The following fossils were obtained. *Falsicatenipora shikokuensis* NODA and HAMADA and *F. shikokuensis* NODA and HAMADA variety together with other tabulate corals, heliolitids, rugose corals, stromatoporoids, brachiopods and trilobites. In most coral specimens corallum shape is fairly well preserved within muddy matrix.

Although branches are often broken in fasciculate forms, their surface characters are preserved in detail. Before burial corals must have been transported to fossilized position but only a small distance from where they grew.

Locality D is along the narrow mountain path on the northern slope of Mt. Yokokura, where the top part of G_2 member and the lower to middle part of G_3 member are exposed. The following fossils were collected from the lower part of G_3 member. *Schedohalysites kitakamiensis* (SUGIYAMA) together with other tabulate corals, heliolitids and rugose corals. Actually gray coloured fossils are firmly embedded in white-gray, massive limestone, so that habits are difficult to observe in field.

Systematic description

Family Halysitidae MILNE-EDWARDS and HAIME, 1850

Suprageneric and generic classification of chain corals by HAMADA (1957b, c; 1958) is largely adopted in the following description. Morphological terms are those defined by HAMADA (1957a, b, c; 1958), and the evaluation of taxonomic weight for each morphological character is after KAWAMURA (1980).

Since fossils treated below were firmly embedded in matrix, and were collected as large or small fragments, it was usually difficult to know external features of corals. Corals were also often strongly recrystallized and were sometimes crushed, so the nature of septal spinules or the nature of walls are usually not readily recognized. The shape and size of corallum, surface characters of corallites, for instance, cannot be ascertained with confidence as the present study has been made in thin sections. In some instances septal spinules may have been obliterated by recrystallization, yet in other cases intergrowth of sparry calcite will give an impression that septal spinules are genuinely present in some forms.

So in the following description, the presence or absence of micro- and/or mesocorallites and the form and size of macrocorallites are considered to be the most important biocharacters in classifying halysitids.

As to the size of macrocorallites, halysitids in general may be grouped into 3 categories, namely large, intermediate and small ones. Large macrocorallites are over 2 mm in short diameter, intermediate ones are around 1.5 mm, while small ones are less 1 mm. In the following description the size of macrocorallites is referred in the way herein described.

Subfamily Schedohalysitinae HAMADA, 1957

Remarks.—Two genera, *Schedohalysites* and *Falsicatenipora*, have been placed within the subfamily Schedohalysitinae. The distinction between the above mentioned two genera is whether microcorallites are present or not. Mesocorallites are present but sometimes not present in both genera. It is noteworthy that the character of septal spinules, whether they are present or not, has not been taken into account in the generic classification of the subfamily Schedohalysitinae, in spite that the character has been employed as important in the subfamilies Cateniporinae and Halysitinae.

The problem is that in a corallites of *Halysites japonicus*, the type species of *Falsicatenipora*, a microcorallite does seem present. See plate XVI, fig. 2 of SUGIYAMA (1940). *Falscicatenipora japonica*, illustrated from Gion-yama by HAMADA in 1958 (pl. VI, fig. 1) clearly indicates the presence of microcorallites. In other words, it would be rather difficult to distinguish *Falsicatenipora* from *Schedohalysites* as far as their type species are concerned, although the author admits that there is a group of schedohalysitids which certainly has no microcorallites (e.g. *Halysites chillagoensis* ETHERIDGE). Until all the type materials for both genera are thoroughly restudied, the author provisionally followed the classification set by HAMADA.

Genus *Falsicatenipora* HAMADA, 1958

1958. *Falsicatenipora* HAMADA, *Jour. Fac. Sci., Univ. Tokyo*, ser. 2, vol. 11, p. 98.

Type species:—*Halysites japonicus* SUGIYAMA, 1940.

Remarks.—The following forms of *Falsicatenipora* have been described until now, apart from the species assigned to the genus by HAMADA (1958).

Falsicatenipora chillagoensis (ETHERIDGE): STRUSZ, 1961
F. dazhubaensis LIN and YEH: LIN, 1975
F. shanxiensis LIN: LIN, 1975
F. wangjiawaensis LIN: LIN, 1975
F. shikokuensis NODA and HAMADA: KAWAMURA, 1980
F. sp. indet: KAWAMURA, 1980

Judged from figures, microcorallites are certainly present in some specimens of *F. shikokuensis* (HAMADA, 1958, pl. 7, fig. 6), *F. dazhubaensis* (LIN, 1975, pl. 57, fig. 2a), *F. shanxiensis* (pl. 70, fig. 1a) and *F. wangjiawaensis* (pl. 70, fig. 2a). By definition all such forms should be classified into the genus *Schedohalysites*. See remarks of the subfamily Schedohalysitinae.

Falsicatenipora shikokuensis NODA and HAMADA

Pl. 16, Figs. 2-4; Pl. 17, Fig. 3; Text-fig. 4b

1958. *Falsicatenipora shikokuensis* NODA and HAMADA, *in* HAMADA, *Jour. Fac. Sci., Univ. Tokyo*, ser. 2, vol. 11, p. 99-100, pl. 6, figs. 4-5; pl. 7, figs. 1-7.
1980. *Falsicatenipora shikokuensis*: KAWAMURA, *Jour. Fac. Sci., Hokkaido Univ.*, ser. 4, vol. 19, no. 3, p. 280, text-fig. 5a, pl. 1. figs. 1-2.

Materials:—Twelve thin sections (UHR 30440a, c; 30445; 30451-30457) were prepared from ten colonies. Eight of them were collected from the upper part of the G_2 member of the Yokokurayama Formation, at Loc. C and two of them (UHR 30440, 30445) were collected from the middle part of the G_2 member, at Loc. B.

Description:—Corallum compound, cateniform but subcylindrical as a whole, and very small in size. Average corallum is about 10×15 mm in width and 20 to 25 mm in height.

In transverse section fenestrules are characteristically small and polygonal but their size and shape is variable. Fenestrules may be triangular, quadrangular, pentagonal, hexagonal or partly more elongated in shape, the size of which varies from 0.5×0.75 mm to 2.0×2.7 mm in width. One side of each fenestrule consists usually of only one, rarely two macrocorallite. New macrocorallite occurs at a free end of macrocorallite or at the junction of chains. Macrocorallites are small, sub-rectangular or suboval, barrel shaped in transverse section. External diameter of them is 0.4-0.6 mm in short side, while it is 0.8-1.0 mm in long side. Corallite wall is thin, being 0.1-0.15 mm in thickness. Wall between corallites is somewhat thinner than those of outer wall. Under the microscope wall is uniform, composed of light coloured, fibrous layer. One or two septal spinules are occasionally seen in some corallites, but the presence of which is quite certain, because of the presence of fine dotts representing the axial ends of them in longitudinal sections. Mesocorallites are normally present, but are lacking in some chains. They are triangular or tetragonal in shape, and are 0.3-0.5 mm in the length of one side. They occasionally become as large as the size of smaller macrocorallites. Microcorallites are usually absent, but in only one section (UHR30453, Pl. 16, Fig. 2; Text-fig. 4b) microcorallites are seen to develop.

In longitudinal section corallites are arranged in somewhat divergently. Tabulae in macrocorallites and mesocorallites are complete and horizontal, or slightly concave downwards. In macrocorallites the vertical distance between adjacent tabulae is 0.3 to 0.45 mm. Tabulae in mesocorallites are more closely spaced than those in macrocorallites. Axial cut edges of septal spinules are to be seen between tabulae as dotts arranged in three or four vertical rows. These dotts do appear to be horizontally lined but somewhat irregularly.

Remarks:—The above description is based on the specimens collected from locality C. They are much better preserved than the type materials of *Falsicatenipora shikokuensis* NODA and HAMADA in HAMADA (1958), and are only slightly different especially from the holotype. The holotype of *F. shikokuensis* has closely set tabulae in longitudinal section, while the paratype and the specimen from Loc. C reveal comparatively coarse tabulae. Otherwise all the specimens mentioned above show subcylindrical corallum, small, polygonal fenestrules composed of one or two, small, suboval macrocorallites. They are thus specifically identical.

Two specimens from Loc. B are badly recrystallized. They are similar to HAMADA's material of *F. shikokuensis* (HAMADA, 1958, pl. 6, fig. 4; pl. 7, fig. 1) in general appearance. Therefore they are provisionally placed here under the same category with *F. shikokuensis*, although there remains uncertainty in the recognition of internal characters in detail as for these two specimens.

A specimen of *Falsicatenipora shikokuensis* from the Kitakami Mountains studied by KAWAMURA (1980) has a little thicker wall compared to the specimens from Southwest Japan. The specimen is badly crushed and recrystallized. *Falsicatenipora hillae* HAMADA (=*Halysites* cfr. *australis* of HILL, 1954, p. 39, pl. 4, figs. 8a-b) resembles *F. shikokuensis* in general, but the former has slightly larger and more rectangularly formed macrocorallites compared to the latter. *Falsicatenipora dazhubaensis* (LIN, 1975) quite resembles *F. shikokuensis* in the form of fenestrules, but possesses much larger macrocorallites compared to the latter form. *Falsicatenipora* sp. of KAWAMURA (1980, p. 280-281, pl. 1, fig. 3; text-fig. 5b) also resembles *F. shikokuensis* in general appearance, but has large corallites. *Falsicatenipora chillagoensis* (ETHERIDGE, 1904; STRUSZ, 1961), *F. shanweiensis* (LIN, 1975) and, *F. wangjiawaensis* (LIN, 1975) and possibly *F. japonica* (SUGIYAMA, 1940; HAMADA, 1958) reveal a little elongate and somewhat meandrine fenestrules and have large macrocorallites. So they are readily distinguished from *F. shikokuensis*.

Falsicatenipora shikokuensis NODA and HAMADA variety

Pl. 16, Fig. 1

Material:—Only one specimen (UHR 30450) from the upper part of the Yokokurayama Formation, at Loc. C.

Remarks:—Compared to the above described specimens of *Falsicatenipora shikokuensis,* the present form reveals a little smaller corallum which appears to be hemispherical rather than cylindrical. The size of fenestrules (0.7×1.6 to 1.0× 2.3 mm) and macrocorallites (0.45–0.5× 0.65–0.75 mm) is also smaller than that in the above described specimens. Microcorallites are absent. Otherwise the present specimen is quite identical with *F. shikokuensis,* of which it must be a small variety. The only comparable form of schedohalysitids with the present variety is *Schedohalysites yarrangobillyensis* HAMADA (=*Halysites* cfr. *lithostrotionoides* of HILL, 1954, p. 38–39, pl. 4, figs. 6a–b) as far as the size of fenestrules and macrocorallites are concerned. But this Australian form is provided with almost rectangular macrocorallites and distinct microcorallites according to description (HILL, 1954, p. 39). Also fenestrules may become irregular in *S. yarrangobillyensis,* while they are polygonal in the present variety. *F. shikokuensis* and *S. yarrangobillyensis* are thus easily distinguishable.

Genus *Schedohalysites* HAMADA, 1957

1957. *Schedohalysites* HAMADA, *Jour. Fac. Sci., Univ. Tokyo,* ser. 2, vol. 10, p. 401.

Type species:—Halysites orthopteroides ETHERIDGE, 1904.

Remarks.—After the review of halysitids by HAMADA (1957b, c) the genus *Schedohalysites* has been described by STRUSZ (1961) and MIRONOVA (1965). *Schedohalysites laxus* is introduced by MIRONOVA (1965) from the Ludlovian of Salair. For discussion on the genus see the above remarks on the subfamily Schedohalysitinae and on the genus *Falsicatenipora.*

Schedohalysites kitakamiensis (SUGIYAMA)

Pl. 17, Figs. 1–2; Pl. 19, Fig. 1; Text-fig. 4a

1940. *Halysites kitakamiensis* SUGIYAMA, *Sci. Rep. Tohoku Imp. Uuiv.,* second ser., vol. 21, p. 129–131, pl. 27(15), figs. 4–9; pl. 28(16), figs. 3–8; pl. 30(18), fig. 14; text-fig. 6.

1956. *Halysites kitakamiensis*: HAMADA, *Japan. Jour. Geol. Geogr.,* vol. 27, p. 134–140, pl. 9, figs. 1–6; text-fig. 1.

1958. *Schedohalysites kitakamiensis*: HAMADA, *Jour. Fac. Sci., Univ. Tokyo,* ser. 2, vol. 11, p. 100–101, pl. 6, fig. 3; pl. 8, figs. 4–5.

Materials.—Ten thin sections (UHR 30458–30461, 30464, 30466) have been prepared from six colonies from the G_3 limestone of the Yokokurayama Formation. One sample (UHR30458) was collected at Loc. D and the other at Loc. A.

Description.—Corallum is compound, cateniform, irregular in shape, varies in size. The largest specimen obtained shows block like appearance, and is 50× 60 mm in width with the height of 40 mm. Other surface characters are unkown.

In transverse section fenestrules are typically pentagonal or hexagonal in shape. They are about 2.3×2.5 mm to 3.2×4.5 mm in size, the average being 2.5×3.0 mm. However they may be irregular or open where free, straight or curved chains are present. Each chain consists of one or two macrocorallites in polygonal fenestrules. But in one fragmental corallum (UHR30446) as many as 12 macrocorallites are observed in a single chain. Macrocorallites are small, slender, subrectangular or elongated oval in shape. Their external size measures 0.6–0.7 mm × 1.0–1.3 mm. Corallite wall is thin, being 0.1 mm at the centre of its lateral side, but is thickened towards the junction between two neighbouring corallites giving the external surface of a chain only a little crenulated. Two or three, very short septal spinules are seen in some corallites (Text-fig. 4a). Mesocorallites are usually present at the junction of chains of corallites. They are triangular, or partly tetragonal, being 0.3 to 0.4 mm long on one side of mesocorallite. Microcorallites are present, but they are happened to be rather occasional in a specimen herein illustrated (Pl. 17, Fig. 1; Text-fig. 4a). The development of microcorallites is therefore variable. They are usually in slit form, and are 0.2×0.3 or 0.1×0.3 mm in size.

In longitudinal section macrocorallites are arranged parallel with each other. Tabulae in macrocorallites are complete and horizontal. Ten to twelve tabulae are counted in a vertical distance of 5 mm. In mesocorallites more densely arranged tabulae are seen. For microcorallites no suitable oriented thin sections to reveal tabulae are obtained. Secondary grown sparry calcite crystals often mask the true nature of tabulae and septal spinules, the latter of which are however definitely seen as dot like cut edges in some corallites. True tabulae are observed as thin dark lines of about 0.02 mm thick between interspaces filled with sparry calcite.

Remarks:—The specimens treated here are quite identical with *Schedohalysites kitakamiensis* described and figured by SUGIYAMA (1940) and HAMADA (1956, 1958), apart from that the microcorallites are less well developed in the present specimens. See HAMADA (1956) for specific comparison amongst various forms of *Schedohalysites*. *Schedohalysites laxus* MIRONOVA (1965, p. 135, pl. 32, figs. 1a-b) is clearly distinguishable from *S. kitakamiensis* in having much larger and oval macrocorallites compared to the latter species.

Schedohalysites sp.

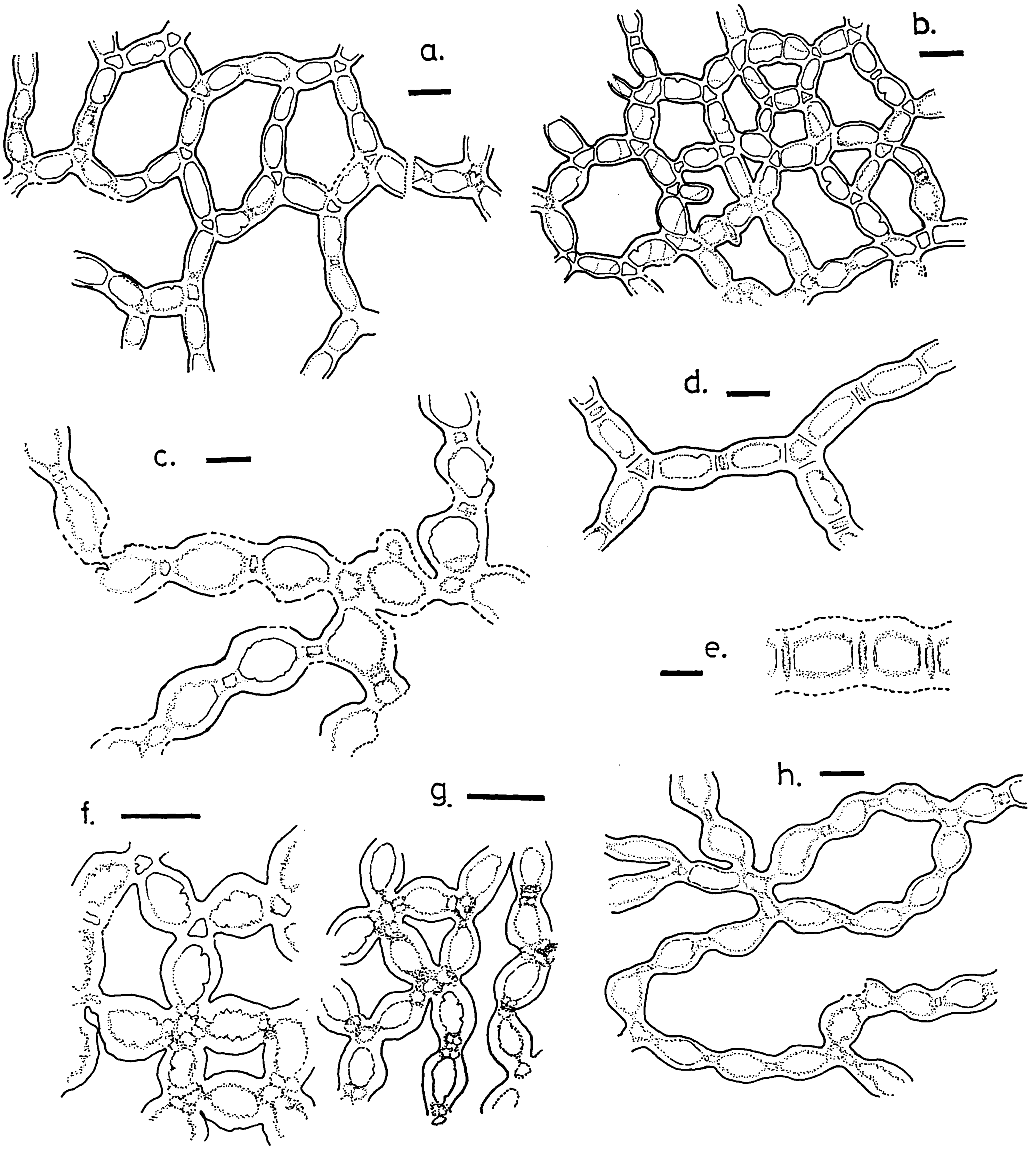
Pl. 16, Fig. 5; Text-fig. 4d

Material:—Single thin section (UHR 30462) collected from the G_3 member of the Yokokurayama Formation, at Loc. A.

Description:—Because of the imperfect nature of the specimen, the shape and surface characters of corallum are unknown. Corallum is small, measures 20× 30 mm in width as far as it is preserved. Fenestrules are irregular in shape and size. Although fragmentally preserved, they are usually tetragonal or pentagonal, from 0.75×1.5 mm to 4.3×5.0 mm in size, but sometimes make imperfect fenestrules. Each side of fenestrules is composed of one or two macrocorallites. Macrocorallites are rectangular or elongated oval in shape. Size of them measures 0.75-0.95 ×1.25-1.5 mm. Corallite wall is originally thin (about 0.1 mm), but partly thickened, being about 0.3 mm. They are thin at the centre of macrocorallites and are thickened at the junctions of two corallites, so that the surface of corallite chains seems somewhat smooth. No definite septal spinules are observed, but short, spinule like projections are occasionally seen on the inner surface of some macrocorallites. Mesocorallites are usually developed but sometimes lacking, when macrocorallites directly contact with each other. Mesocorallites are triangular in shape, 0.5-0.7 mm in length of each side. Microcorallites are partly developed (Text-fig. 4d), tetragonal and being 0.25×0.6 mm in size. Wall between corallites are divisible into three layers. At the centre of that wall dark coloured very thin layer (0.03-0.05 mm in thickness) is observed and then light coloured, fibrous, rather thick layers are developed at both sides of the dark layer. Corallite wall is 0.1-0.3 mm in thickness.

