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new Permian coral from Okinawa-jima, Ryukyu
Islands : Paleontological Study of the Ryukyu
Islands—VII

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<https://doi.org/10.5109/1546074>

出版情報 : 九州大學理學部紀要 : Series D, Geology. 24 (3), pp.179-188, 1981-01-20. Faculty of
Science, Kyushu University

バージョン :

権利関係 :



Waagenophyllum (*Waagenophyllum*) *okinawense*, a new
Permian coral from Okinawa-jima, Ryukyu Islands*

(Paleontological Study of the Ryukyu Islands—VII)

Takehiko HAIKAWA** and Takeshi ISHIBASHI

Abstract

A Permian coral, *Waagenophyllum* (*Waagenophyllum*) *okinawense* sp. nov. is described here from the Permian Yonamine Formation of the Motobu Peninsula, Okinawa-jima, Ryukyu Islands. The present species occurs along with *Verbeekina verbeeki* (GEINITZ) and *Neoschwagerina craticulifera* (SCHWAGER) in a limestone lens of the formation.

Introduction

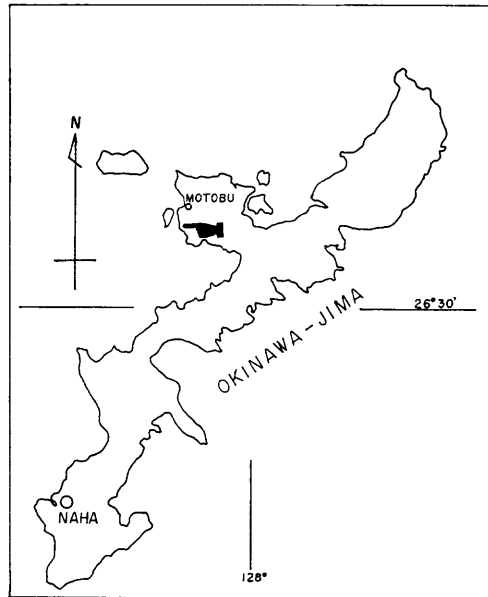
This paper gives descriptions of a new Permian coral species which is assigned to the genus *Waagenophyllum*. This is the first record of a Paleozoic coral from the Ryukyu Islands and offers a new addition to the knowledge of the paleobiogeographic distribution of the waagenophyllids. This species is represented by a single, fairly well preserved specimen. It was collected from the coastal outcrop of a limestone at Sakimotobu, Motobu Peninsula, Okinawa-jima (Fig. 1). It occurs along with *Verbeekina verbeeki* (GEINITZ) and *Neoschwagerina craticulifera* (SCHWAGER).

Regarding the geological setting of the locality, the limestone lens is intercalated in the sequence called the Yonamine Formation, which consists mainly of thick beds of limestone and phyllitic slate with some thin beds of chert. It may probably be of the same horizon as the limestone bed situated near Tamagusuku from which HANZAWA (1933) recorded the occurrence of some fusulinids. FLINT et al. (1959) divided the Paleozoic rocks of the Motobu Peninsula into two formations, the lower Yonamine Formation and the Upper Motobu Formation. From limestones and slates of the Yonamine Formation in the head area of the Motobu Peninsula, ISHIBASHI (1969) found a number of Triassic ammonites and differentiated the Triassic Nakijin Formation from the Yonamine Formation. Consequently the Paleozoic Yonamine Formation has been redefined and restricted in distribution to small areas on the south of the Nakijin Formation. Except for a small amount of fusulinid and algal fossils, no useful fossils for age determination have been known from the Yonamine Formation.

Manuscript received September 10, 1980.

* Read January 22, 1979 at the Meeting of Paleontological Society of Japan at Fukuoka University.

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Text-figure 1. Map showing the locality of *Waagenophyllum*-limestone collected.

Meanwhile, *Waagenophyllum* (s. str.) is one of the well-known Paleozoic corals in the Tethys region and its extensions, especially in Japan and South China. In their comprehensive monograph “*Waagenophyllidae*” MINATO and KATO (1965) summarized all the species of *Waagenophyllum* (s. str.) then known from the Tethys region and gave a systematic classification among them. Since then three species from China were added to the genus. At present the following nineteen species are known;

