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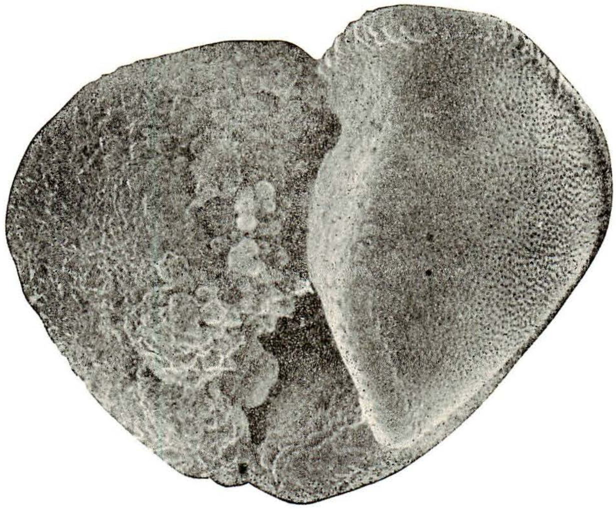

日本古生物学会

Palaeontological Society of Japan
September 30th, 1969

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Fossils on the cover is *Globorotalia truncatulinoides* (D'ORBIGNY, 1839).
The photograph was taken on a scanning electron microscope, JEOL-JSM-2, ×100.

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555. MICROFOSSILS OF THE LOWEST PART OF THE TAISHAKU LIMESTONE (STUDIES OF THE STRATIGRAPHY AND THE MICROFOSSIL FAUNAS OF THE CARBONIFEROUS AND PERMIAN TAISHAKU LIMESTONE IN WEST JAPAN, NO. 4)*

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帝釈石灰岩最下部の微化石（石炭・二畳紀帝釈石灰岩の層序と微化石動物群についての研究, No. 4）: 筆者は帝釈石灰岩最下部の *Eostaffella* 帯より 15 種の微化石を識別した。これらのうち時代決定に重要と考えられる 10 種をここに記載・報告する。記載されたものは 3 種の紡錘虫と 7 種の小型有孔虫である。これらの種によって構成される *Eostaffella* 帯は北米の Chesterian 微化石動物群に比較された福地の *Eostaffella kanmerai* 帯（猪郷, 1957）に対比できる。

Introdaction

Primitive fusulinids and their associated smaller foraminifera have been identified from the lowest part of the Taishaku Limestone in West Japan, which was designated as the *Eostaffella* zone in the preceding paper (SADA, 1967). The identified species from this zone are *Millerella* ? sp. A, *Eostaffella kanmerai* (IGO), *Mediocris* sp. A, *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *Quasiendothyra japonica* SADA, sp. nov., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Burnsia* ? sp., *Climacammina* sp., *Tetrataxis* sp., *Archaediscus* sp. and *Saccamminopsis* sp.

The fauna consisting of the species cited above resembles closely that of the *Eostaffella kanmerai* zone (IGO, 1957) in Central Japan, which was correlated with the North American Chesterian faunas composed of *Millerella*, *Eostaffella* (synonymous with *Paramillerella*) and *Endothyra*.

In this paper I described 10 species from the *Eostaffella* zone which are useful for the determination of the geologic age.

Before going to the description, I would like to appreciate Dr. B. SKIPP of U.S. Geological Survey in Denver who provided me with the valuable information regarding the Pennsylvanian and Mississippian microfossil faunas of Idaho. Thanks are also due to Professors H. TOYODA and Y. TAI of Hiroshima University for their constant encouragements.

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* Received Jan. 4, 1969: read at the 97th Meeting of the Palaeontological Society of Japan at Tokyo, Sept. 23, 1967.

Systematic Paleontology

Family Ozawainellidae THOMPSON and FOSTER, 1937

Genus *Millerella* THOMPSON, 1942

Type-species.-Millerella marblensis THOMPSON, 1942

Millerella ? sp. A

Pl. 12, figs. 20-21

Descriptive remarks.—The shell of the present specimen is minute and discoidal, having a broadly rounded periphery. The shell is about 130 microns in length and 550 microns in width. The form ratio is 0.22. The spirotheca is composed of a tectum and inner and outer tectoria in the last two volutions. The thickness of the spirotheca of the ultimate volution of a specimen is about 10 microns.