No longitudinal section is observed.

Remarks:—Although fragmentally preserved the present specimen belongs to the genus *Schedohalysites*, because of its definite possession of microcorallites. It



Text-fig. 4. Diagrams of halysitid corals collected from the Silurian of Mt. Yokokura region showing such characteristic features appeared in transverse sections as the shape of fenestrules, as the presence or absence of micro- and/or mesocorallites and septal spinules, and as "Balken" like structure in some forms.

a : *Schedohalysites kitakamiensis* (SUGIYAMA) (UHR30460a)
b : *Falsicatenipora shikokuensis* NODA and HAMADA (UHR30453)
c : *Halysites catenularius* (LINNAEUS) (UHR30439a)
d : *Schedohalysites* sp. (UHR30462)
e : *Halysites* sp. B (UHR30467)
f : *Halysites kuraokensis* (HAMADA) (UHR30441a)
g : *Halysites* sp. A (UHR30464)
h : *Halhsites suessmilchi* ETHERIDGE (UHR30463a)
Black bar represents 1 mm.

is similar to *Schedohalysites kitakamiensis* in general appearance. However it is distinguishable from the latter because of having larger corallites. In the shape and size of macrocorallites and fenestrules the present form closely resembles *Falsicatenipora japonica* (SUGIYAMA). Especially the specimen of *F. japonica* (SUGIYAMA) figured by HAMADA (1958, pl. 6, fig. 1) from the Kuraoka district rather closely resembles the present form even in having occasional microcorallites. Microcorallites are said to be absent in the original description of *Halysites japonicus* by SUGIYAMA (1940, p. 131), but this character has to be further confirmed by a restudy of original specimens. If microcorallites are proved to be present in the type materials of *Halysites japonicus*. *Falsicatenipora* based on *Halysites japonicus* would be considered as a junior synonym of *Schedohalysites*. The present specimen together with other identical forms may be called as *S. japonicus*. There is even a possibility that the nature of microcorallites is so variable in *Schedohalysites* that the presence or absence of them cannot be taken as a reliable distinguishing character between genera.

Subfamily Halysitinae MILNE-EDWARDS and HAIME, 1850

Genus *Halysites* FISCHER von WALDHAIM, 1813

1940. *Halysites*: SUGIYAMA, *Sci. Rep. Tohoku Imp. Univ.*, second ser., vol. 21, p. 129. (partim)
1954. *Halysites*: HILL, *Bull. Comm. Austr., Dept. Nat. Develop., Bureau Min. Resour., Geol. Geophy.*, no. 23, p. 37-38.
1954. *Halysites*: THOMAS and SMITH, *Ann. Mag. Nat. Hist.*, ser. 12, vol. 7, p. 766.
1955. *Halysites*: BUHELER, *Bull. Peabody Mus. Nat. Hist.*, no. 8, p. 21-22.
1956. *Halysites*: HILL and STUMM, Treatise on Invertebrate Paleontology, part F, F. 469.
1957. *Halysites*: HAMADA, *Jour. Fac. Sci., Univ. Tokyo*, ser. 2, vol. 10, p. 402.
1957. *Acanthohalysites* HAMADA, *Jour. Fac. Sci., Univ. Tokyo*, ser. 2, vol. 10, p. 402.
1961. *Acanthohalysites*: STRUSZ, *Palaeontology*, vol. 4, p. 353.
1962. *Halysites* (*Acanthohalysites*) YU, "Geology of Chi-len-shan", p. 80.
1966. *Halysites*: KLAAMANN, "Incommunicate Tabulata of Estonia", p. 59-60.
1967. *Halysites*: STASINSKA, *Palaeontologia Polonica*, vol. 18, p. 57.
1971. *Acanthohalysites*: SCRUTTON, *Bull. British. Mus. (Nat. Hist.)*, geol., vol. 20, p. 221.
1972. *Halysites*: LELESHUS, "Silurian Tabulata from Turkestan", p. 51.
1977. *Halysites*: JIA and WU, "Palaeontological atlas of Central-South China", part 1, p. 23-24.
1978. *Halysites*: YANG, KIM and CHOW, "Palaeontological atlas of Southwest China, Guizhou Volume", part 1, p. 228.

Type species:—*Tubipora catenularius* LINNAEUS, 1767.

Remarks:—Within the subfamily Halysitinae, HAMADA (1957b) distinguishes the genus *Acanthohalysites* from the genus *Halysites* (s. str.) for cateniform species with horizontal tabulae and septal spinules. In other words he places taxonomic importance in the character whether septal spinules are present or not in the classification of Halysitinae. However HAMADA (1958) pays little attention to this nature of septal spinules in the classification of Schedohalysitinae. As discussed recently by KAWAMURA (1980), it is still very questionable whether the character of septal spinules is important as generic criterion or not. For example in *Acanthohalysites kuraokensis* HAMADA the degree of development of septal spinules varies from individual corallite to the other, and from a colony to another. In some corallites 4 or 5 long septal spinules are present on one side of macrocorallites, while one or two short spinules are only to be seen in another corallites. The author agree with KAWAMURA (1980) as long as the nature of septal spinules is never a stable biocharacter at least in the subfamily Halysitinae. The genus *Acanthohalysites* is therefore considered here as a junior synonym of *Halysites*.

Halysites catenularius (LINNAEUS)

Pl. 16, Fig. 4; Pl. 19, Figs. 2-3;
Text-fig. 4c

1954. *Halysites catenularius*: THOMAS and SMITH, *Ann. Mag. Nat. Hist.*, ser. 12, vol. 7, p. 766-768, pl. 20, figs. 1a-c.
1955. *Halysites catenularius*: BUEHLER, *Bull. Peabody Mus. Nat. Hist.*, no. 8, p. 24-25, 28-29.
non 1956. *Halysites catenularius*: STEARN, *Mem. Geol. Surv. Canada*, no. 281, p. 71.
1962. *Halysites* sp. cfr. *H. catenularius*, JULL, *Jour. Alberta Soc. Petroleum Geol.*, vol. 10, no. 6, p. 327, fig. 1-I.
1962. *Halysites catenularius*: FLÜGEL, *Jb. Geol. B. A.*, Bd. 105, s. 316-317, taf. 22, fig. 4.

Materials:—Twelve thin sections (UHR 30435-30440) are prepared from six colonies, from the middle part of the G_2 member of the Yokokurayama Formation. They are collected at Loc. B.

Description:—Corallum is compound, cateniform, thick tabular or block like in shape. Specimens at hand are reletively small, being 15-20×30-40 mm in width and 10-15 mm in height. No external characters are observed.

In transverse section fenestrules are usually labyrinthine (Pl. 19, Fig. 2), but in a corallum they are more compressed polygonal in shape (Pl. 16, Fig. 4). A few selected fenestrules measure 2.0×4.5, 1.5×12.0, 6.0×9.5 mm, etc. Each chain is composed of one to five (maximum 7) macrocorallites. Macrocorallites are usually roundish oval or subcircular, and intermediate in size, being 1.45-1.85×1.5-2.0 mm. Average external size is 1.6×1.75 mm. The size of visceral chamber is 1.1×1.4 mm. Judging from calice of macrocorallite, which is filled with matrix, inner side of macrocorallite wall is almost smooth but very short spiny projections are partly developed on that inner wall (Pl. 19, Fig. 2; Text-fig. 4c). Wall is moderately thick, about 0.3 mm, but is recrystallized in many corallites. Mesocorallites may be triangular or tetragonal, 0.3-0.6 mm in length in each side. Microcorallites are rectangular or slit like, 0.2-0.3×0.3-0.4 mm in size. External wall of microcorallites and wall between micro- or mesocorallites and macrocorallites are

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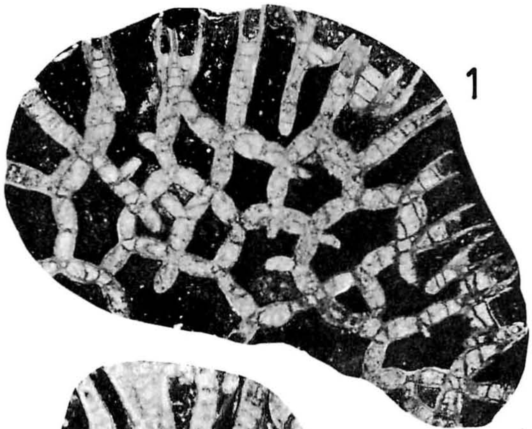
Explanation of Plate 16

Fig. 1. *Falsicatenipora shikokuensis* NODA and HAMADA variety
Transverse and partly oblique section (UHR30450a), Loc. C, ×5.
Figs. 2-3. *Falsicatenipora shikokuensis* NODA and HAMADA
2: Transverse section (UHR30453), Loc. C, ×5.
3: Longitudinal section (UHR30455), Loc. C, ×5.
Fig. 4. *Halysites catenularius* (LINNAEUS) and *Falsicatenipora shikokuensis* NODA and HAMADA in limy sandstone matrix. Transverse section (UHR30440a), Loc. B, ×2.
Fig. 5. *Schedohalysites* sp.
Transverse section (UHR30462), Loc. A, ×5.



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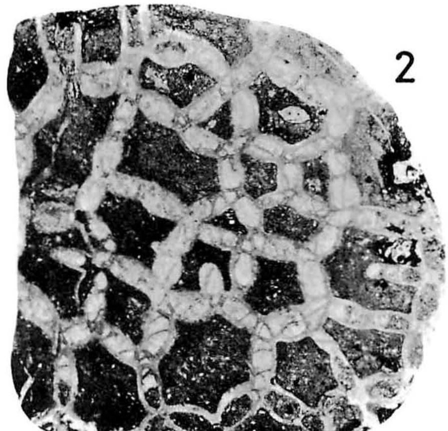

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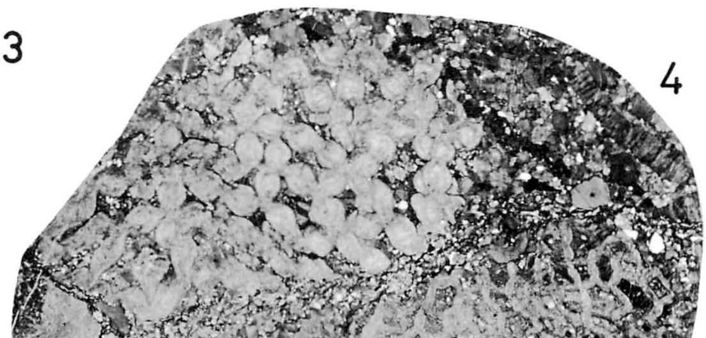

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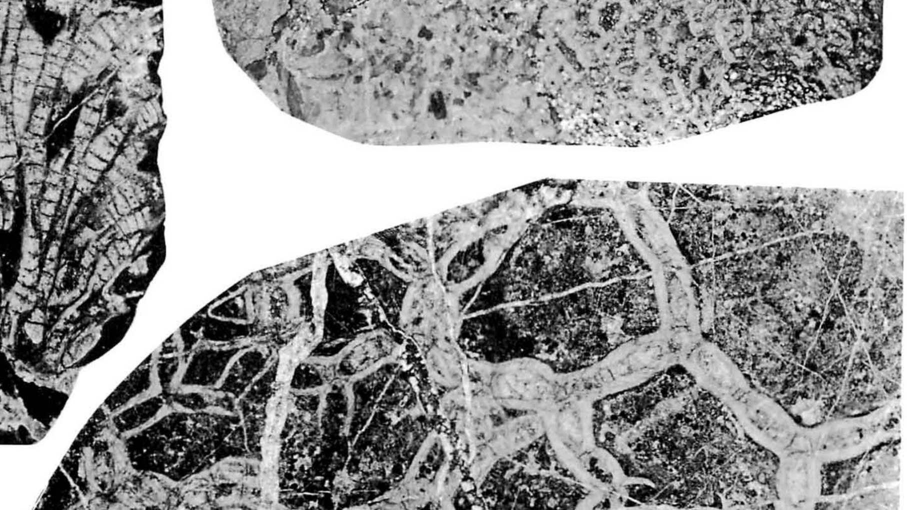

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somewhat thinner than that of macrocorallites and is 0.1-0.2 mm in thickness.

In longitudinal section tabulae in macrocorallites are complete and horizontal or slightly convex, 12-14 in number in a vertical distance of 5 mm. Tabulae in microcorallites or mesocorallites are also complete and horizontal. They are almost equally developed with those of macrocorallites, being 12-15 in 5 mm. Septal spinule like black dots are observable in some macrocorallites, but definite septal spinules are not discovered.

Remarks:—Specimens from the Yokokurayama region are here assigned to *Halysites catenularius,* although they reveal thick corallite wall and less pronounced labyrinthine in the shape of fenestrules compared to the neotype of *H. catenularius* chosen by THOMAS and SMITH (1954). Otherwise they are quite identical with *H. catenularius. H. catenularius* of STEARN (1956) is, according to his description, provided with 12 rows of septal spinules, flexuous tabulae and large macrocorallites. STEARN's form is definitely not assignable to *H. catenularius,* but may be close to *Halysites agglomeratus. H.* sp. cfr. *H. catenularius* figured by JULL (1962) closely resembles the present Japanese form, except that the shape of microcorallites in the Canadian form is more elongated. Probably the Canadian form is included in broadly defined group of *H. catenularius,* to which *H. catenularius* of FLÜGEL (1962) from Iran also belongs.

Halysites suessmilchi ETHERIDGE

Pl. 17, Fig. 5; Pl. 18, Figs. 3-4;
Text-fig. 4h

1904. *Halysites süssmilchi* ETHERIDGE, *Mem. Geol. Surv., New South Wales, Palaeont.,* no. 13, pt. 1, p. 26-27, pl. 3, figs. 3-4; pl. 7, figs. 1-3.

1955. *Halysites süssmilchi*: BUEHLER, *Peabody Mus. Nat. Hist.,* no. 8, p. 52-53.

1958. *Halysites süssmilchi*: HAMADA, *Jour. Fac. Sci., Univ. Tokyo,* ser. 2, vol. 11, p. 102-103, pl. 9, figs. 1-4.

1962. *Halysites* sp. cfr. *H. süssmilchi*: JULL, *Jour. Alberta Soc. Petroleum Geol.,* vol. 10, no. 6, p. 327, fig. 1-J.

Material:—Four thin sections prepared from only one colony (UHR30463a-d) collected from G_3 limestone of the Yokokurayama Formation, at Loc. A.

Description:—Corallum compound, cateniform, thick tabular in form, measures about 30×50 mm in width and 20 mm in height as far as it is preserved. Surface characters are unknown.

In transverse section fenestrules are irregular, mainly labyrinthine, but partly polygonal. They vary in size from 1.5×3.3 mm to 2.0×18.0 mm (Pl. 17, Fig. 5). Short side of fenestrules is composed of usually one or two macrocorallites and long side of fenestrules is composed of two or three macrocorallites in polygonal type. A single chain in labyrinthine fenestrules may be composed of as many as 12 macrocorallites. Macrocorallites are elongated oval or elliptical, sometimes nearly circular in shape, being 0.6-0.85×0.65-1.05 mm in external size. Corallite wall is originally thin, 0.1-0.15 mm thick. Although usually recrystallized, microcorallites are well developed, characteristically small, rectangular, being about 0.2 mm in length on each side. Mesocorallites are always triangular, being 0.3-0.4 mm in diameter. Corallite wall is usually recrystallized and much thickened. Therefore characters of inner side of wall are poorly preserved. Judging from some less recrystallized macrocorallites, inner side of corallite wall is usually smooth, besides septal spinule like undulation may be present in few corallites (Text-fig. 4h).

In longitudinal section tabulae in macrocorallites are complete and horizontal, sometimes only slightly convex upwards. Fourteen to seventeen tabulae are counted in a vertical distance of 5 mm. Only one longitudinal section of a microcorallite or a mesocorallite is available, in which tabulae are horizontal and spaced equally with those of macrocorallites.

Remarks:—The present from is quite identical with the Australian *Halysites suessmilchi* ETHERIDGE in having labyrinthine fenestrules with small, oval macrocorallites possessing no septal spinules. However it is different from the Australian material provided with smaller corallites. The same species has been described from the Yokokurayama region by HAMADA (1958), and that is provided with macrocorallites whose size ranges just between the figures of the Australian form and those of the present one. HAMADA's form (pl. 9, fig. 1) is more labyrinthine than the present form and the Australian one. In vertical section the nature of tabulae of the present form closely resembles that of the Australian form. Therefore except for size differences the present form stands much closer to the Australian form than to HAMADA's form.

Halysites sp. cfr. *H. süssmilchi* of JULL (1962) is very close to and is in fact identical with *H. suessmilchi* ETHERIDGE especially with the present Japanese form.

Halysites bellulus HAMADA (1958) is similar to the present form in the size and shape of macrocorallites. However it has polygonal fenestrules compared to rather meandrine fenestrules of the present specimen. *Halysites tenuis* HAMADA (1958) differs from *H. suessmilchi* in having small, rectangular macrocorallites and somewhat irregularly shaped fenestrules. *Halysites arisuensis* KAWAMURA (1980) closely resembles *H. suessmilchi* at a glance, but is distinguished from the latter by him only in having small and less oval macrocorallites. Feature of fenestrules of the present specimen does not differ considerably from that of *H. arisuensis*. If intraspecific variation should be recognized rather broadly in *H. suessmilchi*, *H. arisuensis* would fall within the category of *H. suessmilchi*.

Halysites kuraokensis (HAMADA)

Pl. 3, Figs. 1-2; Text-fig. 4f

1954. *Halysites* sp. HILL, Bull. Comm. Austr., Dept. Nat. Develop., Bereau Min. Resour., Geol. Geophy., no. 23, p. 39, pl. 4, fig. 9.
1958. *Acanthohalysites kuraokensis* HAMADA, Jour. Fac. Sci., Univ. Tokyo, ser. 2, vol. 11, p. 101, pl. 8, figs. 1-3.

Material:—Eleven thin sections (UHR 30441-30443, 30446-30449) are prepared from seven small colonies collected from

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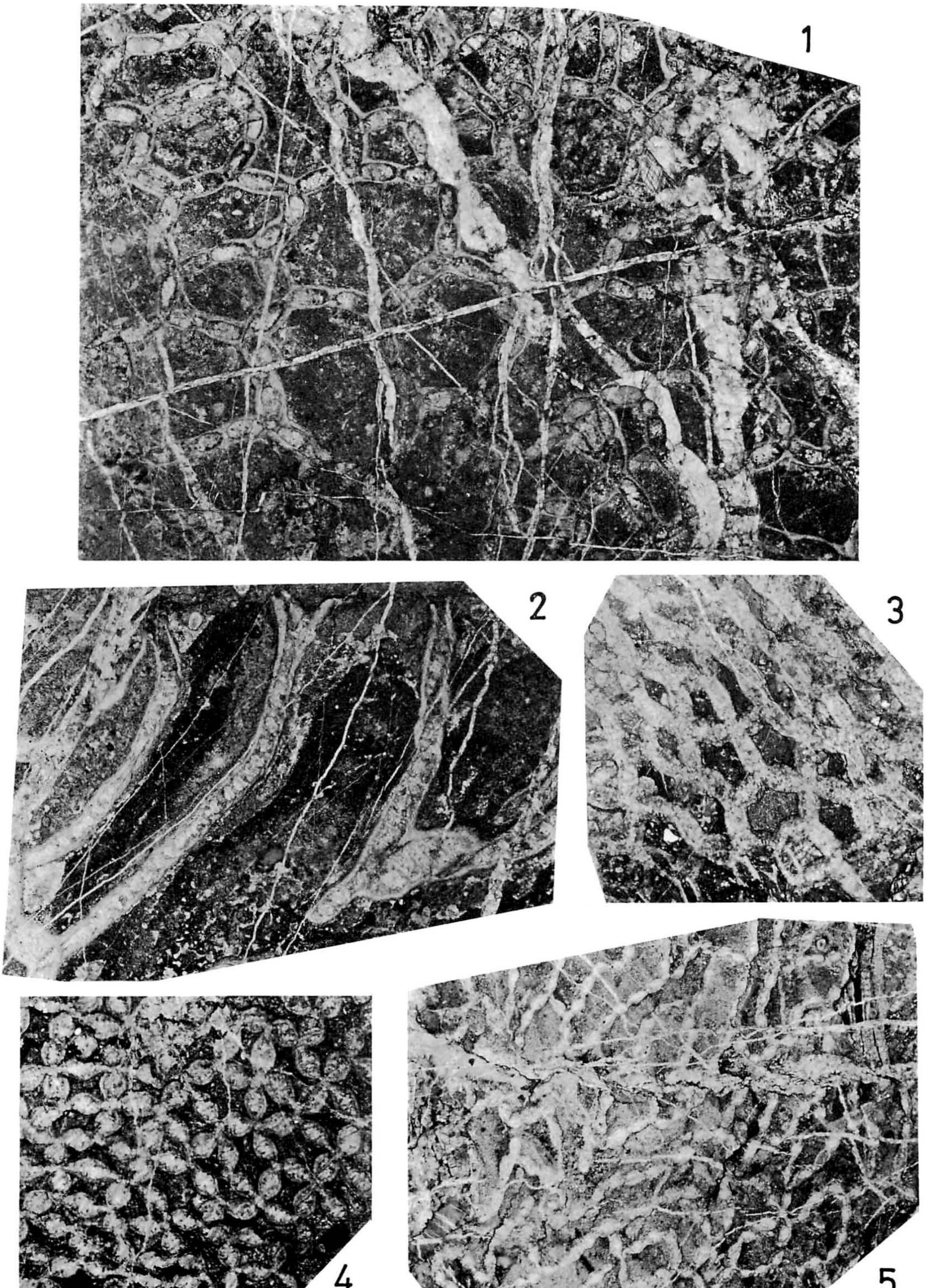
Explanation of Plate 17

Figs. 1-2. *Schedohalysites kitakamiensis* (SUGIYAMA)
1: Transverse section (UHR30460a) showing typically polygonal fenestrules, Loc. A, ×5.
2: Longitudinal section (UHR30459b), Loc. A, ×5.