- | | |
|---|--|
| <i>Waagenophyllum</i> (W.) <i>indicum</i> (WAAGEN et WENTZEL), 1886 | <i>Yabeina-Neoschwagerina</i> zones |
| <i>W.</i> (W.) <i>virgalense</i> (WAAGEN et WENTZEL), 1886 | <i>Yabeina-Neoschwagerina</i> zones |
| <i>W.</i> (W.) <i>akasakense</i> (YABE), 1902 | <i>Yabeina</i> zone |
| <i>W.</i> (W.) <i>kueichowense</i> HAUNG, 1932 | <i>Neoschwagerina-Parafusulina</i> zones |
| <i>W.</i> (W.) <i>wengchengense</i> HUANG, 1932 | <i>Neoschwagerina-Parafusulina</i> zones |
| <i>W.</i> (W.) <i>yunnanense</i> CHI, 1938 | <i>Parafusulina</i> zone |
| <i>W.</i> (W.) <i>longiseptatum</i> TSENG, 1949 | <i>Parafusulina</i> zone |
| <i>W.</i> (W.) <i>huangi</i> DOUGLAS, 1950 | <i>Yabeina</i> zone |
| <i>W.</i> (W.) <i>polyseptatum</i> MINATO, 1955 | <i>Yabeina-Neoschwagerina</i> zones |
| <i>W.</i> (W.) <i>novaezelandiae</i> LEED, 1956 | <i>Yabeina</i> zone |
| <i>W.</i> (W.) <i>simplex</i> WU, 1957 | <i>Yabeina</i> zone |
| <i>W.</i> (W.) <i>pulchrum</i> HAMADA, 1962 | <i>Yabeina-Neoschwagerina</i> zones |
| <i>W.</i> (W.) <i>tsengi</i> (TING et CHE), 1963 | <i>Neoschwagerina</i> zone |

<i>W. (W.) compactum</i> MINATO et KATO, 1965	<i>Yabeina</i> zone
<i>W. (W.) smithi</i> MINATO et KATO, 1965	<i>Neoschwagerina</i> zone
<i>W. (W.) stereoseptatum</i> WU, 1974	<i>Yabeina</i> zone
<i>W. (W.) carinatum</i> XU, 1979	<i>Neoschwagerina</i> zone
<i>W. (W.) maquinense</i> LI et LIAO, 1979	<i>Yabeina</i> zone
<i>W. (W.) okinawense</i> sp. nov.	<i>Neoschwagerina</i> zone

These species stratigraphically range from the *Parafusulina* zone of the lower Middle Permian to the *Codonofusiella* zone of the lower Upper Permian. The present specimen occurs from the *Verbeekina verbeeki* zone of the *Neoschwagerina* genus zone of the Middle Permian.

We are much indebted to Professor Ryuzo TORIYAMA of Fukuoka University and to Professor Kametoshi KANMERA of Department of Geology, Kyushu University for their valuable advice and critical reading of the manuscript. We also express our deep gratitude to Professor Kenji KONISHI of Kanazawa University for his suggestion on the field work, to Dr. Masamichi OTA of the Kitakyushu Museum of Natural History and Mr. Tetsuo SUGIYAMA of Fukuoka University for their discussion and kind help in the course of study on waagenophyllid corals. Thanks are due to Miss Seiko HAYAKAWA for typewriting the manuscript.

Description of Species

Family Waagenophyllidae WANG, 1950

Subfamily Waagenophyllinae WANG, 1950

Genus *Waagenophyllum* HAYASAKA, 1924

Type-species.—*Lonsdaleia indica* WAAGEN et WENTZEL, 1886
(designated by GRABAU, 1931)

Generic diagnosis.—See MINATO and KATO, 1965

Subgenus *Waagenophyllum* HAYASAKA, 1924

Type-species.—*Lonsdaleia indica* WAAGEN et WENTZEL, 1886

Waagenophyllum (Waagenophyllum) okinawense HAIKAWA
and ISHIBASHI, sp. nov.

Pl. 15, Figs. 1–6; Pl. 16, Figs. 1–10; Pl. 3, Figs. 1–2 and Text-fig. 5

Material.—A single colony is available, about 20 cm×30 cm×20 cm in size so far as it is preserved. All thin sections and a polished hand specimen are deposited in the Akiyoshi-dai Museum of Natural History with the registered numbers ASM10736-3a (Holotype), 10734-1a and 1d, 10735-2a and 2g, 10736-3b and 3d, 10737-4a and 4e, 10738-5a and 5g, 10739, 10419, 10743, 10412, 10415, 10416, 10417, 10424, 10426, 10429, 10430, 10744, 10741, 10742, 10757.

Diagnosis.—Corallum fasciculate; corallites cylindrical. Septa in two orders; septal microstructure diffusio-trabecular; major and minor septa 16 to 20, respectively. Septa fairly thick even in mature stage and frequently dilated in the peripheral area and at the inside the wall, forming a peripheral stereozone in immature stage. Axial structure large but remarkably simple and loosely constructed. Tabularium narrow, mainly composed of clinotabulae. Dissepimentarium

broad, composed of elongated dissepiments in the inner part and globose dissepiments in the peripheral part.

Description.—Corallum fasciculate with irregularly spaced corallites. As shown in Fig. 2, corallites are closely spaced or sometimes in contact with one another forming a phaceloid form in most part, but are widely spaced in some other parts. Corallites cylindrical in form, gently curved in phaceloid part and irregular twisted in branching dendroid part. Calice seems to slightly depressed and has a comparatively low calicular boss. External surface not examined, however it is observed in longitudinal sections that the wall surface is slightly annulate or fairly rough. Corallites rounded, consisting of an axial structure, a tabularium and a dissepimentarium. Diameter of corallites in mature stage ranges mostly from 5.4 mm to 7.8 mm, rarely attains more than 8.5 mm.