Fig. 3. *Falsicatenipora shikokuensis* NODA and HAMADA
Oblique but nearly transverse section (UHR30445a), Loc. B, ×5.

Fig. 4. *Halysites kuraokensis* (HAMADA) variety
Transverse section (UHR30444a), Loc. B, ×5.

Fig. 5. *Halysites suessmilchi* ETHERIDGE
Transverse section (UHR30463a) showing labyrinthine fenestrules, Loc. A, ×2.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the middle part of the G_2 member of the Yokokurayama Formation, at Loc. B.

Description:—Corallum compound, cateniform and small. It may be tabulae or hemiglobular, judged from the arangements of corallites in longitudinal sections, which are subparallel or divergent (Pl. 3, Fig. 2). The size of corallum may attain 20-25×30-40 mm in width, and 15-30 mm in height.

In transverse section fenestrules are characteristically small, pentagonal or hexagonal, but partly tetragonal or even triangular in shape, being 1.0-1.5 mm× 1.5-3.0 mm in size. One side of a chain consists of typically one, occasionally of two macrocorallites. Macrocorallites are small, round oval, being 0.7-0.8×0.8-1.0 mm in size. Three to five septal spinules are observed on one internal side of macrocorallites. The long septal spinules may extend towards the axis nearly one-third of the short diameter of macrocorallite. Mesocorallites are always present, small and polygonal in shape, with the diameter of 0.25-0.3 mm. Microcorallites are, when observed, slit like form, being 0.05×0.3 mm in size. No septal spinules are obtained in microcorallites but one distinct septal spinule is observed in a mesocorallite (Text-fig. 4f). Corallite wall is about 0.15 mm thick and the one between a macrocorallite and a micro- or a mesocorallite is about 0.1 mm. When recrystallization has gone too far the visceral chamber of each corallite is completely filled with sparry calcite, leaving almost no internal features in it. In some specimens "Balken" like partition with light colour is seen between corallites to somewhat intrude into a little dark outer wall of corallite (Text-fig. 4f).

In longitudinal section corallites are either subparallel or divergently arranged. Tabulae in macrocorallites and also in mesocorallites are complete, horizontal but sometimes gently convex upwards and downward. They are 0.25-0.3 mm apart in macrocorallites and 0.2 mm apart in mesocorallites. Tabulae in microcorallites cannot be ascertained because of difficulty in obtaining well oriented, suitable thin section to reveal them. Septal spinules arranged in vertical series. And in transverse section of a few corallites, they are seen to be continuous as plates. Therefore septal spinules may be platy at their bases, while splitting and centrally projecting towards the axis of corallite.

Remarks:—Conspicuous feature of *Halysites kuraokensis* is its possession of small and polygonal fenestrules consist of one or two beautifully oval macrocorallites. All the present specimens are assignable to *H. kuraokensis* with certainty. In the mode of fenestrules *Halysites encrustans* BUEHLER (1955) closely resembles *H. kuraokensis* but the former has much larger macrocorallites, while septal spinules are much better developed in the latter. In the size and shape of macrocorallites *Halysites gamboolicus* ETHERIDGE (1904) is quite comparable with *H. kuraokensis*. But this Australian species shows much wider fenestrules which are polygonal but sometimes meandrine, compared to the Japanese form. In the size and shape of macrocorallites *Halysites louisvillensis* STUMM (1965) has some similarity with *H. kuraokensis*. Presence of many spinules in macrocorallites of the former species is also similar to the state in *H. kuraokensis*. However the American species reveals clearly meandrine fenestrules and is distinct from the Japanese species.

Halysites kuraokensis (HAMADA) variety

Pl. 17, Fig. 4

Material:—Only one specimen (UHR

30444) was collected from the middle part of the G_2 member of the Yokokurayama Formation, at Loc. B.

Remarks:—The specimen at hand is almost identical with the preceding *Halysites kuraokensis* in detail. The only difference between the two is that the former specimen reveals smaller size in every respect compared to the latter. The size of fenestrules in the present specimen is 0.3-0.8 mm×0.6-1.75 mm, the average being 0.75×1.25 mm. External size of macrocorallites is 0.6-0.8 × 0.7-0.9 mm. The present specimen is here considered to represent a small variety of *H. kuraokensis* described above.

Halysites sp. A

Pl. 19, Fig. 1; Text-fig. 4g

Material:—Only one fragmental specimen (UHR30464) was available from the G_3 member of the Yokokurayama Formation, at. Loc. A.

Description:—Because of fragmentally preserved, corallum shape and size are not exactly observed. Corallum is cateniform, very small, being 5.0×15.0 mm in width as far as it is preserved.

In transverse section fenestrules are distinctly very small, and polygonal in shape. They are tetragonal, pentagonal and hexagonal, or partly triangular in form. Their size is somewhat variable and measures 0.5-0.7×0.5-1.5 mm in width. Each side of fenestrules consists of one or two macrocorallites. Macrocorallites are characteristically small and typically eye shaped, or rugby ball like in form, being 0.45-0.55×0.65-0.8 mm in external size. One or two very short septal spinules are often observed on each side of macrocorallite wall. Mesocorallites are well developed, triangular or rectangular, 0.2-0.3 mm in length on each corallite side. Microcorallites are also developed and very small. They are subrectangular in shape and 0.1 mm in diameter. Wall is very thin and 0.05 to 0.07 mm in thickness. "Balken" like structure is usually developed at each junction of two corallites (Text-fig. 4g).

No longitudinal section is obtainable.

Remarks:—The present form is characterized by very small, polygonal fenestrules with very small macrocorallites having less pronounced septal spinules. No comparable forms with the present one have been described in a group of halysites without septal spinules (ETHERIDGE, 1904). In a group of halysitids with characteristically polygonal shape of small fenestrules the present form closely resembles *Halysites encrustans* and *H. kuraokensis*. *H. encrustans* differs however from the present form in having much larger macrocorallites. *Halysites kuraokensis* most resembles the present form but is distinguishable from the latter in

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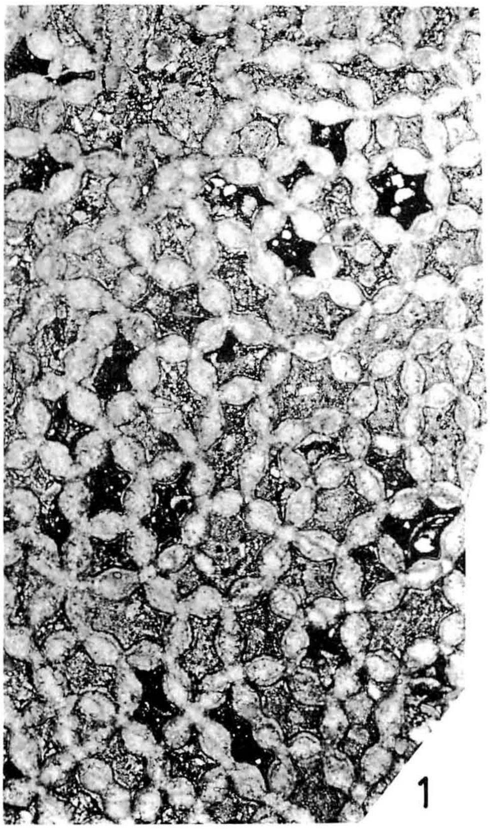
Explanation of Plate 18

Figs. 1-2. *Halysites kuraokensis* (HAMADA)
1: Transverse section (UHR30441a), Loc. B, ×5.
2: Longitudinal section (UHR30443b), Loc. B, ×5.

Figs. 3-4. *Halysites suessmilchi* ETHERIDGE
3: Transverse section (UHR30463b), Loc. A, ×8.
4: Longitudinal section (UHR30463c), Loc. A, ×8.

Fig. 5. *Halysites* sp. B
Transverse section of fragmental specimen (UHR30467), Loc. A, ×5.



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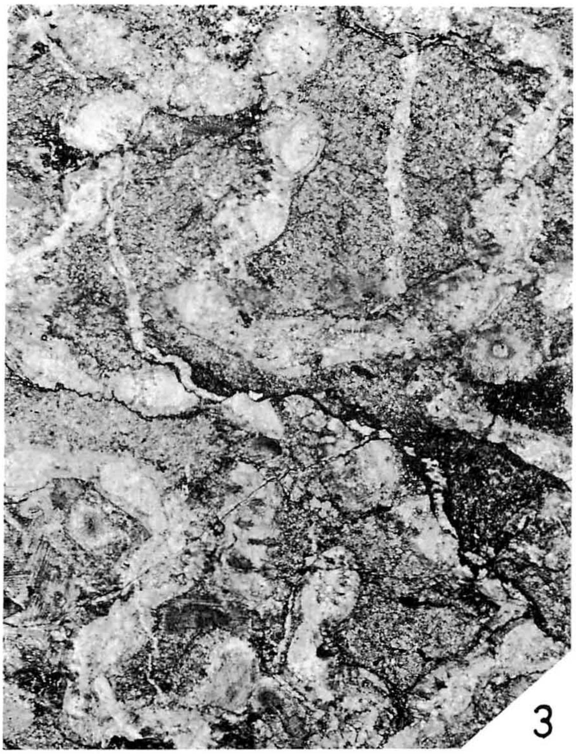

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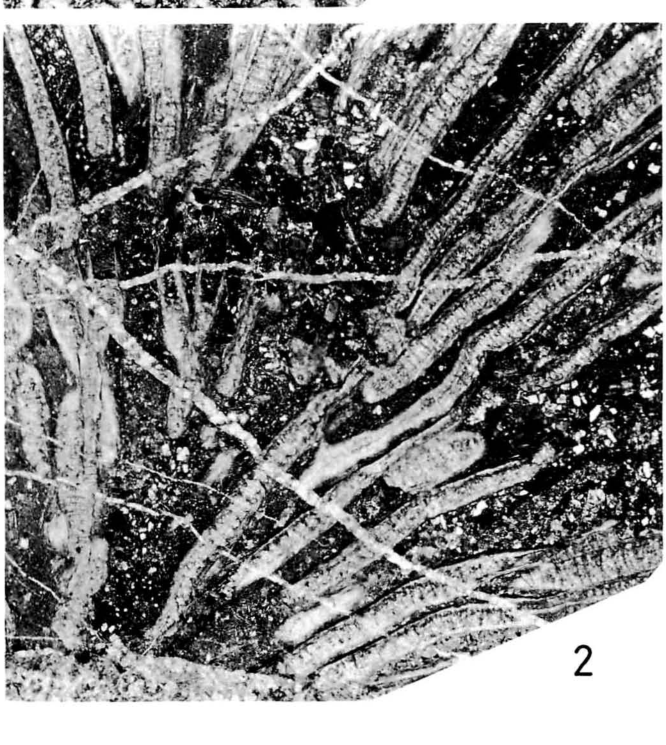

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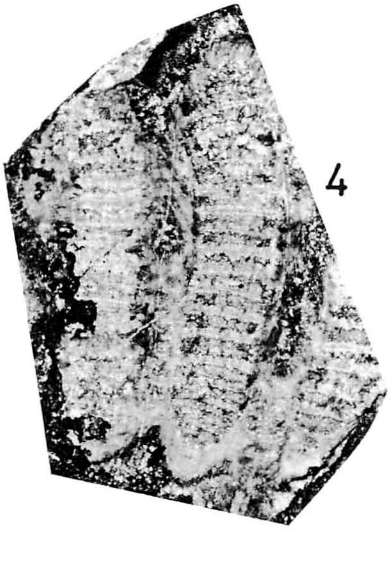

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having larger macrocorallites with well developed septal spinules. Another comparable species with the present one is *Halysites gamboolicus* ETHERIDGE from Australia, especially in respect to their size and shape of macrocorallites which carries less developed septal spinules. This Australian species differs from the Japanese form in having larger fenestrules and macrocorallites which have more conspicuous septal spinules compared to the latter.

The present form belongs to the smallest member of the genus *Halysites* as far as the size of macrocorallites are concerned. It may represent a new species related to *Halysites kuraokensis*. More specimens are needed to clarify its nature in longitudinal section and the extent of morphological variation within the form, before the author proposes a new species for this type of coral.

Halysites sp. B

Pl. 18, Fig. 5; Pl. 19, Figs. 4-5;
Text- fig. 4e

Material:—Three fragmental specimens represented by three thin sections (UHR30465-30467) have been collected from the G_3 limestone of the Yokokurayama Formation, at Loc. A.

Description:—All specimens are fragmentally preserved. Corallum shape and size and fenestrule characters are not observed. The largest specimen collected by the author, is a gently curved, single chain which consists of only six macrocorallites (Pl. 19, Fig. 4).

In transverse section macrocorallites are roundish oval or circular, being 1.5×1.7 mm in external size. Corallite wall is extremely thick, and measures 0.5 to 0.6 mm in thickness. In contrast, wall between macro- and microcorallite is very thin, being 0.05-0.1 mm in thickness. Mesocorallites are not preserved. Microcorallites are slit-like, being 0.05-0.1×0.3 mm in size (Text-fig. 4e). Because corallite wall is usually recrystallized and sometimes much thickened, inner characters of macro- and microcorallites cannot be examined.

In transverse section tabulae of macrocorallites are thin, complete and horizontal or gently concave upwards. They distribute 0.3-0.4 mm apart. Tabulae of microcorallites are not observed.

Remarks:—No identical species with the present form is readily available, although the latter is imperfectly preserved and poorly represented.

Amongst forms of halysitids with round and thick walled macrocorallites *Halysites cratus* ETHERIDGE of HAMADA (1958, pl. 10, fig. 5), *H. regularis* FISCHER-BENZON figured by KLAAMANN (1966, pl. 19, figs. 6-7), *H. junior* KLAAMANN (1966), *H. senior* KLAAMANN (1966) described by STASINSKA (1967, 1974), *H. crassus* STASINSKA (1974) and *H. junioformis* STASINSKA (1974) may be comparable with the present Japanese form. *Halysites cratus* of HAMADA (1958) is a badly crystallized form which shows thin and at the same time much thickened corallite wall. The present form has more round macrocorallite with much thicker wall, and much thinner microcorallites compared to HAMADA's form. *Halysites junior* KLAAMANN (KLAAMANN, 1966, pl. 18, figs. 1-4; pl. 19, figs. 4-5; text-fig. 28a-b, STASINSKA, 1967, pl. 8, figs. 1, 3a-b and STASINSKA, 1974, pl. 18, figs. 4-5) and *H. senior* KLAAMANN (KLAAMANN, 1966, pl. 19, figs. 2-3, STASINSKA, 1967, pl. 9, fig. 2a-b and STASINSKA, 1974, pl. 8, figs. 1, 3; pl. 9, fig. 2) and *H. regularis* FISCHER-BENZON figured by KLAAMANN (1966) all have decidedly larger macrocorallites than the Japanese form which has macrocorallites of intermediate size. In the size of macrocorallites *Halysites junioformis* is comparable to the present form. The former has a little smaller macrocorallites with less thick wall. Microcorallites are wider in *H. junioformis* than in the present form.

Halysites sp. A of KAWAMURA (1980, p. 288-290, pl. 7, fig. 4, pl. 8, figs. 1-2; text-figs. 7a-b) is another ally to the present form. But this form has more oval, slightly larger macrocorallites which are more distinctly spaced; while the present form has round, closely spaced macrocorallites with much thicker wall.

The present form is unfortunately too imperfect to treat as representing a new form.

Acknowledgement:—The author acknowledges Emeritus Professor Masao MINATO and Dr. Makoto KATO of Hokkaido University, and Professor Masae OMORI of Azabu University for their guidance, supervision and encouragements. Dr. KATO critically read the manuscript. Assistance has been rendered by the staff and fellow students of the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University.

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Explanation of Plate 19

Fig. 1. *Halysites* sp. A, with fragments of *Schedohalysites kitakamiensis* (SUGIYAMA) and thamnoporoid
Transverse section (UHR30464), Loc. A, ×8.

Figs. 2-3. *Halysites catenularius* (LINNAEUS)
2: Transverse section (UHR30439a), Loc. B, ×5.
3: Longitudinal section (UHR30439b), Loc. B, ×5.

Figs. 4-5. *Halysites* sp. B
4: Transverse section (UHR30465), Loc. A, ×5.
5: Tangential section (UHR30466), Loc. A, ×5.