Septa are in two orders; major and minor ones, but no tertiary septa present. They are fairly thick throughout the growth of corallites. Number of major septa 16 to 20 in mature stage. Major septa nearly or completely reach the axial structure throughout the growth of corallites, where a few of major septa are connected with septal lamellae. Major septa thick near the wall and sharply thin near the axial structure with an average thickness of 0.20 mm at the half way of major septa. Minor septa relatively long and mostly about three-fifths, rarely a little more than a half of the length of major ones. Minor septa thinner



Text-figure 2. A sketch showing the disposition of corallites of *Waagenophyllum (W.) okinawense* in cross section. See also Pl. 17, Fig. 2.

than major ones, and about 0.12 mm thick at their half way. Septa, especially minor ones, are irregularly flexuous throughout the growth of corallites, as seen in Plate 15, Figs. 12 and 13 and Plate 17, Fig. 1.

Micro-structure of septa of a diffuso-trabecular form with fibre fascicles arranged perpendicular to calcification axis (Pl. 16, Fig. 8). The septa are often dilated in the peripheral area in immature stage, forming a fairly broad stereozone. Stereozone in mature stage about 0.55 mm broad. Wall usually thin in mature stage, with average thickness of 0.20 mm.

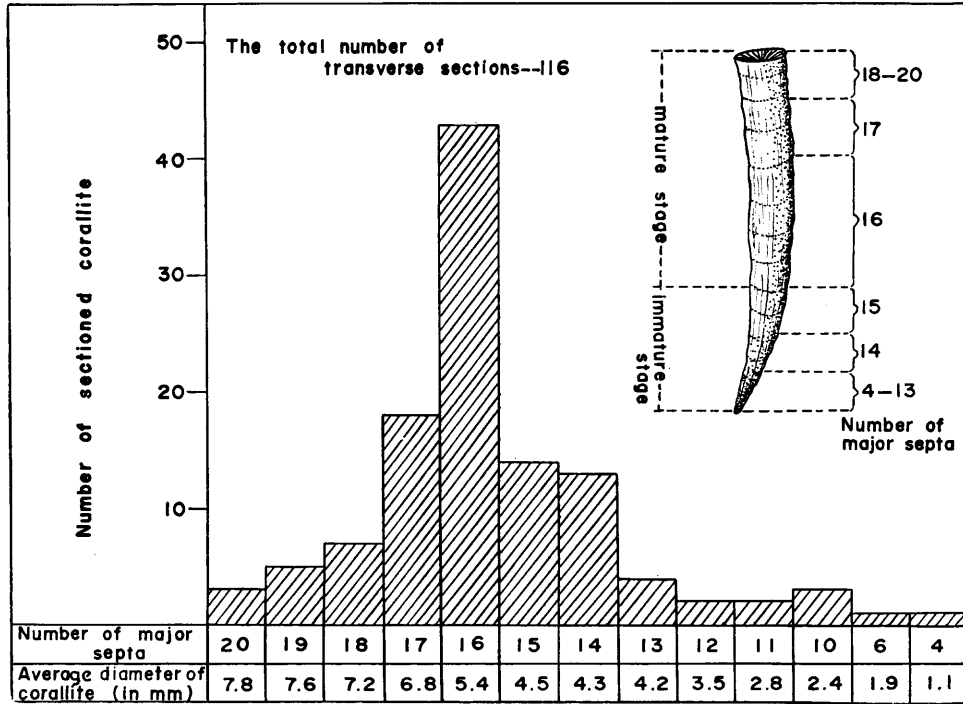
Axial structure less than 2.4 mm in diameter in mature stage, occupying about one-third of diameter of corallites. Axial structure remarkably simple and loosely constructed; composed of large, gently domed to broadly conical axial tabellae, a few short, sparsely spaced septal lamellae, and short irregularly sinuous median plate.

Axial tabellae are also widely spaced, about 25 in a distance of 1 cm in longitudinal sections (Pl. 15, Figs. 11 and 14). Septal lamellae, irregularly flexuous and discontinuous. Median plate also flexuous and discontinuous, so that it sometimes can not be distinguished from the axial lamellae.

Dissepimentarium broad, occupying about a half of radius of the corallite. It is composed of three or four rows of dissepiments. Dissepiments generally elongated and moderately to steeply inclined in the peripheral part of corallites, and highly elongated and disposed nearly vertical in the inner part (Pl. 15, Fig. 11; Pl. 16, Figs. 5 and 6). They show an anglo-concentric arrangement in transverse sections.

Tabularium narrow, occupying about one-fifth of diameter of the corallite. Tabulae varying in spacing, composed of long, steeply inclined clino-tabulae. Short nearly flattened and variably inclined transverse tabulae are rarely present. Increase of corallites is produced by budding of offsets with laterally projected branching (Pl. 16, Fig. 1).