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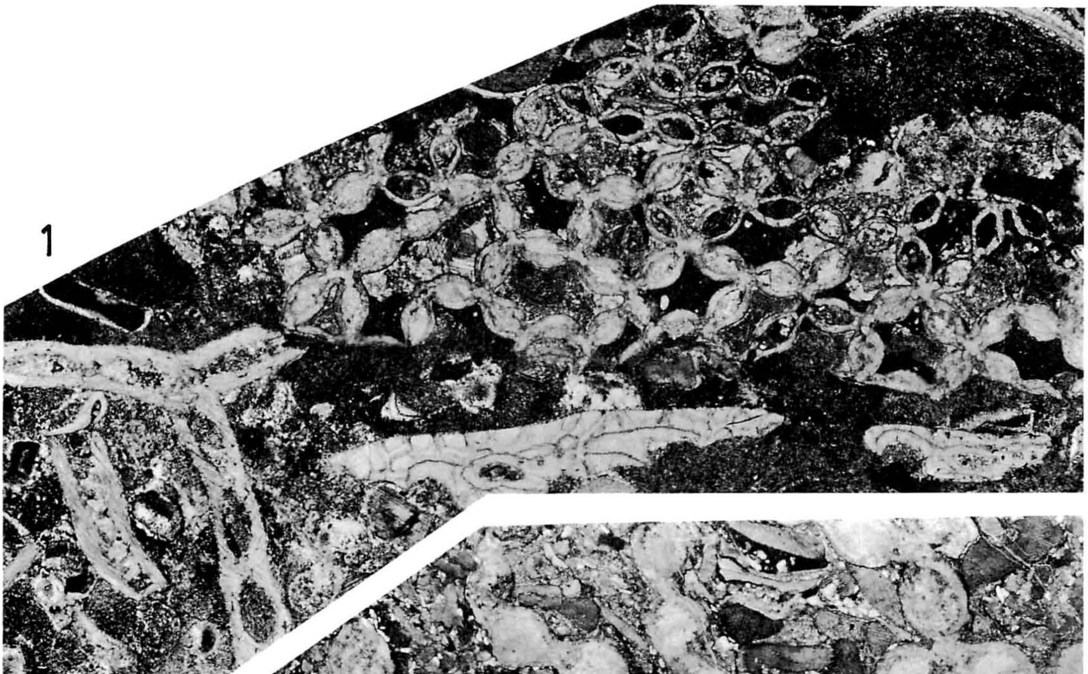

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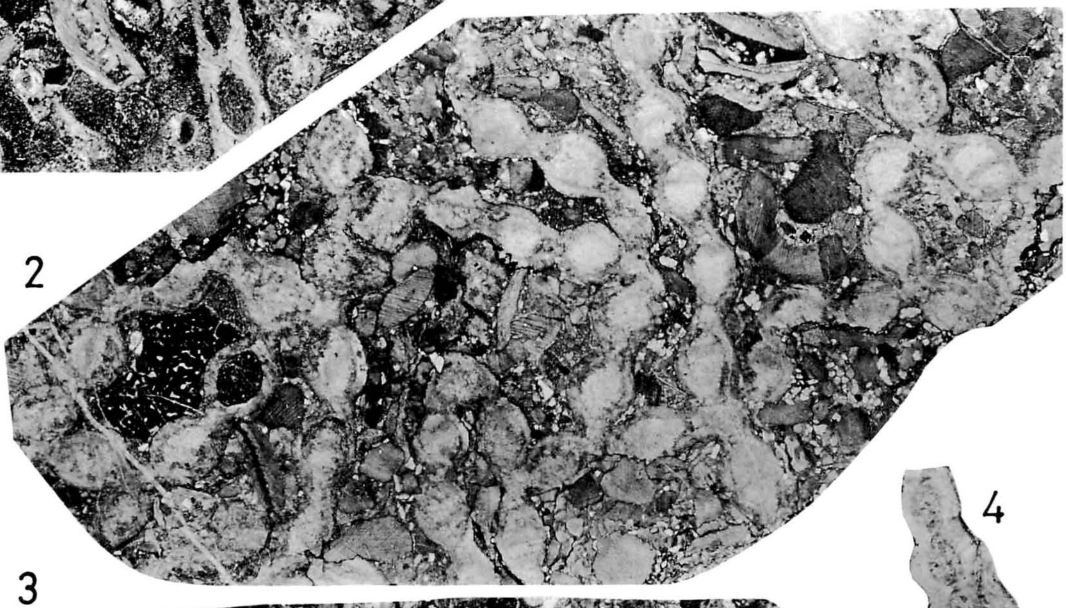

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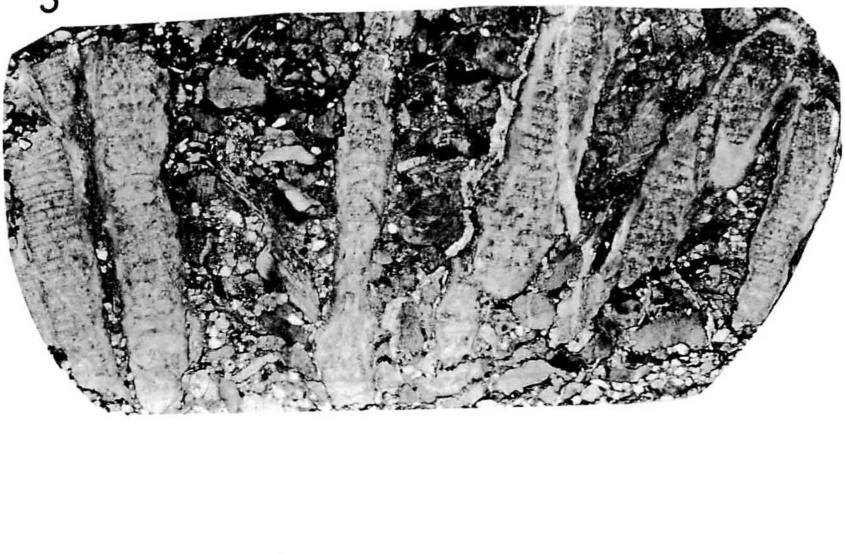

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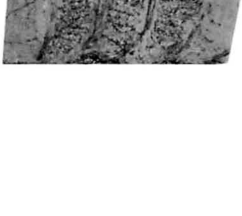

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Gomi 五味, Kuraoka 鞍岡, Kurosegawa 黒瀬川, Ochi 越知, Shiroishi 白石, Gion-yama 祇園山, Mt. Yokokura (=Yokokurayama) 横倉山, Niyodo R. 仁淀川, Ogiri R. 大桐川

高知県横倉山の横倉山層産シルル紀サンゴ類—その 1, Halysitidae—: 筆者は, 現在, 高知県横倉山産のシルル紀サンゴ類について, 古生物学的研究を進めているが, ここに第 1 報として, 同地域の 4 地点より産出した Halysitids, 8 種を記載し, あわせて, 同産地の地質について略記する。本報告で記載した種は以下の通りである。*Schedohalysites kitakamiensis* (SUGIYAMA), *S.* sp., *Falsicatenipora shikokuensis* NODA and HAMADA, *Halysites catenularius* (LINNAEUS), *H. suessmilchi* ETHERIDGE, *H. kuraokensis* (HAMADA), *H.* sp. A, *H.* sp. B. これらのうち, *Halysites* sp. A と *H.* sp. B は, 不完全な標本ではあるが, おそらく新種と考えられる。また, *Halysites catenularius* (LINNAEUS) と *H. kuraokensis* (HAMADA) は, 本地域からは初めての産出である。 中井 均

Trans. Proc. Palaeont. Soc. Japan, N.S,, No. 123, pp. 159-167, pls. 20,21, September 30, 1981

734. STUDIES ON THE ONTOGENIC AND PHYLOGENIC DEVELOPMENT OF TWO UPPER CAMBRIAN TRILOBITES FROM SOUTH DAKOTA*

CHUNG-HUNG HU

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Abstract. The ontogenic and phylogenic development of *Parabolinoides contractus* and *Taenicephalus shumardi* are described. The morphogenesis of these trilobite larvae are subdivided into three different metamorphic stages: paraprotaspid, early meraspid, and late meraspid stages. These two trilobites were possibly the direct descendants of the *Elvinia-Irvingella* stock due to the neotenic evolution of late meraspis, and the progenitor of the later trilobite *Ptychaspis-Prosaukia* through continuum orthogenetic neoteny of the early meraspis.

Introduction

The purpose of the present report is to describe the ontogenic and phylogenic development of two Upper Cambrian, *Conaspis* Zone trilobites from North America: *Parabolinoides contractus* FREDERICKSON and *Taenicephalus shumardi* (HALL). The ontogenic sequences of the species are subdivided into three different morphologic stages: paraprotaspid, early meraspid, and late meraspid stages. All of these stages are with distinct morphologic characteristics. In the paraprotaspid stage, the carapace is subround or trapezoidal in outline, about 0.50-0.80 mm in length (sag.), and consists of a large cephalic and a small transverse protopygidial shield. The early meraspid skeleton is often disassociated from the pygidium, the sagittal length of the cranidium is about 0.75-1.20 mm long (sag.); the anterior border appears, and the posterior fixigenal border broadens. The late meraspid cranidium is 0.90-1.60 mm long (sag.), trapezoidal in outline with a narrow preglabellar field lying between the frontal furrow and the preglabellar margin, and with complete glabellar furrows.

Quite a few ontogenic development of pre-*Conaspis* Zone (=*Elvinia* Zone) trilobites are known. These include *Elvinia roemeri* (SHUMARD), *Cliffia typica* HU, *Irvingella major* ULRICH & RESSER, *Cameraspis convexa* (WHITFIELD) (HU, 1979), *Housia ovata* PALMER, *Aphelotoxon triangulata* HU, *Pulchricapitus davisi* KURTZ (HU, 1980), *Ponumia obscura* (LOCHMAN), *Housia canadensis* (HU, 1970)...etc. Within these species, the protaspis and meraspis of *Parabolinoides contractus* and *Taenicephalus shumardi* both have morphologic characteristics similar to the late meraspis and even early holaspis of *Elvinia-Irvingella*, all possess the small ocular lobe, narrow anterior border, broad triangular fixigena, incomplete glabellar furrows, and the same shaped pygidium.

* Received February 27, 1981.

Thus, it might be postulated that the direct progenitor of *Parabolinoides* and *Taenicephalus* was possibly the *Elvinia-Irvingella* stock due to neotenic evolution.

A very well preserved ontogenic sequence of the post *Conaspis* Zone (= *Ptychaspis-Prosaukia* Zone) trilobite *Ptychaspis bullasa* LOCHMAN & HU was reported from Preston Quadrangle, Idaho by HU (1971). This trilobite has some morphologic similarities to the early meraspis or even late protaspis of *Parabolinoides-Taenicephalus*. They all possess a narrow anterior border, medium-sized palpebral lobe, segmented glabella, broad triangular fixigena, and densely granulated skeletal surface. The similarities of these species may also be indicative of neotenic evolution of the early meraspis of *Parabolinoides-Taenicephalus*, i. e., the continuum orthogenetic neoteny from the *Elvinia-Irvingella*, thoughout the *Parabolinoides-Taenicephalus* to the *Ptychaspis-Prosaukia* stocks.

Acknowledgements.—The author wishes to express his thanks to Dr. C. LOCHMAN-BALK, New Mexico Institute of Mining and Technology, for her guidance at the summer field camp around the Black Hills, South Dakota, 1962, on which the present studied materials were collected. Thanks are also go to Dr. Kenneth E. CASTER, University of Cincinnati for reading over the present manuscript. The described specimens are all stored in the Geology Museum, University of Cincinnati (GMUC), Ohio.

Paleontological Description

Genus *Parabolinoides* FREDERICKSON, 1949

Parabolinoides contractus FREDERICKSON

Pl. 20, Fgs, 1-35; Text-fig. 1.

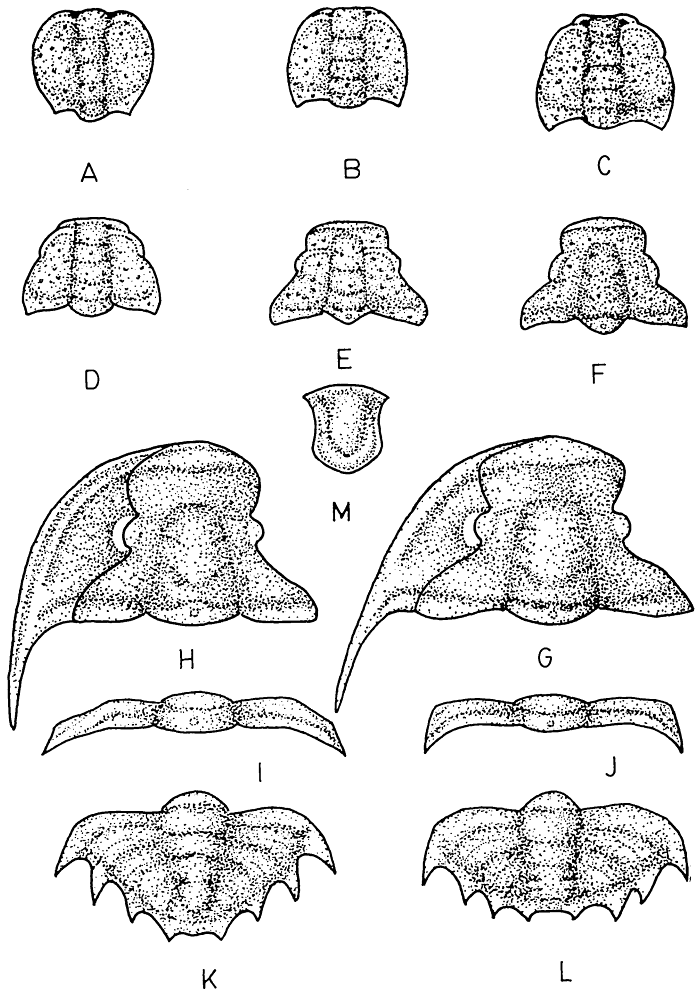
Parabolinoides contracus FREDERICKSON, 1949, p. 311, pl. 71, figs. 4-10; BERG, 1953, p. 564, pl. 59, fig. 3; BELL & ELLINWOOD, 1962, p. 399, pl. 56, fig. 12; LOCHMAN, 1964, p. 49, pl. 12, figs. 1-14; HU, 1969, p. 449, pl. 3, figs. 1-38 & text-fig. 5.

Parabolinoides hebe FREDERICKSON, 1949, p. 361, pl. 70, figs. 7, 8; pl. 71, figs. 1-3; BERG, 1953, pl. 564, pl. 59, fig. 24; BELL & ELLINWOOD, 1962, p. 400, pl. 56, figs. 6-11; KURTZ, 1975, p. 1040, pl. 4, figs. 38, 39.

Remarks.—The present species is represented by very abundant immature and mature skeletal fragments. The adult skeletons are characterized by two different morphologic groups; one group has a broad and short glabella, broad anterior brim, broad librigena, and semicircular pygidium; and the other group has a narrower and longer glabella, narrower anterior brim, narrower librigena, and subtriangular pygidium. These differences are here postulated as sexual dimorphism within the same species population. The first groups is briefly assigned to "male" and the second to "female" forms.

BELL & ELLINWOOD (1962) figured a few cranidia and pygidia identified as *P. hebe* (pl. 54, figs. 6-11) and *P. contractus* (pl. 56, fig. 12). The cranidia (=*P. hebe*; pl. 56, figs. 6-9) are here identified as "female" forms, and those of cranidium and pygidium (=*P. contractus*, pl. 56, fig. 12; *P. hebe*, pl. 56, figs. 10, 11) are correlated as "male" in the present report. STITT's (1971) *P. contractus* (pl. 2, figs. 11, 12) and KURTZ's (1975) *P. hebe* (pl. 4, figs. 38, 39) are synonymized as "female" and "male" forms, within the same species population in the present text.

The ontogenic development of the present species are comparable with those materials reported from the same general area and the formation by HU (1969), except that the earliest known immature skeletons found in the present studied materials are assigned to the paraprotaspid stage (Pl, 20, Fgs. 1-6; Text-fig. 1A). This instar is subround with five axial rings and possibly a small protopygidium; the protopygidium is tilted sharply downward, so that its characteristics are not easily discerned. The skeletal surface is coarsely covered by granules. The larger instars are similar to occurrences in the Bear Butte reported by HU (1969).



Text-fig. 1. *Parabolinoides contractus* FREDERICKSON.

A-C, a growth sequence of paraprotaspid cranidia, showing the breadth of the posterior fixigenal border. ×60, ×55, ×50; D, an early meraspid cranidium, showing the presence of the anterior border. ×30; E, F, two sizes of late meraspid cranidia; notice the presence of the preglabellar field. ×24; G, H, "female" and "male" cranidia associated with left librigena, showing the different shaped glabella and the incomplete last glabellar furrows. ×4, 5; I, J, two different shaped thoracic segments. ×4, ×5; K, L, "female" and "male" pygidia, showing the triangular and semicircular pygidial shapes. ×3, ×4; M, a small hypostoma.

A small hypostoma from the present studied materials is a bit longer and broader than that of the Bear Butte assemblage and is assigned to an early or late meraspid stage of the same species.

The ontogenic development of the present species is certaintly closely related to *Aphelaspis* sp. (PALMER, 1962; HU, 1969; HU & TAN, 1971), *Olenus, Dunderbergia, Dytremacephalus* (STRAND, 1927; STØRMER, 1942; HU, 1971), *Elvinia, Irvingella, Cameraspis* (HU, 1979), and *Parabolinoides* (HU, 1969). The earliest progenitor of the genus *Parabolinoides* was the *Aphelaspis-Olenus* stock and the most proximal progenitor was the *Elvinia-Irvingella* stock. The adult cranidium of the genus *Parabolinoides* has some morphologic charateristics similar to those of the meraspid cranidium of *Elvinia*; i. e., the same shaped glabella, an incomplete last glabellar furrow, broad triangular fixigena, and same breath of preglabellar field, and a medium-sized palpebral lobe. These similarities are possibly due to neoteny of the genus *Elvinia* or *Irvingella* during its late meraspid stage.

There are also quite a few genera whose protaspides were similar to *Elvinia*; i. e., *Housia, Ponumia, Cliffia, Aphelotoxon* (HU, 1970, 1979, 1980) etc., but it seems that these forms are unlikely to be the direct progenitor of the genus *Parabolinoides*, because their meraspid cranidia all possess a conical glabella, unsegmented glabellar lobe, and shallow dorsal furrows.

Horizon and Locality.—Deadwood Formation, Upper Cambrian, *Conaspis* Zone; White Canyon, about 5 miles, north-east of Deadwood City, South Dakota.

Figured specimens.—GMUC. 43344, 43344 a-z, 43344a'-e'.

Genus *Taenicephalus* ULRICH & RESSER, 1924

Taenicephalus shumardi (HALL)

Pl. 21, Figs. 1-28; Text-fig. 2.

Taenicephalus shumardi (HALL), LOCHMAN & HU, 1960, p. 811, pl. 95, figs. 12-23, 31 (synonymy to date).

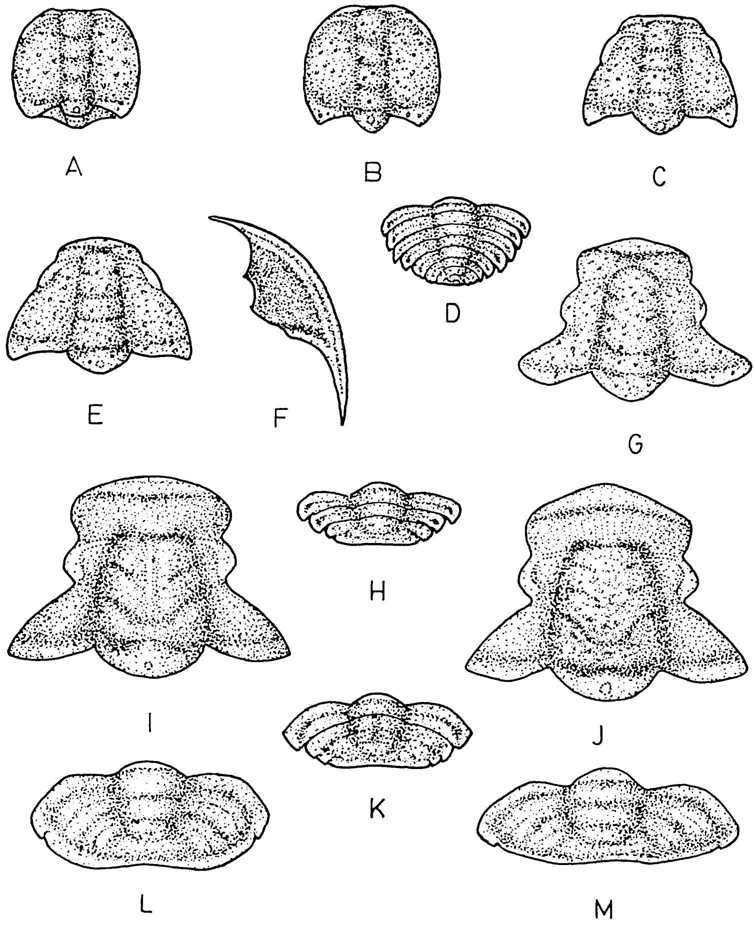
Taenicephalus shumardi (HALL), KURTZ, 1975, p. 1041, pl. 4, figs. 44, 45 (synonymy to date).

Remarks.—The present studied materials are closely related to those from the Wind River Mtns. reported by LOCHMAN & HU (1960). The similarities are especially indicated by the transverse pygidium and the short marginal spines. GRANT (1965) figured two triangular to round pygidia from the Snowy Range Formation, Montana. These two different form pygidia might not be *Taenicephalus shumardi* but *Parabolinoides contractus*, since they are distinctly different with those of typical ones.

The present species is represented by two different morphologic groups as was the case in *Parabolinoides contractus*. The first group has a quadrate glabella and broader pygidial marginal border, the other a truncatoconical glabella and narrower pygidial margin. These bimodal phenomena are postulated as sexual dimorphism within the same species population. The former is "female" and the latter "male", as commonly reported in various species by the author (HU, 1968, 1971... etc.).