Ontogeny.—The description given above is based on the observation of a polished plane of corallum (Pl. 17, Fig. 2), and a number of thin sections of corallites. 116 transverse sections were studied to know the ontogenetic development of the present specimen. The relationship between the number of major septa and the diameter of corallites is shown in the histogram of Text-fig. 3 and in the scatter diagram of Text-fig. 4 with the indications of the correlation coefficient and the first regression line. The number of major septa in the mature stage is 16 to 20 in the present species. The corallite which has a diameter less than the average diameter of 4.5 mm is here considered to represent the immature stage (refer the inserted figure in Fig. 3). The corallite having a diameter of 1.1 mm to 1.9 mm, that represents the earliest stage (ASM10735-2b) among the sectioned corallites, has four long protosepta and some other short septa, but has no axial structure. The dissepiments begin to grow in part in this stage. In the corallites ranging from 2.4 mm to 4.2 mm in diameter the major septa are 10 to 13 in number, and alternating minor septa are also present. Some of major septa reach the axial area. The axial structure is formed at first by a median plate that is connected with the counter septum and occasionally with the cardinal



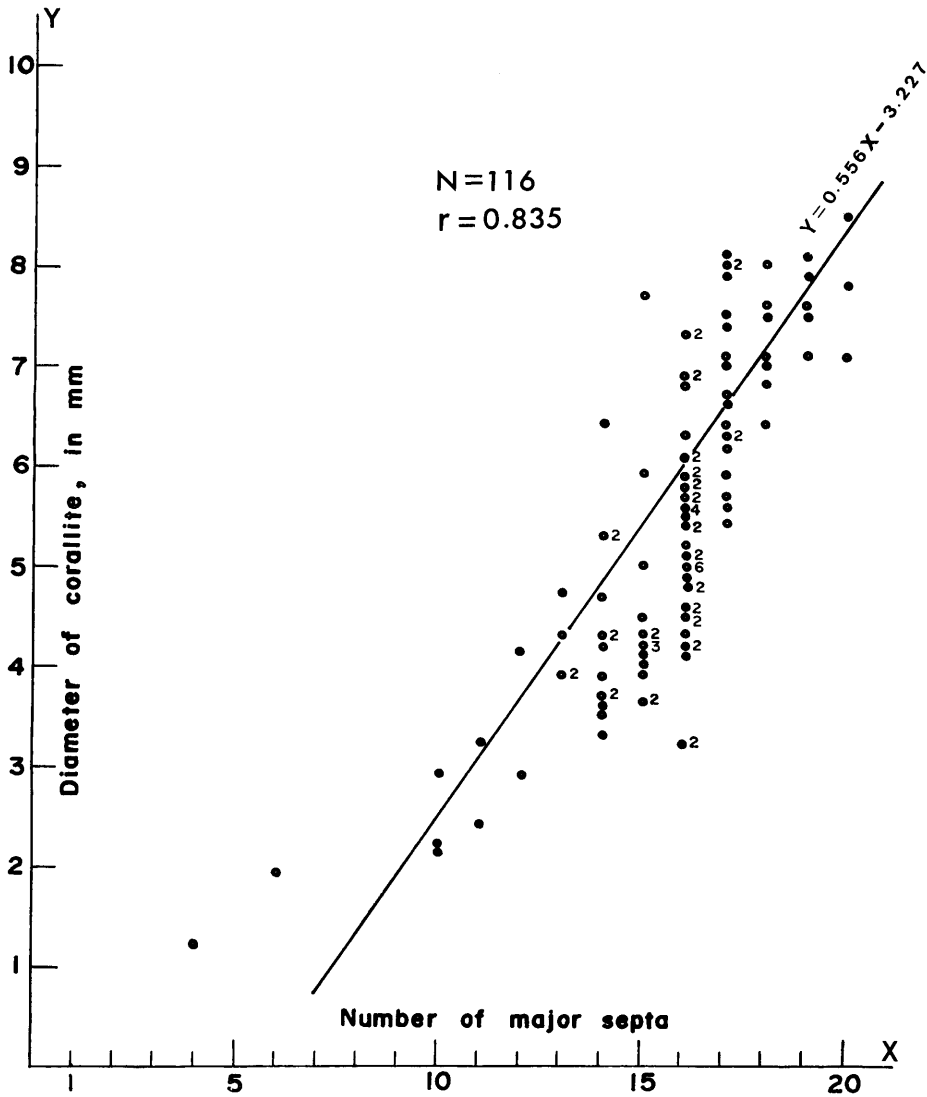
Text-figure 3. Histogram showing the average diameter of corallite in respective major septa and the relationships between the number of transverse section and the number of major septa.

septum. By joining of the axial tabellae with this simple median plate the axial structure becomes gradually complicated in structure and larger in size. The dissepiments gradually increase in number as corallites grow. The cardinal septum is short and the cardinal fossula is clearly observed in the immature stage. The corallites which are about 4.3 mm to 4.5 mm in diameter have 14 to 15 major septa. Throughout the immature stage the septa are often dilated so as to laterally anastomose with each other in the peripheral area, and form a rather broad stereozone (Pl. 15, Figs. 15a, b).

Remarks.—The present species is similar to *Waagenophyllum* (*W.*) *huangi* described by DOUGLAS (1950) from the *Yabeina* Zone of the Bampwr Basin, Iran, in having a small number of major septa and a very simple axial structure. The former differs, however, from the latter in possessing a broader tubularium, thinner walls and septa, smaller corallites in the mature stage, and well developed globose dissepiments.

Waagenophyllum (*W.*) *simplex* described by WU (1957) from the Wunchiaping limestone of Liangshan, China resembles *W.* (*W.*) *okinawense* in having nearly equal number of major septa and a simple axial structure, but it can be distinguished in its smaller axial structure with smaller and more globose axial tabellae, more globose dissepiments and relatively broader tabularium.

It somewhat resembles *W.* (*W.*) *yunnanense* described by CHI (1938) from

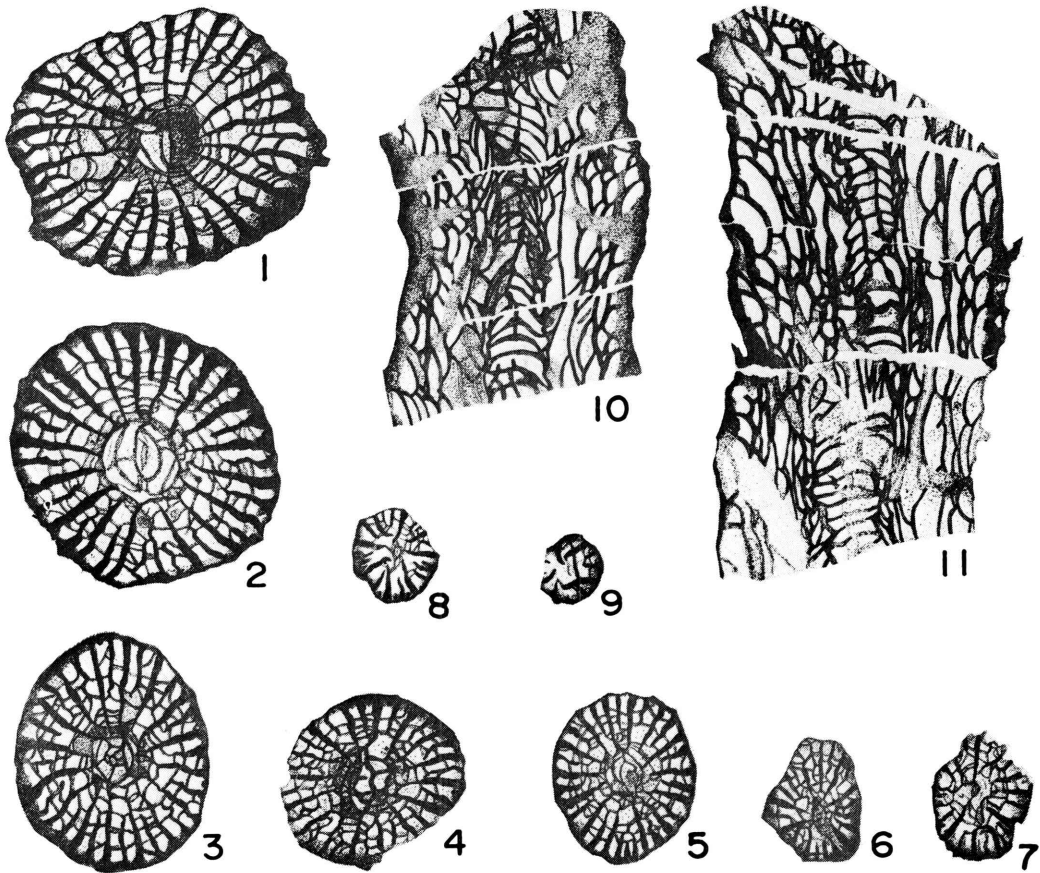


Text-figure 4. Scatter diagram showing the relationships between the number of major septa and the diameter of corallite.

The figures (2, 3, 4 and 6) mean a number of individual.

the Chihisia limestone of Yangsinian, China in its large, simple axial structure, but it is distinguished in having thicker and fewer septa, and more gently domed axial tabellae.

W. (W.) okinawense has thick septa throughout the immature stage. This feature is also observed in *W. (W.) akasakense* reported by YABE (1902) from the Akasaka Limestone of Gifu Prefecture, Japan. Furthermore, both species have a simple and loosely constructed axial structure. Thus, these two species seem to be close in systematic relationship to each other, so far as the characteristics in the immature stage are concerned. However, *W. (W.) okinawense*



Text-figure 5. Diagrammatic representation of the corallite structure *Waagenophyllum* (*Waagenophyllum*) *okinawense* sp. nov.