Taenicephalus shumardi (HALL), ontogeny

The ontogenic development of the present species is incompletely known. However, the instars can be assigned to three different stages: paraprotaspid, early meraspid, and late meraspid. The main morphologic characteristics of these stages



Text-fig. 2. *Taenicephalus shumardi* (HALL).
A, B, paraprotaspides. ×35, ×25; C, early meraspis. ×20; E, G, two late meraspid cranidia. ×18, ×14; F, a librigena. ×3; D, a protaspid pygidium. ×24; I, J, "female" and "male" cranidia. ×4, ×6; H, K, two meraspid pygidia, showing the associations of one or two thoracic segments. ×15, ×10; L, M, "female" and "male" pygidia. ×3, ×5.

are comparable to those of *Parabolinoides contractus* FREDERICKSON.

Paraprotaspid stage (Pl. 21, Figs. 1-4; Text-fig. 2A, B).—The shield is about 0.45 to 0.60 mm in sagittal length, trapezoidal to subround in outline, convex, divided into a large cranidium and a small transverse triangular protopygidium; the cranidial shield is divided into axial and pleural lobes by deeply impressed furrows; the axis is cylindrical, contains five annular rings—a round frontal lobe, three transverse oval segments, and a small terminal portion; all are distinctly demarked by furrows; the sides of the frontal lobe are depressed by a pair of distinct triangular pits, and a pair of superciloid ridges extends laterally from the frontal lobe in front of the anterior pits; the fixigenal area is broader than the axis on the mid-line of the cranidium (tr.), convex along the free margin, and defined by a narrow marginal border; the narrow elevated palpebral ridges are curved posterolaterally from the sides of the frontal lobe behind the anterior pits and end at the same level as the anterior second axial ring (tr.); the posterior fixigenal border is narrow, distinctly demarked by a border furrow, and is about the same width as the occipital ring (tr.); the lateral end of the fixigenal border is modified by a pair of short broad fixigenal spines which projected posteriorly; the convex protopygidium slopes downward sharply from behind of the posterior cranidial margin; it is small, transverse lenticular, and contains one or two segments; no marginal spines are observed. The surface of the skeleton is covered by coarse granules.

Early meraspid stage (Pl. 21, Figs. 5, 8-10; Text-fig. 2C, E).—The cranidium is trapezoidal in outline, convex, and about 0.50-0. 80 mm in length (sag.); the glabella is deeply defined by a dorsal furrow, and divided into four glabellar segments by deep furrows; the anterior glabellar segment is roundly quadrate, and the second to fourth are similar in shape, being convex, and transverse oval; the occipital ring is subtriangular and convex, bearing a tiny median node; a narrow arched anterior border appears along the cranidium; it is elevated and distinctly delimited by furrows; the triangular fixigena is convex, and has a medium-sized well-delimited and narrow palpebral lobe situated in front of the mid-line of the glabella (tr.); the elevated palpebral lobe is arched and extends continuously from the anterior palpebral ridge, and ends on the same transverse line as the second glabellar segment; the posterior fixigena is about the same width as the occipital ring between the fixigenal spine and the base of the glabella; the fixigenal border is narrow toward the occipital ring, broad laterally, and ends in a short fixigenal

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Explanation of Plate 20

Figs. 1-35; *Parabolinoides contractus* FREDERICKSON.

1-6, a growth sequence of paraprotaspides, showing the annular axial segments and the completion of the posterior fixigenal border. 1-4, ×60; 5, 6, ×55; GMUC. 43344, 43344a-d.

7-11, a growth series of early meraspid cranidia, showing the presence of the anterior border and the slender conical glabella. ×23, ×30, ×25, ×28, ×24. GMUC. 43344e-i.

12-16, a growth sequence of late meraspid cranidia, showing broadening of the preglabellar field. 12, ×24; 13-15, ×13; 16, ×10; GMUC. 43344j-n.

18, 28, 31, dorsal and side views of small and large triangular "female" pygidia. 18, ×6.5; 28, ×3; 31, ×3.5; GMUC. 43344p, 43344a'.

19, 34, two small librigenae, showing the narrow ocular platform. ×8, ×6; GMUC. 43344q, 43344d'.

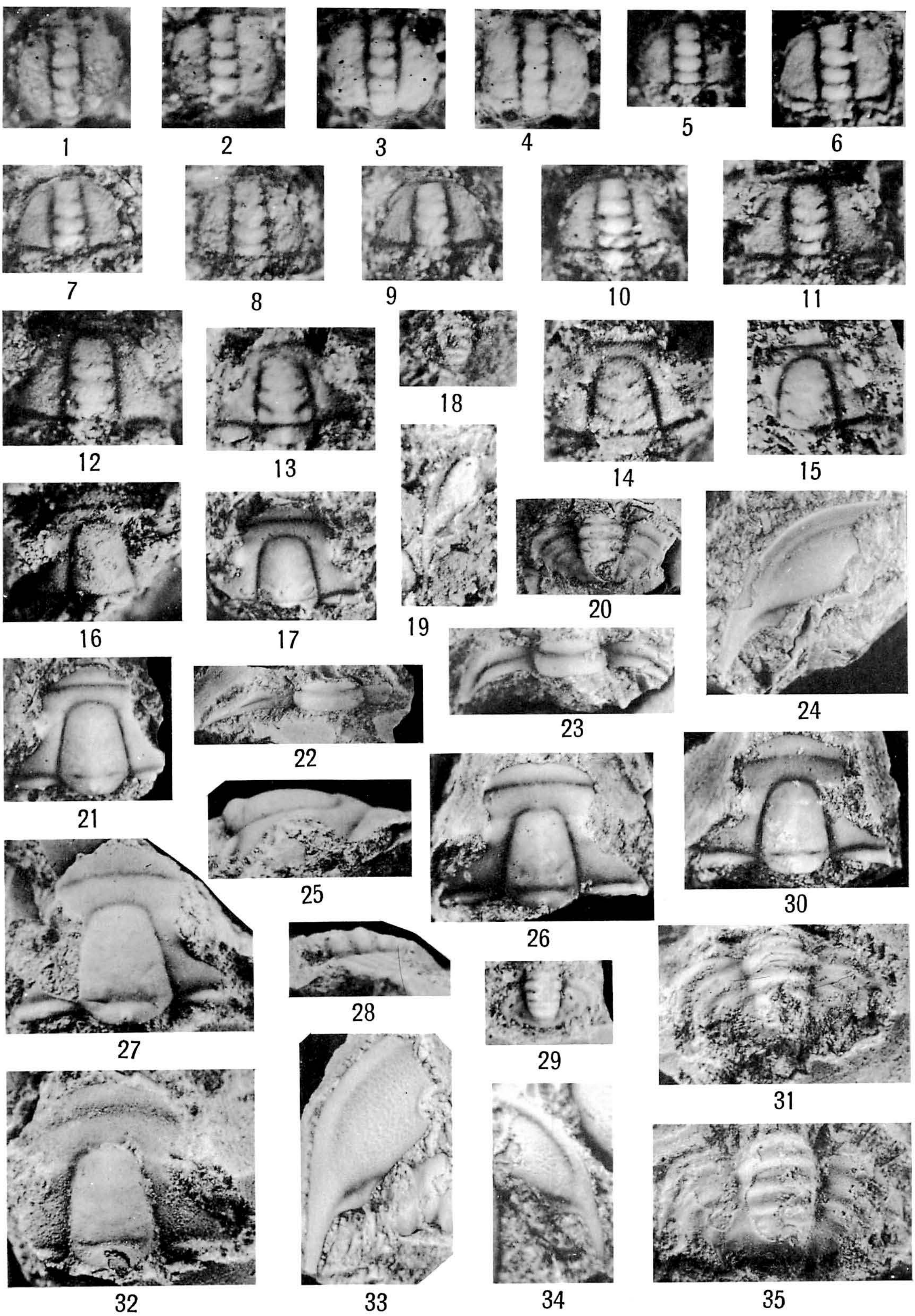
22, 23, two morphologically different thoracic segments. ×10, ×5; GMUC. 43344t, u.

17, 21, 25, 27, dorsal and side views of a few different sized "male" cranidia; showing the subquadrate glabella. ×7, ×6, ×5; GMUC. 43344o, 43344s, 43344x.

24, 33, "female" and "male" librigenae. ×5; GMUC. 43344v, 43344c'.

26, 30, 32, three different-sized "female" cranidia, showing the cylindrical glabella. ×4; GMUC. 43344w, 43344z, 43344b'.

20, 29, 35, three different-sized semicircular "male" Pygidia. ×5, ×3.5, ×6; 43344v, 43344y, 43344e'.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spine; the anterior facial suture is convergently convex, and the posterior one is divergent posterolaterally and convex. The surface of the shield is thickly covered by coarse granules.

Late meraspid stage (Pl. 21, Figs. 7, 11, 15; Text-fig. 2G).—The cranidium is trapezoidal in outline, convex, about 0.80–1.45 mm in sagittal length; the glabella is slenderly conical, tapering forward, and divided into four segments by deep furrows; the first pair of glabellar furrows are short and faint; the second to occipital furrow are deepen laterally and shallow across the central line; the occipital ring is transverse triangular, convex, and bearing a medium-sized median spine; the preglabellar field is narrow and has a median depression; the anterior border is narrow, arches forward and has the outer margin pointed slightly posteriorly; the frontal furrow is deep and distinct, with the central portion behinding inwardly, the fixigena is about one-half the width of the glabella between the small palpebral lobe and the dorsal furrow; the posterior fixigena is broad and triangular, and its elevated border is about the same width as the occipital ring; the skeletal surface is covered by medium-sized granules.

A few rather well preserved small and large pygidia are assigned to the present species. The smallest pygidium (Pl. 21, Fig. 14; Text-fig. 2D) is roundly triangular in outline, convex, and made of six to seven segments without ankylosed pygidial plate; it is possibly a protaspid pygidium showing the initiation of the thoracic segments. There are also two relatively large pygidia (Pl. 21, Figs. 7, 16, 24; Text-fig. 2H, K) showing a well ankylosed transverse plate and articulated with one or two thoracic segments; these are arbitrarily assigned to the meraspid stage. It is evident that the thoracic segments originated from the anterior margin of the pygidium, which simultaneously the posterior pygidial margin gives rise to the pygidial segments from its terminal germinal region.

Remarks.—The ontogenic development of the present species is closely similar to those of *Parabolinoides contractus* of the present text. No doubt, these two species are generically related each other, both being descended from the same progenitor; their furthest progenitor was *Aphelaspis-Olenus* stock; both would appear have derived from the neoteny of the late meraspis of *Elvinia* or *Irvingella* as discussion previously in the phylogenic development of *Parabolinoides*.

The ontogenic development of *Ptychaspis bullasa* LOCHMAN & HU was reported by HU (1971). The adult cranidium of this species is rather similar to those of the early meraspis of *Parabolinoides-Taenicephalus*; all lack a preglabellar field, and show a narrow convex anterior border, segmented glabellar lobe, small to medium-sized palpebral lobe, broad triangular fixigenae, and coarsely granulated skeletal surface. Obviously that this was again due to the neoteny of the early meraspis of the *Parabolinoides-Taenicephalus* stock. Presumably neotenic evolution was an orthogenic continuum from the *Elvinia-Irvingella* throughout the *Parabolinoides-Taenicephalus* to the *Ptychaspis-Prosaukia* stocks.

Horizon and Locality.—Deadwood Formation, Upper Cambrian, *Concaspis* Zone; east side of road cut. Brownsvill Junction, about 6 miles south of Deadwood City, South Dakota.

Figured specimens.—GMUC. 43343, 43343 a-x.

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Explanation of Plate 21

Figs. 1-28; *Taenicephalus shumardi* (HALL).

1-4, four different-sized paraprotaspides, showing the axial segments and the completion of the posterior fixigenal border. ×32, ×31, ×24, ×16; GMUC. 43343x, 43343w, 43343v, 43343u.

5, 8-10, four different-sized early meraspid cranidia, showing the appearence of the anterior border and the dorsal facial sutures. ×22, ×18, ×14, ×18; GMUC. 43343t, 43343q, 43343p, 43343o.

6, 19, 22, three different-sized librigenae; notice the small ocular ring and the short genal spine. ×6; GMUC. 43343s, 43343g, 43343d.

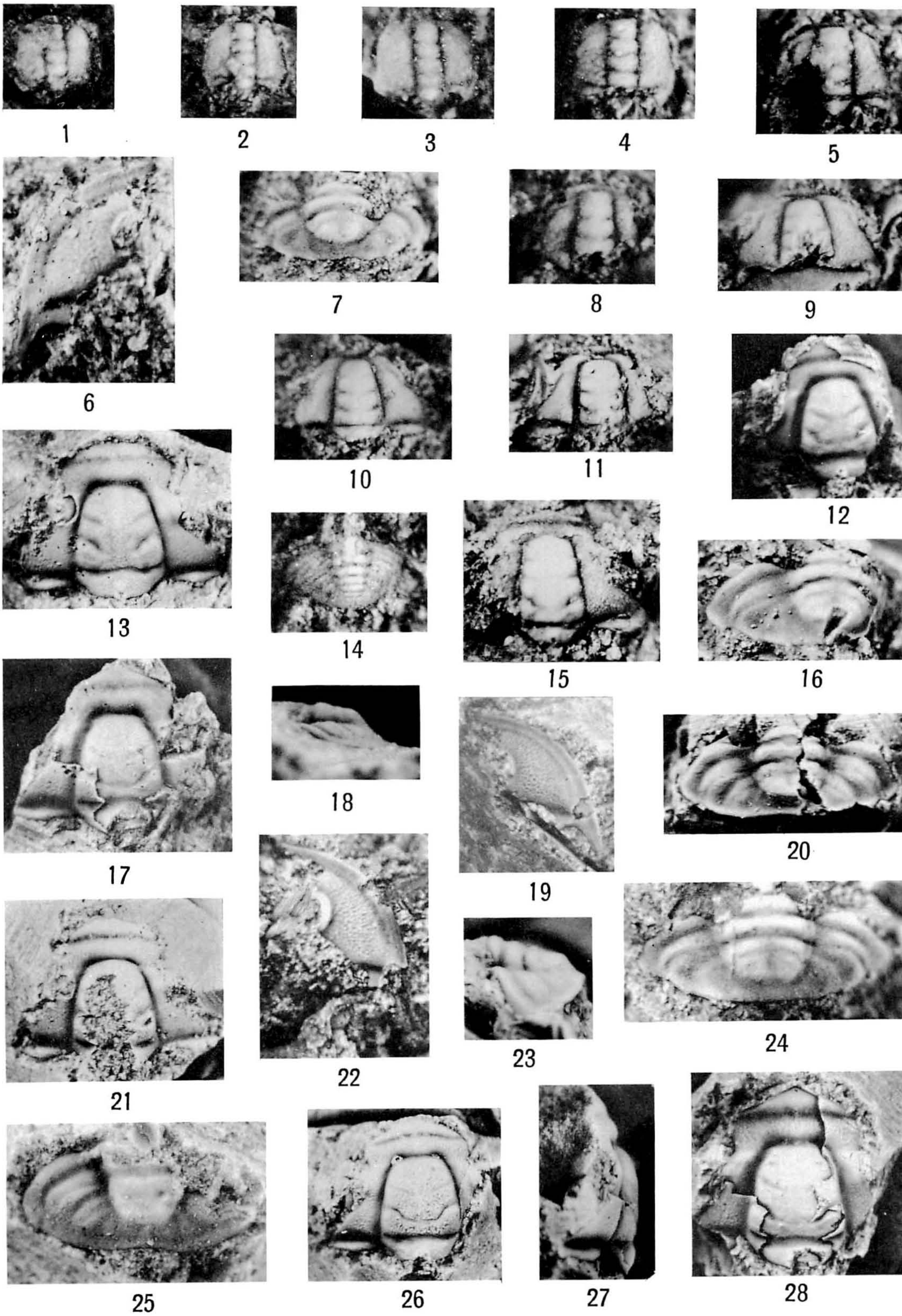
7, 16, 24, three meraspid pygidia, showing the segmentation of the thoracic segments and the short marginal spine. ×15, ×12, ×10; GMUC. 43343r, 43343i, 43343c.

14, a protaspid pygidium, showing the thoracic segmentation. ×24; GMUC. 43343k.

11, 15, two late meraspid cranidia; notice the presence of the preglabellar field and the completion of the glabellar furrows. ×12, ×16; GMUC. 43343n, 43343j.

13, 18, 25, dorsal and lateral views of a "female" cranidium and a pygidium; notice the subquadrate glabella and the broad pygidial margin. ×4, ×2.5, ×5; GMUC. 43343l, 43343b.

12, 17, 20, 21, 23, 26-28, dorsal and lateral views of a few "male" cranidia and pygidium; notice the truncatoconical glabella and the narrow elevated pygidial margin. 12, ×7; 17, ×5; 20, ×8; 21, ×4; 23, ×10; 26, ×4; 27, 28, ×4; GMUC. 43343m, h, f, e, a. 43343.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サウス・ダコタ産上部カンブリア紀三葉虫２種の個体発生と系統発生の研究：米国南ダコタ州産上部カンブリア紀三葉虫 *Parabolinoides contractus* および *Taenicephalus shumardi* の個体発生を記載し，系統発達を考察した。これらの三葉虫の個体発生史は，準原楯期・早中年期・晩中年期の３期に分けることができる。準原楯期の虫体は頭蓋と原始尾板より成り，早中年期に頭鞍前縁が現われ，晩中年期に前頭鞍面ができる。

P. contractus および *T. shumardi* の成虫は *Elvinia—Irvingella* の晩中年期の幼虫の形態を示し，neotenic evolution の１例と考えられる。また，*Parabolinodes—Taenicephalus* の後裔 *Ptychaspis—Prosaukia* は *Elvinia—Irvingella* の早中年期の幼虫の形態を示し，これは定向的な幼形進化の結果と思われる。 胡 忠恒

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 123, pp. 168-178, pls. 22-26, September 30, 1981

735. NOTE ON *PRAVITOCERAS SIGMOIDALE* YABE (CRETACEOUS HETEROMORPH AMMONITE) *

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Abstract. *Pravitoceras sigmoidale* YABE (1902) was established on several fragmentary specimens. Based on better preserved specimens of subsequent collections, we have made clear the characters of this peculiar heteromorph ammonite, giving a redefinition. This species has an affinity with and was probably derived from a species of *Didymoceras*, with an increase in the apical angle of the helical phragmocone so that it lies almost in one plane on which the uncoiled and then retroversed body-chamber also lies. Therefore, it should be assigned to the family Nostoceratidae. It occurs at a particular horizon of the Izumi Group above the part containing *Didymoceras awajiense* YABE and below the beds containing *Inoceramus* (*Endocostea*) *shikotanensis* NAGAO et MATSUMOTO. This horizon can be ascribed to the uppermost part of the Lower Hetonaian Stage [K6a] of the Japanese scale, i. e. approximate correlative of the Campanian.

Some discussions are given on the habitat and mode of life of this peculiar ammonite.

Introduction

Pravitoceras sigmoidale YABE, a Cretaceous ammonite species of a peculiar form, was described by YABE (1902, 1915) on a number of specimens, which were, however, more or less incompletely preserved. Therefore, its true features may not have been properly understood. Fortunately, several better preserved specimens are at our disposal. In this paper we redescribe this species on these as well as previous specimens and discuss its taxonomic position, geological age and habitat.

Before going further, we thank Dr. Yasuo MAEDA and Messrs. Isamu SHINOHARA, Hideo ITO, and Shigeki NANKO, who have provided the specimens of their collections for this study. Thanks are extended to Professor K. NAKAZAWA and Dr. D. SHIMIZU of the University of Kyoto [KU.], Dr. I. HAYAMI of the University Museum, the University of Tokyo [UMUT.], Professor T. KOTAKA of Tohoku University [IGPS], Dr. I. OBATA of National Science Museum [NSM.], Dr. Y. KANIE of Yokosuka City Museum [YCM.], Professor K. KANMERA of Kyushu University [GK.] and Dr. M. CHIJI of the Osaka Museum of Natural History [OMNH.], who gave us facilities to study

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the collections of the respective institutions. We also owe thanks to Dr. C. W. WRIGHT for his kindness in critically reading the typescript, Professor K. ICHIKAWA for his kind help and Messrs. Y. MIZUNO and Y. YASUI for giving valuable information. Miss Kazuko HARA assisted us in preparing the typescript. The repositories of the described specimens are in the above institutions and also Kagawa University [GLKU.], with abbreviations indicated in square brackets.

Palaeontological Description

Pravitoceras sigmoidale YABE

Pl. 22, Fig. 1; Pl. 23, Figs. 1, 2;
Pl. 24, Fig. 3; Pl. 25, Figs. 1, 2;
Pl. 26, Fig. 1; Text-fig. 1

1902. *Pravitoceras sigmoidale* YABE, *Jour. Geol. Soc. Tokyo,* vol. 9, p. 6, pl. 1, figs. 2-4.
1915. *Pravitoceras sigmoidale* YABE; YABE, *Sci. Rept. Tohoku Imp. Univ.*, 2nd ser., vol. 4, no. 1, p. 19, pl. 2, figs. 1-4 (*non* pl. 3, fig. 1).

Material:—Although YABE (1902) indicated a number of syntypes, only the following two are accessible at present:

UMUT. MM7478 (YABE, 1902, pl. 1, fig. 2), from Minato, internal mould, coiled part (incomplete)
UMUT. MM7479 (YABE, 1902, pl. 1, fig. 3), from Minato, internal mould, a part of the body-chamber

The hypotype of S. YEHARA's collection, described by YABE (1915, pl. 2, fig. 1) from Anaga, internal mould, last part of the body-chamber, and that of H. SASAI mentioned by SASAI (1936, p. 593) [UMUT. MM7961], from Minato have been also examined.

The specimens which well supplement the above for the present description are as follows:

OMNH. M2177 (Pl. 22, Fig. 1; Text-fig. 1), a fairly well preserved specimen with test, and OMNH. M2178 (Pl. 23, Fig. 2), both obtained by A. MATSUOKA (1976-4-1), from the same rock at Minato
S. NANKO's private collection (Pl. 24, Fig. 3), from Minato, internal mould with well exposed sutures
GLKU. IZ-80003 (Pl. 26, Fig. 1), from Komori, internal mould, somewhat secondarily compressed
H. ITO's private collection (Pl. 23, Fig. 1), from Minato, secondarily deformed
KU. JM11321 (Pl. 25, Fig. 2) and KU. JM 11322 (Pl. 25, Fig. 1), both from Anaga, internal mould (collector unrecorded)
KU. JM11323, retroversal last part of body chamber and another unnumbered specimen (body chamber) for general education (no record of coll.)
NSM. PM7385, from Nakano, collected by K. SABURI, T. SAWAKI and T. OTA (1972-5-4)
YCM. GP557, from Anaga, collected by Y. YASUI, deformed as in H. ITO's collection
GK. H. 5913, collected by Y. MAEDA, from Minato

There are many other specimens in the collection of H. HASHIMOTO from the Naruto area, but they are mostly deformed. Other fragmentary specimens from Awaji island (Minato, Anaga, etc.) are omitted from the list.

Diagnosis:—The phragmocone is nearly planispiral, consisting of polygyral, evolute whorls, which are circular in cross-section and enlarge rather slowly. The body-chamber at first follows the coiling of the phragmocone for nearly or slightly more than a quarter whorl, then is gradually separated from the coiled part to form a gently sigmoid arc and finally twisted to form a retroversal hook of U- or rather C- shape. The last part of the body-chamber is subelliptical and higher than broad in section, with the aperture facing obliquely upward to the venter of the early part of the body-chamber. The entire shell, thus, seemingly takes a S-shape, whose length is normally 225-240 mm and the diameter of the coiled part at the last septum 130-140 mm. Occasionally the dimensions may deviate from these normal values (see *remarks*).

The shell is ornamented with numerous radial ribs and two rows of tubercles. The ribs on the whorls of early growth-stages are rather coarse, separated by wider interspaces; and all or alternate ribs are provided with ventrolateral tubercles. On the rest of the main part of the shell the ribs are numerous, dense and gently flexuous, while the tubercles occur rather irregularly at every third or fourth rib or sometimes at every fifth or sixth. On the earlier shaft of the hooked part the rows or tubercles are shifted in accordance with the twisting of the body which finally takes the position of its hyponome (i. e. venter) on the outer (i. e. external) part of the hook. Along with the shifting, one row of the tubercles on the twisted portion may be bullate and weakened or even obsolete, but on the last part of the hook the tubercles in two rows become again distinct and are situated at the ventrolateral shoulders, occurring at every fourth to second rib and finally at every rib. On this and earlier parts the ribs form loops at some tubercles. The tubercles are nodose at the base and shortly spinose at the top, except for the weakened bullate ones mentioned above.

Periodic shallow constrictions occur at irregular intervals. There is a flared rib at the last constriction, in front of which there are two or three dense ribs without tubercles. This last portion is slightly narrower than the preceding part. The apertural margin is rather simple, with a pair of shallow (probably ocular) sinuses at the inner lateral corner.

Suture is quadrilobate, consisting of E, L, U and I, which are finely and deeply incised, leaving narrowed stems. All the elements, except I, are bifid. L is the largest, and U somewhat smaller than L but may have a broader stem; E and I much shorter than the adjacent L or U.

Remarks:—The S-shaped shell-form is fairly constant among the individuals examined. Even the shape of the retroversal hook does not vary much.

The variation in size is significant. One of the specimen examined (OMNH. M2178, Pl. 23, Fig. 2) is exceptionally small, measuring 184 mm in length of the S-form, whereas larger examples, as represented by the NANKO's specimen (Pl. 24, Fig. 3) and KU. JM11322 (Pl. 25, Fig. 1), measure 284 mm and 295 mm in length respectively. Examples of normal size are represented by OMNH. M2177 (Pl. 22, Fig. 1) (L=235 mm), GLKU. IZ-80003 (Pl. 26, Fig. 1) (L=225 mm), KU. JM11321 (Pl. 25, Fig. 2) (L=238 mm) and several others.

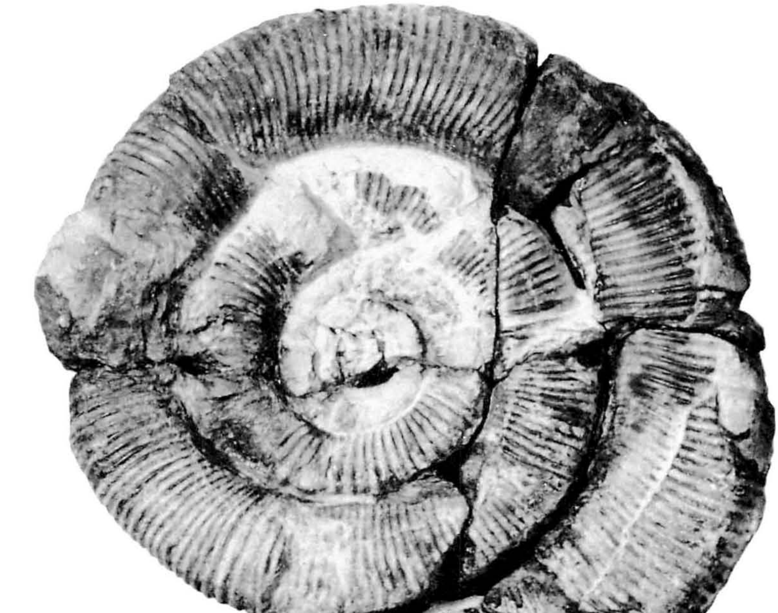
Explanation of Plate 22

Fig. 1. *Pravitoceras sigmoidale* YABE

OMNH. M2177, fairly well preserved specimen with test, from Minato, Awaji island (coll. A. MATSUOKA).

Lateral (a), frontal (b) and lower (c) views, ×2/3

(All the photos of Pls. 22-26 by Y. MOROZUMI)



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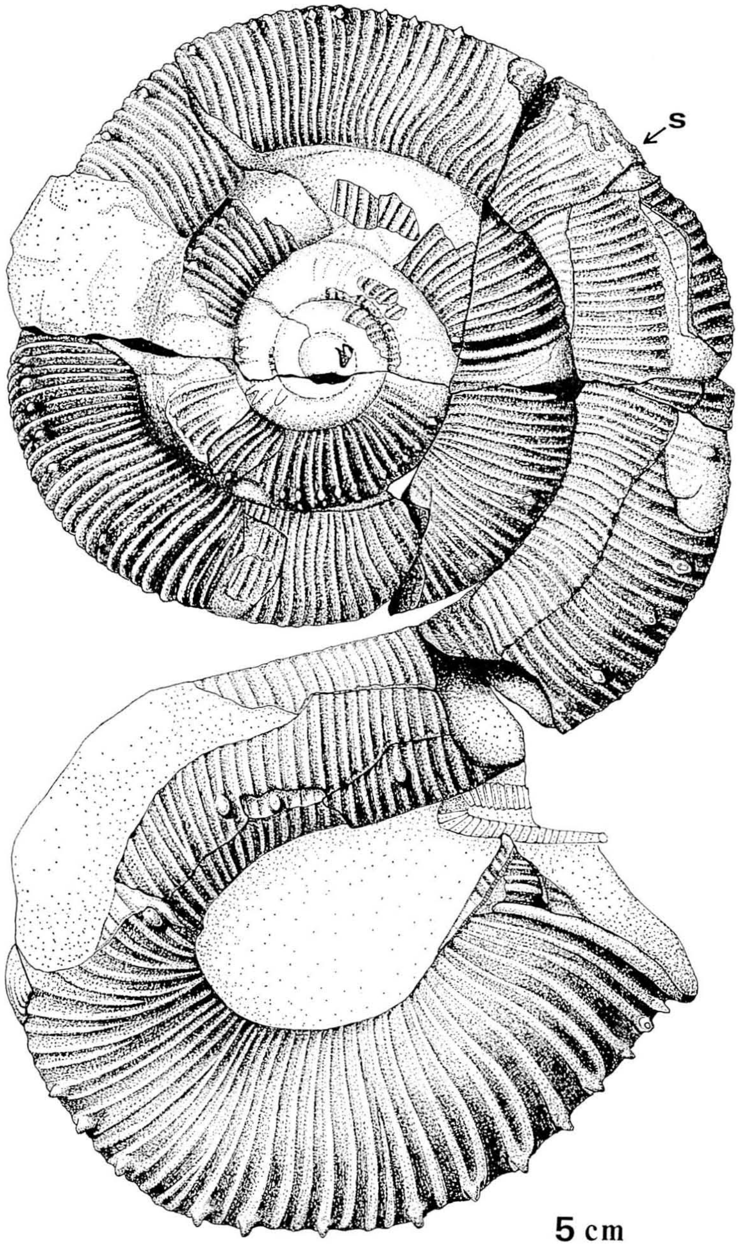

Text-fig. 1. Sketch of *Pravitoceras sigmoidale* YABE. Lateral view of OMNH. M2177 (see Pl. 22, Fig. 1a). S: Position of the last septum. Y. MOROZUMI DELIN.

Therefore, the exceptionally small individual mentioned above is not the microconch of a dimorphic pair, but probably an individual dwarf.

For some reasons the initial stage is not preserved in any specimen listed under *Material*. There are, however, two small specimens with helical coiling embedded in the same nodule as OMNH. M2177 and OMNH. M 2178. Possibly they represent the young stage of the present species. Pending a conclusion, we will describe them in an appendix under a separate heading.

The main part of the phragmocone sometimes shows a nearly but not strictly planispiral coiling. Whether this is reminiscent of a very low helical coiling or an effect of secondary deformation is not determined with certainty. Possibly there could be variation from a very low helical coiling to strictly planispiral one in this stage. Anyhow, the whorls are just touching in the main part of the phragmocone.

In the observable early part of the phragmocone the ribs are comparatively coarser than the rest main part. This coarsely ribbed stage continues for a variable duration, sometimes up to 30 mm or so in diameter but in other times up to 50 mm. In this stage the ribs number 5 or 6 within the interval as large as the whorl height. In later stages the ribs are denser, numbering 10 to 12 in the same interval. They are simple for the most part, except for looping at some tubercles. In the strongly curved portion of the body-chamber, intercalated or branched shorter ribs may occur. The ribs along the constriction are somewhat stronger than others.

The tubercles vary in strength and frequency with growth and also among individuals, but we have not seen any specimen which has no tubercle at all, although YABE's (1902, 1915) descriptions may have given the mistaken idea that there were some individuals without tubercle. In fact, IGPS. 4524, from Toyajo (Wakayama Prefecture), which was described by YABE (1915, pl. 3, fig. 1) as an example of *Pravitoceras sigmoidale*, has no tubercles. It is unusually large, about 190 mm in diameter of the coiled part, and the ribs are denser and more numerous than in unmistakable specimens of *P. sigmoidale*. It is probably a coiled part of a *Diplomoceras* sp. which is allied to, if not identical with, "*D. notabile* (WHITEAVES)" of KILIAN and REBOUL (1909, pl. 5, fig. 1) [=*D. lambi* SPATH, 1953]. Another specimen of YABE (1915, pl. 2, fig. 1), from Anaga, does have ventrolateral tubercles on the last part, although they were somewhat eroded. It is as large as and shows nearly the same shape as KU. JM11323, being regarded as the body-chamber (later part) of a comparatively larger individual.

When we look at carefully the position of the two rows of tubercles on the twisted part of the body-chamber, we notice that there are two forms, which can be called dextral, as represented by OMNH. M2177 (Pl. 22, Fig. 1), and sinistral, as represented by GLKU. IZ-80003 (Pl. 26, Fig. 1),

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Explanation of Plate 23

Figs. 1, 2. *Pravitoceras sigmoidale* YABE

1. H. ITO's Coll., fairly deformed shell, from Minato, Awaji island. Lateral view, ×2/3.
2. OMNH. M2178, exceptionally small shell with the length of 184 mm, from Minato (coll. A. MATSUOKA). Lateral view, ×2/3.

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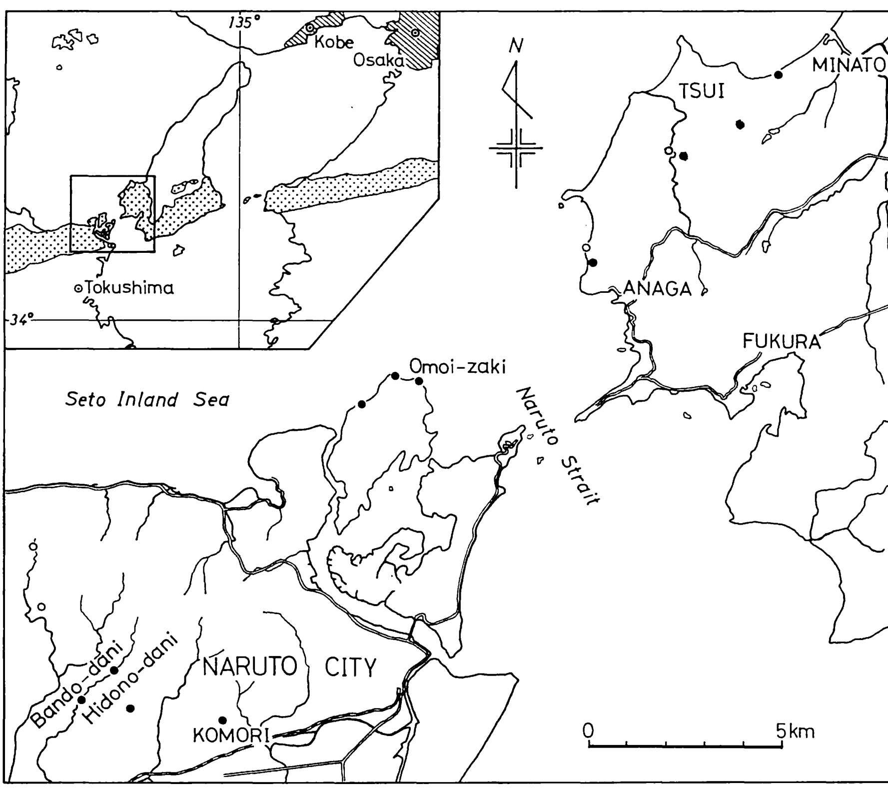
Table 1. Measurements (in mm) of *Pravitoceras sigmoidale*.

Specimen	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OMNH. M2177	235.0	117.0	39.2*	35.0*	132.0	77.0	30.0	31.0
OMNH. M2178	185.0	87.0	34.0	—	~110.0	57.0	—	—
NANKO's	284.0	130.0	42.0**	39.0**	154.0	94.0	35.-	—
GLKU. IZ-80003	225.0	~110.0	—	—	123.0	74.0	29.0	—
KU. JM11321	238.0	115.0	40.0	—	~142.0	79.0	33.0	33.5
KU. JM11322	295.0	144.0	48.0	—	160.0	90.0	38.0	—
KU. JM11323	—	144.0	46.0	—	—	—	—	—

(1) length of S-shape [L], (2) width of U- or C-shape of the body-chamber, (3) height of the last shaft, (4) breadth of the last shaft, (5) diameter of the shell at the last suture, (6) umbilicus, (7) whorl-height, (8) whorl-breadth at the same position.
* 42.0 and 36.0 near the apertural end
** 51.0 and 37.0 at the apertural end



Text-fig. 2. Map showing the localities of *Pravitoceras sigmoidale* (with solid black circle) and those of *Didymoceras* spp. (with empty circle). Inset at the upper left corner is an index map, in which the dotted area indicates the distribution of the Izumi Group.

respectively.

Occurrence:—The localites where we have confirmed the occurrences of this species are as follows (Text-fig. 2):

(1) Minato (about 2 km southwest from the streets of Minato).

a. The fossils occur mostly in calcareous nodules within a nearly 10 m unit of fine sandy shale. OMNH. M2177 and M 2178 were found within the same nodule together with several poorly preserved ones of the same species and *Solenoceras* (*Oxybeloceras*) cf. *humei* (DOUVILLÉ). Several shells of *Anomia* (?) sp. are attached to the shell of *P. sigmoidale*. This unit is prolific and most of the specimens in previous collections with locality record "Minato" may have come from here.

b. The described specimen of NANKO's Coll. came from the unit of alternating shale and sandstone immediately below the above described unit (a). (a) and (b) both belong to the Minato Shale Member in the lower part (above the Tsui Basal Conglomerate) of the Izumi Group (SASAI, 1936).

(2) Anaga (about 1 km northwest of the Anaga harbour). The fossils occur in the sandy shale with some interbeds of sandstone. This part belongs to the upper part of the Minato Shale. *Didymoceras* spp. have been found in the underlying part of the shale exposed on the tidal zone of the coast.

(3) Nakano, southern part of Tsui. At the point indicated by empty circle we have found *Didymoceras* sp. According to the locality record, NSM. PM7385 was found, together with some other specimens, from another locality of Nakano stratigraphically above this locality of *Didymoceras*.

(4) Uchihara, Tsui, half way between (1) and (3). Fragmentary specimens. These four localities are in the southwestern part of Awaji island.

As has been recently made clear (SUYARI, 1973; MATSUMOTO and MOROZUMI, 1980) in Shikoku and in the Izumi Mountains, the lower shale member of the Izumi Group is eastward time-transgressive. The same relationship would probably be applied to the Minato Shale in the island of Awaji. In other words the Subzone of *Pravitoceras sigmoidale* runs through different lithological subdivisons of the Minato Shale from southwest to northeast.

In the area belonging administratively to Naruto City at the northeastern corner of Shikoku, several localities of *Pravitoceras sigmoidale* have recently been found at first by Mr. SHINOHARA and then by one of us (H. H.). They belong to the member of a turbidite facies consisting of shale, sandstone and conglomerate, which lies on the shale member, i. e. the lithostratigraphic (but diachronous) extension of the Minato Shale (BANDO and HASHIMOTO, 1981).

Explanation of Plate 24

Figs. 1, 2. *Pravitoceras sigmoidale* YABE (juvenile) (?)

1. OMNH. M2179, sinistrally coiled shell, from Minato, Awaji island (coll. A. MATSUOKA). Apical (a), basal (b) and three lateral (c, d, e each 90° rotated) views, ×2.
2. OMNH. M2180, dextrally coiled shell, from Minato (coll. A. MATSUOKA). Upper (a) and two lateral (b, c 90° rotated) views, ×2.