Figs. 1-4. Transverse sections of mature stage. 1. ASM10736-3b 2. ASM10736-3a
3. ASM10736-3c 4. ASM10736-3a.

Fig. 5. Transverse section of immature stage. ASM10736-3c.

Figs. 6-9. Transverse sections of immature stage. 6. ASM10736-3c 7. ASM10736-3b
8. ASM10736-3b 9. ASM10735-2b

Figs. 10-11. Longitudinal sections of mature stage. 10. ASM10737-4c 11. ASM10739.
All figures $\times 5$. See also Pl. 15, Figs. 1-11.

can easily be distinguished from *W. (W.) akasakense* in its fewer number of major septa and more widely spaced axial tabellae.

W. (W.) okinawense is apparently similar to *W. (W.) pulchrum* described by HAMADA (1962) from the Takagami conglomerate at Choshi City, Chiba Prefecture, Japan. Both the species have thick septa in the immature stage. But they can easily be distinguished from each other in that the number of major septa is 24 to 27 in *W. (W.) pulchrum*, while 16 to 20 in *W. (W.) okinawense*. Furthermore, these two species are discriminated from each other by the axial structure, namely that of *W. (W.) pulchrum* has a much more complicated spider-web structure formed by well developed axial tabellae and septal lamellae.

Occurrence.—Locality SK-1, Sakimotobu at the Motobu Peninsula, Okinawa-jima. The specimen was collected from a brownish grey to dark brownish grey fossiliferous limestone composed mainly of lime-mud. Since the present species occurs along with *Verbeekina verbeeki* (GEINITZ) and *Neoschwagerina craticulifera* (SCHWAGER), the *Waagenophyllum* limestone is referred to the *Verbeekina verbeeki* zone or the Middle part of the *Neoschwagerina* Zone. The specimen described herein is deposited in the Akiyoshi-dai Museum of Natural History.

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Jour. Geol. Soc. Japan, 9, (104), pp. 1-5, fig. 3.

Explanation of Plate 15

Figs. 1-16. *Waagenophyllum (Waagenophyllum) okinawense* sp. nov.

Figs. 1-4, and 12-13. Transverse sections of mature corallites.

1. ASM10736-3b 2. ASM10736-3a (Holotype) 3. ASM10735-3c 4. ASM-10736-3a 12. ASM10734-1b 13a and 13b. ASM10734-1b

Figs. 5 and 15. Transverse sections of immature corallites.

5. ASM10736-3a 15a. ASM10738-5c 15b. ASM10738-5b

Figs. 6-9. Transverse sections of immature corallites.

6. ASM10736-3c 7. ASM10736-3b 8. ASM10736-3b 9. ASM10735-2b

Figs. 10, 11, 14 and 16. Longitudinal sections of mature corallites.

10. AMS10737-4c 11. ASM10739 14. ASM10737-4b 16. ASM10743

See also Text-figure 5.

(All figures $\times 5$)

Explanation of Plate 16

Figs. 1-10. *Waagenophyllum (Waagenophyllum) okinawense* sp. nov.

Fig. 1. Transverse section showing an offset in mature stage. ASM10734-1a $\times 5$.

Fig. 2. Transverse section of calice. ASM10419 $\times 5$.

Fig. 3. Transverse section of mature corallite. AMS10736-3e $\times 5$.

Fig. 4 and 7. Transverse sections of an axial structure.

4. ASM10736-3a $\times 20$ 7. ASM10736-3c $\times 20$.

Figs. 5 and 6. Longitudinal sections of an axial structure.

5. ASM10737-4c $\times 20$ 6. ASM10737-4b $\times 20$.

Fig. 8. Transverse section showing a fine structure of septa. ASM10736-3c $\times 40$.

Figs. 9 and 10. Transverse sections showing the structure of septa and wall.

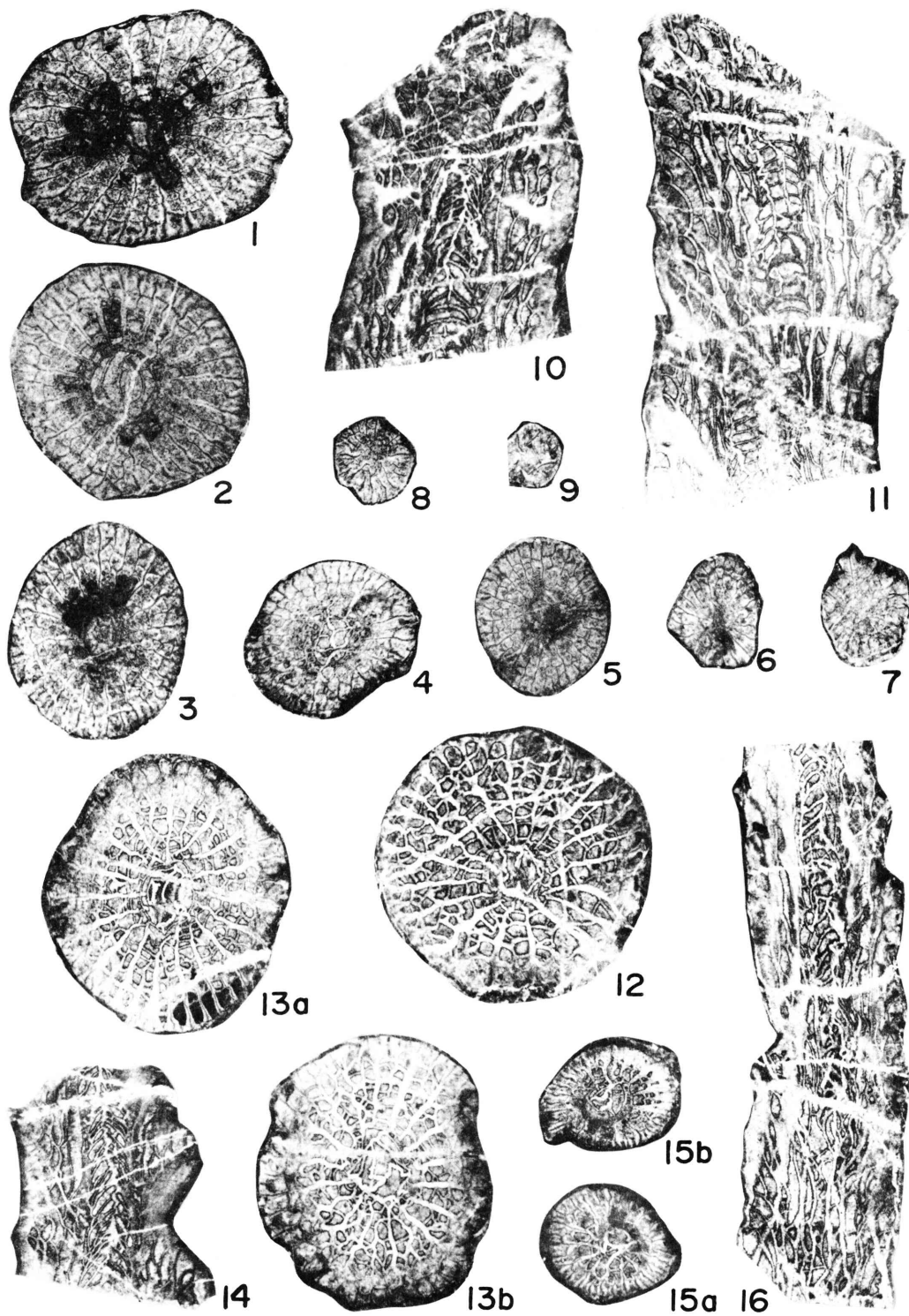
9. ASM10736-3c $\times 20$ 10. ASM10736-3b $\times 20$.