Fig. 3. *Pravitoceras sigmoidale* YABE

S. NANKO's Coll., internal mould of a large example from Minato. Lateral (a) and frontal (b) views, ×1/2.


1a


1b


2a


1c


1d


1e


2b


2c


3a


3b

(5) Omoi-zaki, Seto (northern part of Naruto). Several deformed specimens of *P. sigmoidale* were embedded in school in the sandstone and also the shale of the turbidite facies. There are two other localities on the coast to the west of Omoi-zaki.

(6) Komori (a pit), Ôasa (eastern part of Naruto). Here alternating sandstone and shale are exposed. GLKU. IZ-80003 was clinging to the top surface of a turbidite sandstone. Some other examples were found in the shale and the sandstone.

(7) Shimoda (about 2.5 km west of Komori), Ôasa. Again from the sandstone and the shale of the turbidite facies.

(8) Hidono-dani (about 1 km northwest of Shimoda). An impression of *Pravitoceras* on the top of a sandstone bed.

In the northwestern branch of the Bando-dani (western part of Ôasa), there are localities with *Didymoceras awajiense*. They are of lower stratigraphic level than the *Pravitoceras* bearing part. Still westward, i. e. at still lower levels than the *Didymoceras*-bearing beds, there are localities with *Baculites kotanii* MATSUMOTO, HASHIMOTO et FURUICHI and then *Metaplacenticeras subtilistriatum* (JIMBO) (see MATSUMOTO et al., 1980). On the other hand, at a locality in Naruto, SUYARI (1973) recorded *Inoceramus* (*Endocostea*) *shikotanensis* NAGAO et MATSUMOTO, an index of the lower Upper Hetonaian [K6b1]. This locality is stratigraphically higher than the *Pravitoceras*-bearing beds.

In short, *Pravitoceras sigmoidale* occurs characteristically in a limited part within the thick sequence of the Izumi Group in the island of Awaji and in northeastern Shikoku. It represents a local subzone in the uppermost part of the Lower Hetonaian Stage [K6a] of the Japanese scale, i. e. the approximate correlative of the Campanian in terms of the international scale. This species, however, has not yet been found in Hokkaido, where the reference scale of the Hetonaian [K6] (the approximate correlative of the Campanian *plus* Maastrichtian) has been established.

Affinity: —*Pravitoceras sigmoidale* is unique in its S-shaped shell-form. Its retroversal body-chamber with evidence of a twisted, instead of a simply hooked body, two kinds of coiling which correspond to dextral and sinistral, mode of ribbing, bituberculation and particular pattern of sutures, as well as the stratigraphic occurrence, suggest that it was probably derived from a species of *Didymoceras*, with lowering of the helical phragmocone. The ancestor is probably *D. awajiense* (YABE). There seem to be more than one species of *Didymoceras* in the unit underlying the Subzone of *P. sigmoidale*. *D. awajiense* needs revision. So far, we have noticed some variation (e. g. in the mode of retroversion from the helical part) in *D. awajiense* but we have not yet obtained an example which could be regarded as precisely transitional. In other words, at least seemingly *P. sigmoidale* appeared rather suddenly.

So far as the available evidence is concerned, *Pravitoceras sigmoidale* is endemic and has a short vertical range, without leading to a descendant. At present it is the monotypic representative of the genus.

In short, *Pravitoceras* has an evident affinity with *Didymoceras* and should be assigned to the family Nostoceratidae. It is probably a short, dead-end offshoot from *Didymoceras*. An analogous, if not identical, form of coiling is shown by *Nostoceras* (*Planostoceras*) LEWY, 1967, which also is a member of the Nostoceratidae.

Further remarks

We attempt here to give preliminary

remarks on the habitat and the mode of life of this peculiar ammonite.

Pravitoceras sigmoidale has a fairly long dody-chambdr. Should the U-shaped part be assumed to follow the normal coiling, the body-chamber would occupy almost a full whorl. In the case of evolute ammonites of normal coiling, the body-chamber is generally long, occupying nearly a full whorl or more to take the favourable condition of buoyancy. In this respect there is no significant difference between *Pravitoceras* and normally coiled, evolute ammonites, although the center of buoyancy must be at different position. As to the center of buoyancy *Pravitoceras* may be comparable to but not quite identical with *Macroscaphites,* since in *Pravitoceras* the last quarter of its coiled part is occupied by a part of the body-chamber. Although we mention the body-chamber, the buoyancy is concerned with the phragmocone in proportion to the entire shell.

The aperture of the retroversed body-chamber is facing fairly closely to the ventral surface of the last part of the coiled whorl. The space to produce the funnel and tentacles must have been limited and these frontal part of the body were so situated that they were normally concealed or protected underneath the main part of the shell. In other words, *Pravitoceras* in the adult stage may have been less active than most of the normally coiled ammonites.

There is, however, sufficient space to let the water stream out from the funnel at the outer portion of the shell aperture. Therefore, *Pravitoceras* may have been able to swim, when necessary. Judging from the position of the last septum and that of the aperture, *Pravitoceras* may have moved with its curved part of U forward, although locomotion may have been slow. Normally its S-shape was not upright but must have been in some oblique attitude.

Fossils of *Pravitoceras* are found often in groups from the same bed or even from the same nodule. If we take this into consideration, together with the peculiar shell-form and the less activity mentioned above, we can presume that *Pravitoceras* took primarily a benthic mode of life and that it may have moved in the water occasionally. At what depth of the sea bottom the animal preferred to live is a problem yet to be worked out, but the finely and deeply incised suture suggest that the favourable condition may not have been so shallow. This may be compatible with the particular nature of the sedimentary trough of the Izumi Group, as discussed by TANAKA (1965).

Appendix

Possibly juvenile shell of *Pravitoceras*

Two tiny specimens of helical coiling are embedded in the same nodule as OMNH. M2177 and M2178, unmistakable

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Explanation of Plate 25

Figs. 1, 2. *Pravitoceras sigmoidale* YABE

1. KU. JM11322, internal mould of another large example, from Anaga, Awaji island. Lateral view, ×0.45. The specimen is so fragile that the shell is surrounded with cement.
2. KU. JM11321, incomplete internal mould, from Anaga. Lateral view, ×1/2.

2

1

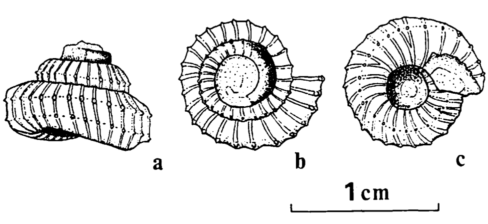
adult specimens of *Pravitoceras sigmoidale*. They are described here, as we have mentioned in *remarks* of the main text.

Pravitoceras sigmoidale YABE
(juvenile) (?)

Pl. 24, Figs. 1, 2; Text-fig. 3

Material:—OMNH. M2179 and OMNH. M2180, obtained by A. MATSUOKA from Minato.

Description:—OMNH. M2179 (Pl. 24, Fig. 1) is sinistral and OMNH. M2180 (Pl. 24, Fig. 2) dextral. The former is better preserved. It shows rather low helical coiling with a slight overlap of the whorls. It is 10.3 mm in diameter and 8.2 mm in height, although the very initial stage is unpreserved. The observable earliest part below 5 mm in diameter is smooth. The succeeding main part is ornamented with ribs which are separated by wider interspaces. There are 25 ribs per whorl. They are mostly simple, somewhat flexuous, but branching occur occasionally (4 times within the last whorl preserved) on the basal surface. Every rib is bituberculate; the tubercles of the upper row are distinctly visible on the side and those of the lower row are weak and discernible on the basal surface. The whorl is somewhat angulated at the tubercles.



Text-fig. 3. Sketch of a possibly juvenile shell of *Pravitoceras sigmoidale* YABE. Lateral (a), upper (b) and basal (c) views of the helical shell, OMNH. M2179 (see Pl. 24, Fig. 1e, a, b). Y. MOROZUMI *delin.*

OMNH. M2180 is somewhat taller than OMNH. M2179, about 9.5 mm in diameter and 9.0 mm in height (of the helix). Again the observable first stage is smooth and the rest main part is ornamented with the same type of ribbing and bituberculation as OMNH. M2179.

Remarks:—The mode of ornamentation described above is similar to that of the observable early part of unmistakable specimens of *P. sigmoidale* described in the main text.

It is too bad that we have not yet obtained a good specimen which shows both the very early part as large as the above two examples and also the main part of *P. sigmoidale*. KU. JM11321, however, seems to suggest that the earliest part may be helical.

Didymoceras spp., including *D. awajiense*, occur commonly in the subzone below the Subzone of *P. sigmoidale*, but we would not deny the possibility that some species of *Didymoceras* or *Nostoceras* could be found, although rarely, together with *P. sigmoidale*. In other words, the two tiny specimens described here might be early parts of *Didymoceras* sp. or *Nostoceras* sp. We should search for better preserved specimen to give the final decision. Unmistakable examples of *Nostoceras* are actually found at higher levels (see MATSUMOTO and MOROZUMI, 1980).

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Anaga 阿那賀, Awaji 淡路, Bando-dani 板東谷, Fukura 福良, Hidono-dani 樋殿谷, Izumi 和泉, Komori 小森, Minato 湊, Nakano 仲野, Naruto 鳴門, Ôasa 大麻, Omoi-zaki 思崎, Seto 瀬戸, Shimoda 下田, Tsui 津井, Uchihara 内原

白亜紀異常巻きアンモナイト *Pravitoceras sigmoidale* YABE について：本種の原標本は断片的だったが，その後採集された標本に保存の良いのがある。これらを図示し，種の再記載をした。ごく初期は立体螺旋だったらしい資料がある。その部分と平面緩巻きの初期では，肋が相対的に粗く，各肋に突起がある。住房は長く，初めは緩巻きを続け，次いで緩い弧を画きながら軟体部はねじれ，後屈する。このやり方に右巻き左巻きに相当する2型が認められる。2列の突起は頻度は不規則ながらどの標本にもあり，ねじれる部分では部分的に現われないことがある。本種は淡路島の南西部～四国北東部の和泉層群の下部の一定層位（*Didymoceras awajiense* 亜帯のすぐ上位）に特徴的に産し，しばしば群生する。カンパニアン最上部の亜帯を示す。*Pravitoceras* は *Didymoceras* から由来したと解釈し，Nostoceratidae に入れた。なお生活様式についても考察を試みた。

松本達郎・両角芳郎・坂東祐司・橋本寿夫・松岡　篤

Explanation of Plate 26

Fig. 1. *Pravitoceras sigmoidale* YABE

GLKU. IZ80003, internal mould, from a pit at Komori, Naruto City, northeastern Shikoku (coll. I. SHINOHARA).

Lateral view, 2/3.

1

Trans. Proc Palaeont. Soc. Japan, N.S., No. 123, pp. 179-185, pls. 27-29, September 30, 1981

736. THREE SPECIES OF *LITHOSTROTION* FROM THE ICHINOTANI FORMATION (UPPER PALEOZOIC CORALS FROM FUKUJI, SOUTHEASTERN PART OF THE HIDA MASSIF, PART 5)*

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Abstract. The Lower Member of the Ichinotani Formation distributed in Fukuji, Gifu Prefecture yields many well-preserved corals. We describe three species of *Lithostrotion*, such as *Lithostrotion* (*Lithostrotion*) *decipiens* (M'COY), *L.* (*Siphonodendron*) *nipponalpinum* IGO and ADACHI, n. sp. and *L.* (*S.*) *hidense* KATO yielded from the Lower Member of the Ichinotani Formation. These corals indicate Late Viséan in age, but *L.* (*L.*) *decipiens* extends to slightly upper levels characterized by the Lower Namurian microfossils.

Introduction

The Ichinotani Formation distributed in Fukuji, Kamitakara Village, Yoshiki County, Gifu Prefecture consists mainly of fossiliferous limestones and intercalated thin shales. Stratigraphical and paleontological studies of this formation were done by IGO (1957 and others). He elucidated that the formation is one of the most complete sequences ranging from the uppermost Lower Carboniferous to the basal Permian in the Japanese Islands. Coral faunas of this formation were reported by KAMEI (1957), MINATO and KATO (1957), FUJIMOTO and IGO (1958), KATO (1959), IGO (1958, 1959, 1961), KATO and NIIKAWA (1977), NIIKAWA (1979), and IGO and ADACHI (1980). Corals are commonly yielded from various levels of the Ichinotani Formation, but these are particularly prolific in the lower part of the Lower Member. Characteristic corals from this unit are *Kueichouphyllum sinense* YÜ, *Palaeosmilia murchisoni* EDWARDS and HAIME, *Lithostrotion* (*Siphonodendron*) *hidense* KATO, *Neokoninckophyllum nipponense* KATO, *Lonsdaleia duplicata* (MARTIN), "*Chienchangia*" *minatoi* (KATO), *Carcinophyllum lonsdaleiforme* SALÉE and others.

Besides them, there are some undescribed coral species in IGO'sco llection. We describe two species of *Lithostrotion* (s. l.) and redescribe *L.* (*S.*) *hidense* KATO came from the Lower Member of the Ichinotani on this occasion.

A large colony of *Lithostrotion* (*Lithostrotion*) *decipiens* (M'COY) was found from the upper part of Unit 1 (IGO and ADACHI, 1981). This colony is hemispherical to mound-like and attains 50 to 70 cm in diameter. Small gibbous colonies of the same species, about 10 to 20 cm in diameter, were also obtained from this level and slightly higher levels of Unit 2. Some of the specimens came from Unit 2 are silicified.

Lithostrotion (*Siphonodendron*) *nipponal-*

* Received March 26, 1981

pinum IGO and ADACHI, n. sp. was obtained from almost the same level with *Lithostrotion* (*L.*) *decipiens* of Unit 1. This new species is represented by a fairly large colony that was collected along with *Syringopora*. This colony is platy in shape with the length of 50 cm, width of 30 cm and height of 20 cm.

Lithostrotion (*Siphonodendron*) *hidense* KATO was found in Unit 1 as a rather small colony.

As already discussed by the aforementioned authors, Unit 1 yielding these corals is correlated with the Upper Viséan based upon the various paleontological data. *Lithostrotion* (*Lithostrotion*) *decipiens* is also yielded from Unit 2 that is characterized by the occurrence of Lower Namurian conodonts and smaller foraminifers. The present paper is a new additional contribution to our serial study of the Upper Paleozoic corals from Fukuji.

Systematic Descriptions

Order Rugosa EDWARDS and HAIME, 1858

Family Lithostrotionidae GRABAU, 1927

Genus *Lithostrotion* FLEMING, 1828

Subgenus *Lithostrotion* FLEMING, 1828

Lithostrotion (*Lithostrotion*) *decipiens* (M'COY, 1849)

Pl. 26, Figs. 1-3, Text-figs. 1a-d.

Lithostrotion decipiens, EDWARDS and HAIME, 1851, p. 441; HILL, 1940, p. 178-180, pl. 10, figs. 2-4, 5?, 6?; FAN, 1974, p. 267, pl. 136, figs. 14, 15; ZAHANG, 1977, p. 193, pl. 75, fig. 6; WANG, 1978, p. 127, pl. 37, fig. 5.

Petalaxis portlocki, EDWARDS and HAIME, 1851, p. 453; EDWARDS and HAIME, 1852, p. 204, pl. 38, figs. 4, 4a; EDWARDS and HAIME, 1860, p. 441; SEMENOFF-TIAN-CHANSKY and NUDDS, 1979, p. 255, pl. 1, figs. 6, 7; pl. 4, figs. 4, 5.

Stylaxis portlocki, EDWARDS and HAIME, 1851, p. 453.

Lithostrotion portlocki, GORSKY et al., 1975, p. 85, pl. 26, fig. 3; ZAHANG, 1977, p. 194, pl. 72, fig. 2; WANG, 1978, p. 128, pl. 38, fig. 1.

Lithostrotion heptagonale KAMEI and IGO (MS) nomen nudum, in FUJIMOTO and IGO, 1958, p. 159, 162, (listed).

Corallum compound, cerioid, large, hemispherical to mound-like in shape and attains about 50 to 70 cm in maximum diameter.

Corallites are unequal in size, about 5.0 mm in average diameter. Large corallites attain 8.5 mm in diameter. Mature corallites are mostly heptagonal or hexagonal in transverse sections. New corallites arise at corner of mature corallites and have three or four sides. In marginal part of corallum, corallites are frequently circular in transverse sections, phaceloid as in *Siphonodendron*. Corallite wall is rather thin and straight.

Septa are of two orders, major and minor. There are 15 to 17 septa of each order in mature corallites. Septa are more or less strongly thickened by secondary

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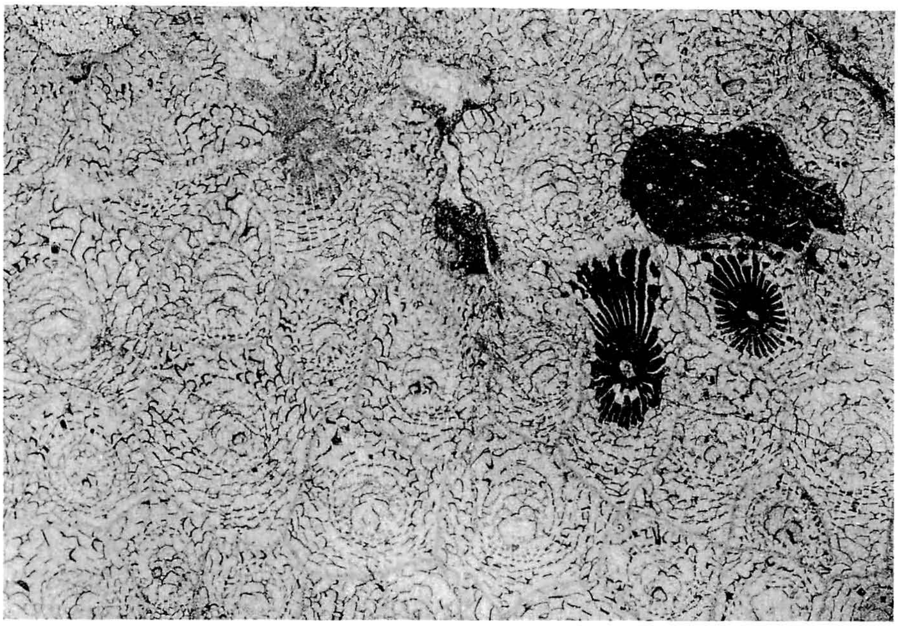
Explanation of Plate 27

Figs. 1-3. *Lithostrotion* (*Lithostrotion*) *decipiens* (M'COY)
1. Transverse section of a partly silicified specimen collected from Unit 2, IGUT 5364, ×4.
2. Transverse section of a specimen collected from Unit 1;
3. Longitudinal section of the same specimen as 2, IGUT 5363, ×4.