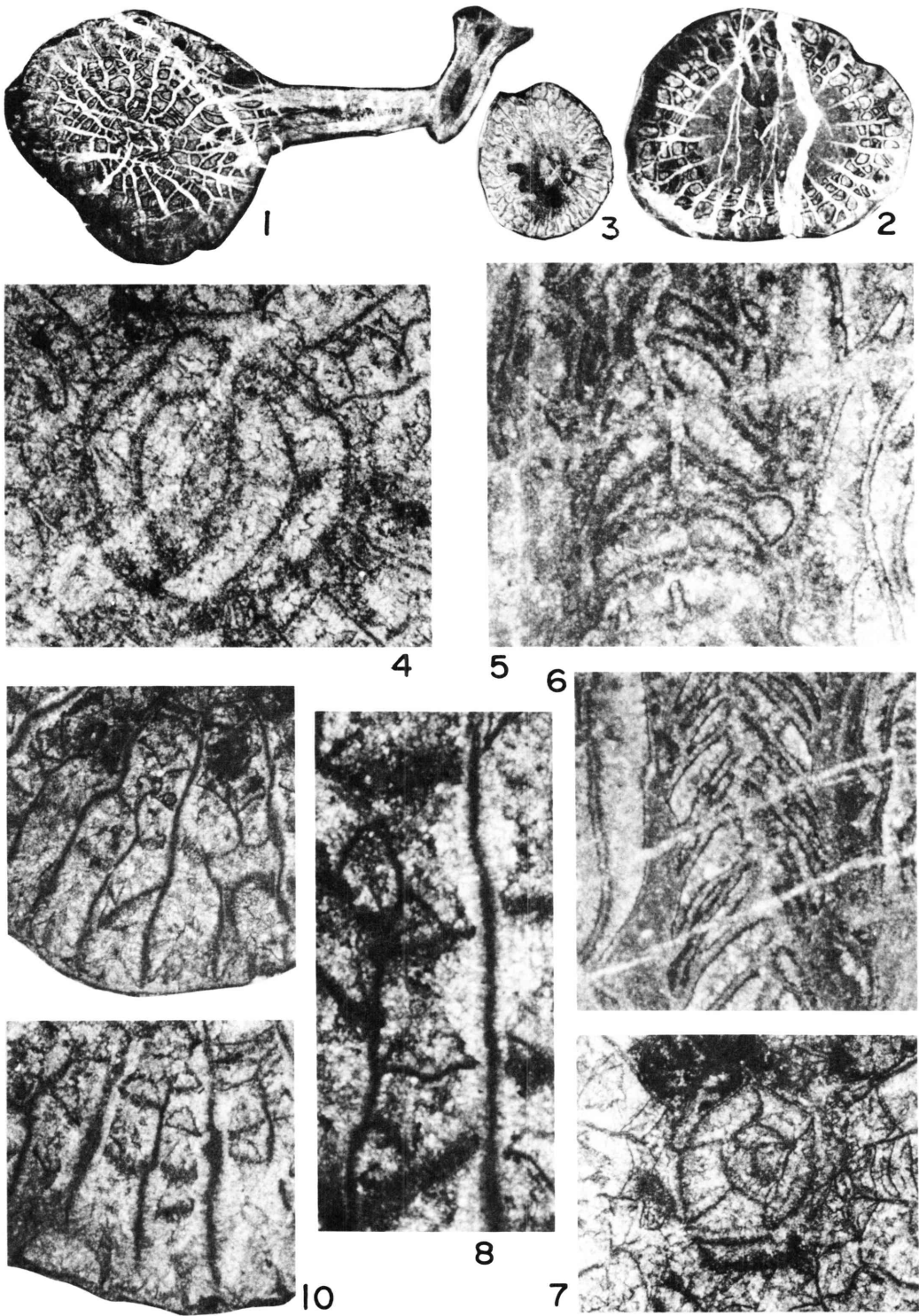
Explanation of Plate 17

Figs. 1 and 2. *Waagenophyllum (Waagenophyllum) okinawense* sp. nov.

Fig. 1. Transverse section of a part of a corallum (The type thin section), ASM10736-3a $\times 5$.

Fig. 2. Polished section of the *Waagenophyllum*-limestone showing the mode of occurrence of corallites. See also Text-figure 2.

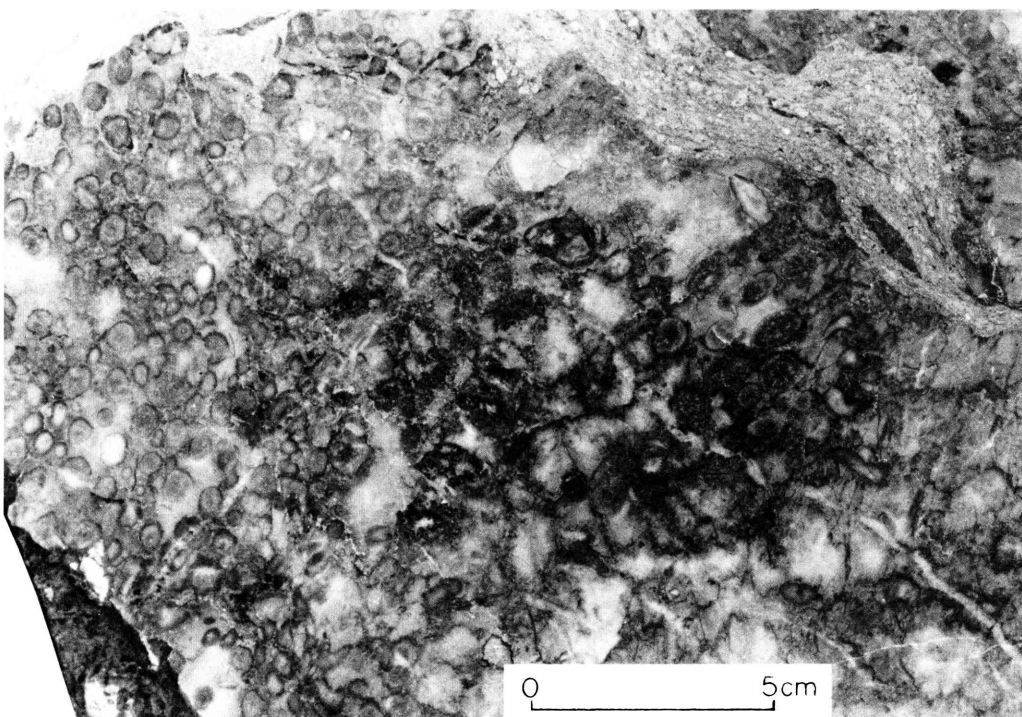




T. HAIKAWA & T. ISHIBASHI: *Waagenophyllum*



1



2