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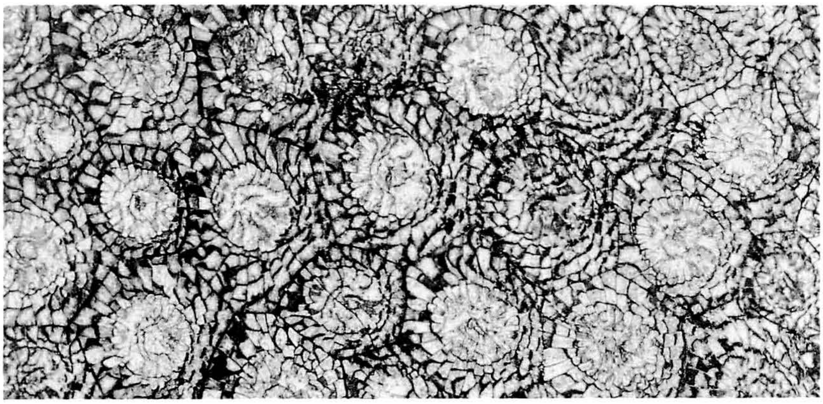

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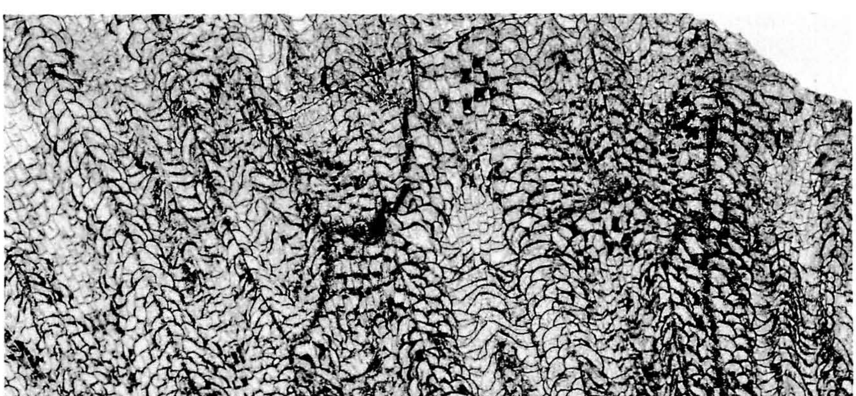

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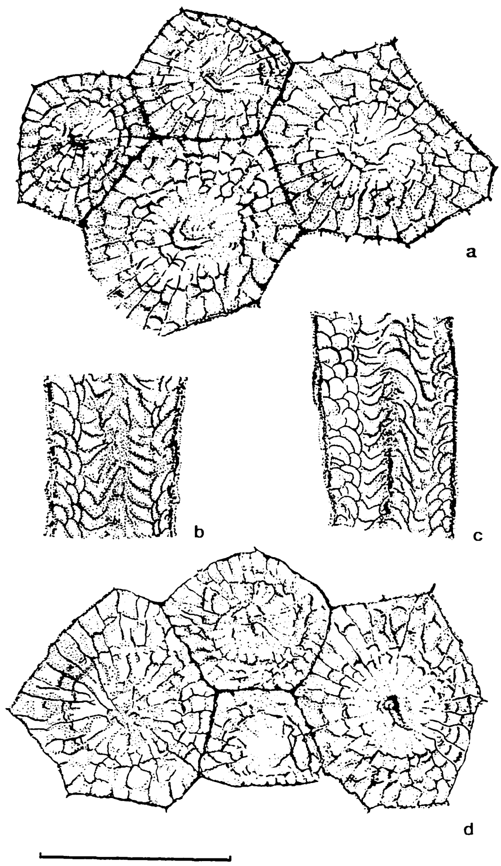


Text-figs. 1a-d. *Lithostrotion* (*Lithostrotion*) *decipiens* (M'COY)
1a, 1d. Transverse sections;
1b, 1c. Longitudinal sections, IGUT 5363, scale bar 0.5 cm.

deposits. Major septa are long, straight or slightly flexuous. Counter septum usually joints with columella. Some of major septa are occasionally discontinuous in dissepimentarium. Minor septa are slightly shorter than major septa in fully grown corallites, but 3/4 or 1/2 as long as major septa in young corallites.

Columella is continuous with counter septum and some major septa, elongate elliptical in transverse sections. Dissepimentarium occupies about or slightly more a half radius of corallites. Dissepiments are rather large, arranged in two or three rows, rarely one row, facing upwards but those of inner series are facing inwards. Tabulae are of two series, inner and outer. Inner ones are steeply arching and reinforcing axial structure. Outer ones are narrow and mostly concave but rarely flat.

Comparison:—The present specimens are similar to the specimens which were identified by many authors with both *Lithostrotion portlocki* (EDWARDS and HAIME) and *Lithostrotion decipiens*(M'COY). Recently, SEMENOFF-TIAN-CHANSKY and NUDDS (1979) pointed out that the former species is considered to be a synonym of the latter species based upon the detailed observation of the type specimen preserved at Institut de Paléontologie, Museum national d'Histoire naturelle, Paris.

The present form resembles the lectotype of *Lithostrotion decipiens* (M'COY) which was fully described by HILL (1940). However, the former has more commonly heptagonal corallites and fewer series of dissepiments than the latter. *Lithostrotion decipiens* described by WANG (1978) from Guzihou, Southwestern China is very similar to the present specimens, but the Chinese specimens have horizontal tabulae and more numerous rows of dissepiments. *Lithostrotion portlocki* introduced from the same district resembles the present specimens, but the latter has larger corallites and longer minor septa than the former. *Lithostrotion decipiens* described by FAN (1974) is also similar to the present form. *Lithostrotion portlocki* described from Urals by GORSKY et al. (1975) is also related with our present ones.

Occurrence:—Upper level of Unit 1 and the middle level of Unit 2, Lower Member of the Ichinotani Formation.

Reg. nos. IGUT 5363-5367.

Subgenus *Siphonodendron* M'COY, 1849

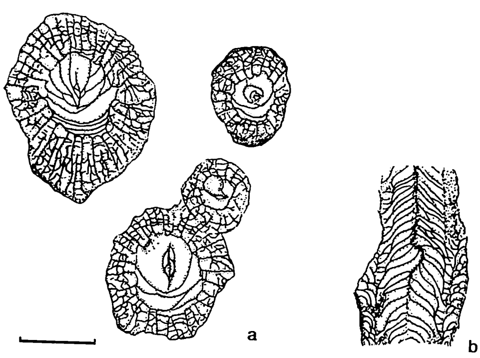
Lithostrotion (*Siphonodendron*) *nipponalpinum* IGO and ADACHI, n. sp.

Pl. 27, Figs. 1, 2, Text-figs. 2a, b.

?*Lithostrotion proliferum* (THOMSON and NICHOLSON), DOBROLYUBOVA, 1958, p. 158-160, pl. 24; DOBROLYUBOVA and KABAKOVITSH, 1966, p. 160-163, pl. 31, figs. 2-5, pl. 33, fig. 1.

Corallum fasciculate, dendroid to phaceloid and its external shape is platy with length of about 50 cm, width of 30 cm and height of 20 cm. Corallites closely arranged and often in contact. Corallite wall is rather thin and has no pronounced septal grooves.

Diameter of corallites is variable, ranging from 4 to 16 mm, but in most of corallites is 8 to 9 mm. Septa are of two orders, major and minor. Number of septa is also variable according to corallite diameter, 18 to 20 each in diameter of about 5 mm; 21 to 29 in 7 to 9 mm; 36 to 41 in 15 to 16 mm. The third order septa very rarely and sporadically appear in some large corallites.



Text-figs. 2a, b. *Lithostrotion* (*Siphonodendron*) *nipponalpinum* IGO and ADACHI, n. sp.
2a. Transverse section of the holotype;
2b. Longitudinal section of the holotype, IGUT 5368, scale bar 0.5 cm.

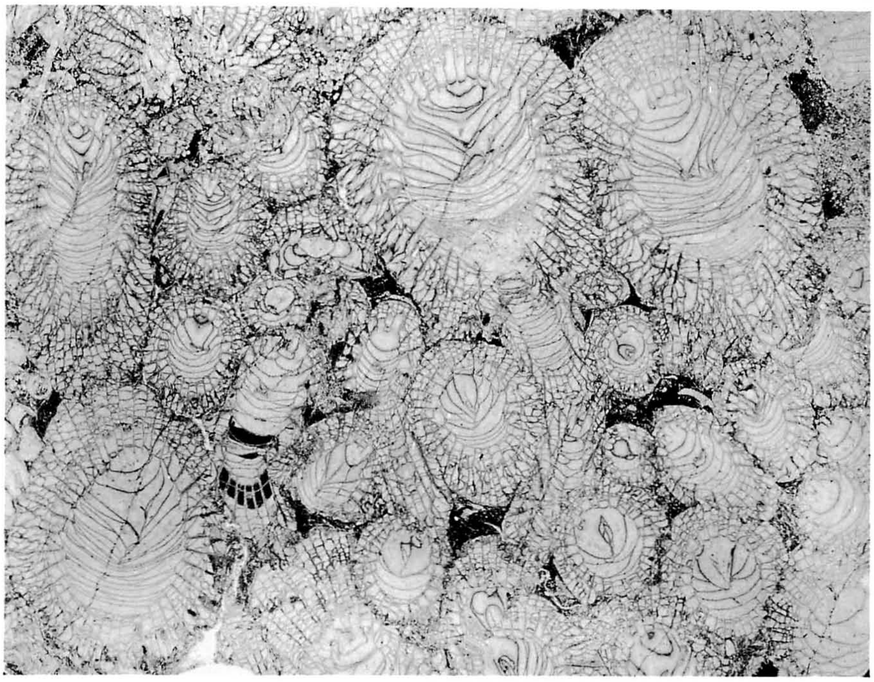
Major septa are straight or flexuous, subequal in length, attain about one half radius of corallite. Counter septum is longer than other major septa and sometimes connected with columella. Minor septa are short, about 2/3 length of major septa, and alternate with major septa. Columella is simply constructed, thin and lath-shaped, anastomosed by axially elevated tabulae. It is straight or sinuous in longitudinal sections.

Dissepimentarium is narrow, consists of various-sized two rows of dissepiments. Three to five rows of dissepiments are partly appeared in some large corallites. They are gently inclined facing inward as well as upward. Two series of tabulae are present. Outer peripherial ones are narrow and horizontal. Inner ones comprise mostly complete, conical to gently domed series, and are rather densely disposed, 9 to 10 in distance of 5 mm.

Comparison:—This new species is similar to *Lithostrotion* (*Siphonodendron*) *affine* (FLEMING) which was fully redescribed by KATO (1971). He further noted that the species is a senior synonym of well-known species, *Lithostrotion* (*Siphonodendron*) *proliferum* (THOMSON and NICHOLSON) reported from Europe and Asia. The present species differs from *Lithostrotion* (*Siphonodendron*) *affine* in having more closely disposed corallites, larger corallites, more strongly arched tabulae and

Explanation of Plate 28

Figs. 1, 2. *Lithostrotion* (*Siphonodendron*) *nipponalpinum* IGO and ADACHI, n. sp.
1. Transverse section of the holotype, IGUT 5368, ×2.
2. Longitudinal section of the holotype, IGUT 5368, ×2.



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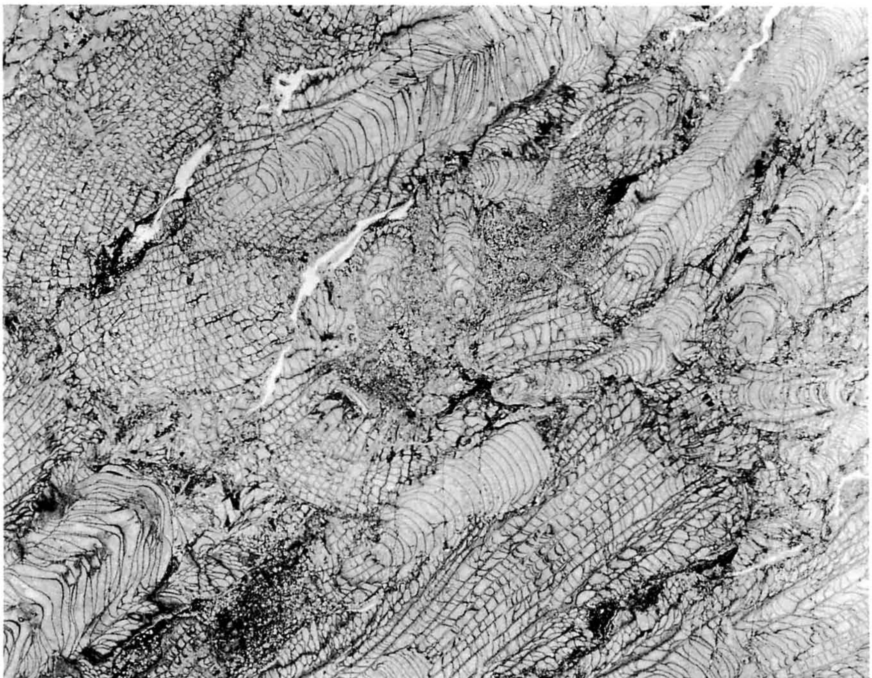

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fewer series of dissepiments. It also closely resembles *Lithostrotion* (*Siphonodendron*) *proliferum* described by DOBROLYUBOVA (1958) and DOBROLYUBOVA and KABAKOVITSH (1966) from Soviet Union. As already pointed out by KATO (1971), these Russian specimens differ from both *Lithostrotion* (*Siphonodendron*) *affine* and *L.* (*S.*) *proliferum*. The present new species slightly differs from these Russian specimens in its shorter major septa and more simply constructed columella, but the Russian specimens seem to be the same species with the present new species.

Occurrence:—Uppermost level of Unit 1, Lower Member of the Ichinotani Formation.

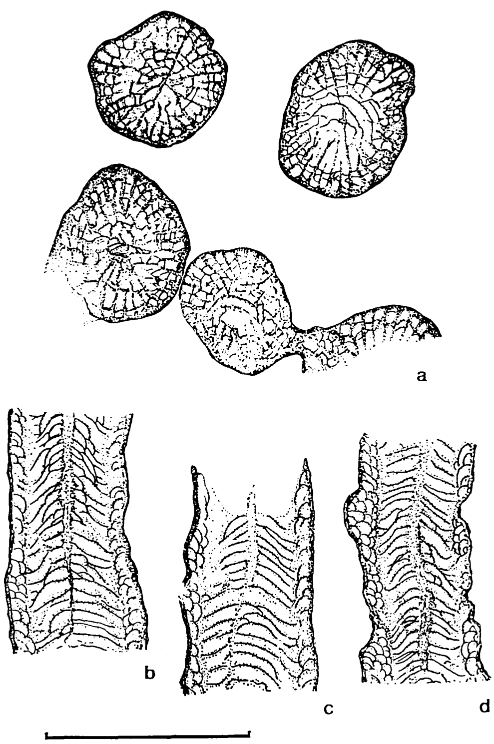
Reg. no. IGUT 5368 (Holotype).

Lithostrotion (*Siphonodendron*) *hidense* KATO, 1959

Pl. 28, Figs. 1-3, Text-figs. 3a-d.

Siphonodendron hidense KATO, 1959, p. 277-279, pl. 3, fig. 5; MINATO and KATO, 1957, p. 548, fig. 2, (listed).

Lithostrotion asiatica YABE and HAYASAKA, FUJIMOTO and IGO, 1958, p. 159, 162, (listed).



Text-figs. 3a-d. *Lithostrotion* (*Siphonodendron*) *hidense* KATO
3a. Transverse section, IGUT 5369;
3b-d. Longitudinal sections, IGUT 5369, scale bar 0.5 cm.

Corallum compound, fasciculate, dendroid to phaceloid. Increase of corallite is lateral. Corallites are cylindrical, subparallel, rather closely arranged and occasionally in contact.

Corallites are circular to subcircular in transverse sections and 3.0 to 4.0 mm in diameter. Corallite wall is comparatively thick for size of corallite and has distinct septal grooves. Septa are in two orders. Major septa are straight or slightly flexuous, long and 15 to 18 in number, reach central part of corallite, and some of them joint with columella. Counter septum is usually continuous with columella. Minor septa alternate with major ones. These are slightly shorter than major septa and attain about 2/3 to 4/5 length of major septa.

Columella is distinct, elliptical to thick fusiform in transverse sections and connected with counter septum and also with some major septa. It is stout and straight or flexuous in longitudinal sections.

Dissepimentarium is narrow, composed of one or two, rarely three rows of subequal dissepiments. Their convex sides are generally facing upward. Interthecal dilation is developed along inner side of dissepimentarium and forms inner wall. Tabulae are rather densely disposed, mostly complete, gently arched to flat in longitudinal sections. There are 8 to 10 tabulae in a vertical distance of 2 mm.

Comparison:—The present specimens have essentially identical biocharacters with KATO's holotype of *L.* (*S.*) *hidense*, but their corallites are more separately disposed. KATO's specimens have two or three rows of dissepiments, but our specimens generally have one or two rows of dissepiments. Tabulae of our specimens are more crowded than those of the holotype. KATO listed several similar species for comparison. Besides them, *Lithostrotion* (*Siphonodendron*) *cerifasciculatum* XU which was described from Junnan, South China (in ZAHANG, 1977) is also similar to the present species, but the Chinese species has fewer and longer major septa that extend to the columella, a wider dissepimentarium and less dense tabulae.

Reg. nos. IGUT 5369-5371.

Repository:—All specimens described herein are kept at the Institute of Geoscience, the University of Tsukuba.

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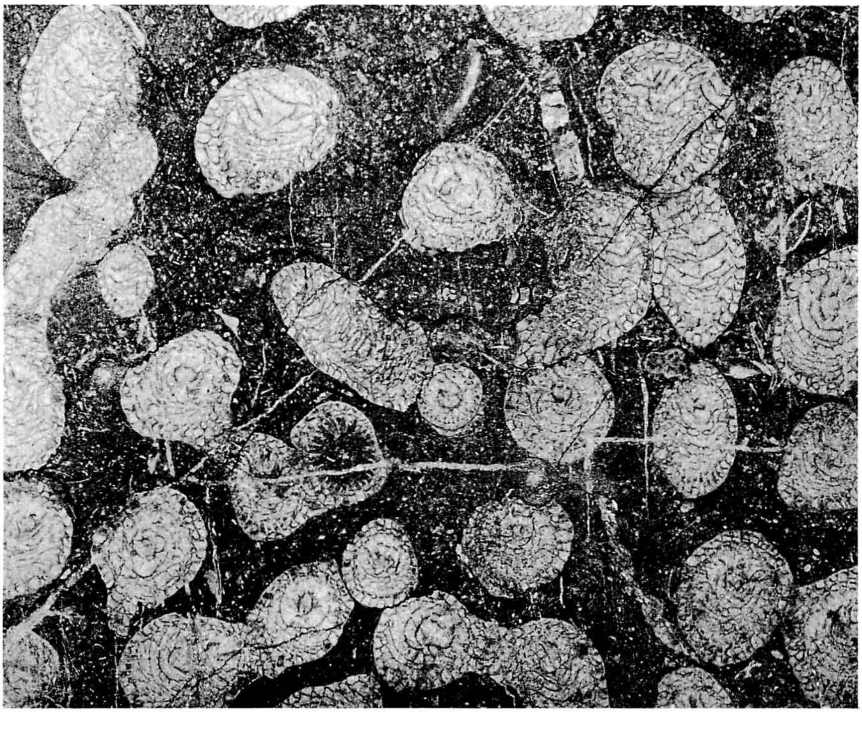
Explanation of Plate 29

Figs. 1-3. *Lithostrotion* (*Siphonodendron*) *hidense* KATO
1. Longitudinal section, IGUT 5369, ×4.
2. Transverse section, IGUT 5369, ×4.
3. Transverse section, IGUT 5370, ×4.

1

2



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一の谷層産 *Lithostrotion* 三種（飛騨山地南東部福地産の上部古生界サンゴ化石，その5）：一の谷層下部層産の *Lithostrotion* 三種，*Lithostrotion* (*Lithostrotion*) *decipiens* (M'COY), *L.* (*Siphonodendron*) *nipponalpinum* IGO and ADACHI, n. sp., *L.* (*Siphonodendron*) *hidense* KATO を記載した。これらのサンゴはビゼー世後期を指示する。*L.* (*L.*) *decipiens* はナムール世前期を指示する微化石を含む層準からも産出する。 猪郷久義・安達修子

BIBLIOGRAPHY OF PALAEONTOLOGY IN JAPAN, 1976－1980
に つ い て 会 員 の 皆 様 に お 願 い

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ISHIJIMA Wataru (1980): On the Calcareous Algae from the Nanatsugama Sandstone of the Nishisonogi Peninsula, Nagasaki Prefecture. Bulletin of the National Science Museum, Tokyo, Series C (Geology & Paleontology), Vol. 5, No.4, pp.131-137, Plates 1-4.

Oligocene　　Calcareous algae

行事予定

	開催地	開催日	講演申込締切
第128回 例会	広島大学	1981年10月3,4日	1981年8月3日
1982年総会・年会	千葉大学	1982年1月23,24日	1981年11月23日

第128回例会ではシンポジウム「白亜紀非海成層の対比」が予定されている。(世話人：木村達明・田代正之・松本達郎)
講演申込先：〒113 東京都文京区弥生2-4-16 日本学会事務センター 日本古生物学会行事係

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○日本学術会議第12期の発足にともなって，古生物学研究連絡委員会委員が次のように改選された。(アルファベット順)
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