The present specimen is in very poor preservation and it is very difficult to observe acculately the internal characteristics of the shell. Therefore the specimens described here are referred to Genus *Millerella* with question.

Occurrence.—Very rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Quasiendothyra japonica* SADA, sp. nov. and *Endothyra* spp.

Genus *Eostaffella* RAUSER-CHERNOUSSOVA, 1948

Type-species.-Eostaffella parastruvei RAUSER, 1948

Eostaffella kanmerai (IGO)

Pl. 12, figs. 1-13; Pl. 13, figs. 1-2

1957. *Millerella kanmerai* IGO. *Sci. Rep. Tokyo Kyoiku Daigaku, Ser. C,* vol. 5, nos. 47-48, pp. 175-177, pl. 1, figs. 20-26, pl. 2, fig. 14.
1964. *Eostaffella kanmerai,* SADA. *Jour. Sci. Hiroshima Univ., Ser. C,* vol. 4, no. 3, pp. 230-231, pl. 21, figs. 8, 16, 17.
1967. *Eostaffella kanmerai,* SADA. *Trans. Proc. Palaeont. Soc. Japan, N. S.,* no. 67, pp. 144-145, pl. 12, figs. 1-10.

Description.—The shell of *Eostaffella kanmerai* (IGO) is fairly large and discoidal in shape, having a broadly rounded periphery and convex lateral slopes. The shells of four to five volutions are 128 to 270 microns in length and 309 to 634 microns in width, giving the form ratios of 0.41 to 0.46. The inner three to four volutions are involute but the last one is partly evolute.

The outside diameter of the proloculus ranges from 29 to 52 microns. The radius vectors of the 1st to the 5th volution of five specimens are 30-49, 51-88, 77-154, 142-245 and 223-349 microns, respectively. The spirotheca is composed of a distinct tectum and inner and outer dense layers. The thickness of the spirotheca of the 1st to the 5th volution of five specimens is 3-8, 8-11, 9-15, 12-17 and 16-19 microns, respectively. The average thickness of the proloculus wall is 6 microns in five specimens. The septa slightly bend anteriorly and the septal counts of the 1st to the 4th volution of a specimen (A72301-18d) illustrated as fig. 11 on Pl. 12 are 6, 8, 10 and 6(+), respectively. The chomata are small. The tunnel angles of the 2nd to the 4th volution of a specimen (A72301 20a) illustrated as fig. 1 on Pl. 12 are 25, 27 and 35 degrees, respectively.

Remarks.—In a large number of the specimens, the shells of the five volutions are very rare but the four volutions are common. The shell of the five volutions

Table 1. Measurements of *Eostaffella kanmerai* (IGO)

Specimen	Vol.	A72301-20a	A72302-21a	A72301-56a	A72301-21a	A72301-74b
Pl.-fig.		12-1	13-2	12-3	12-7	13-1
Length		0.190	0.154	0.137	0.128	0.270
Width		0.409	0.494	0.492	0.309	0.634
Form ratio		0.46	0.31	0.32	0.41	0.42
Prol.		0.038	0.034	0.052	0.049	0.029
Radius vector	1	0.030	0.043	0.049	0.040	0.035
	2	0.051	0.057	0.088	0.069	0.067
	3	0.077	0.095	0.154	0.112	0.118
	4	0.142	0.160	0.245	0.176	0.204
	5	0.223	0.270			0.349
Thickness of spirotheca	0	0.005	0.014	0.008	0.005	0.006
	1	0.003	0.009	0.005	0.008	0.005
	2	0.008	0.009	0.011	0.009	0.011
	3	0.013	0.018	0.015	0.010	0.009
	4	0.017	0.015	0.014	0.012	0.012
	5	0.016	0.014			0.019

(Measurements in millimeters)

is represented by the specimen (A72301-20a) illustrated as fig. 1 on Pl. 13 and it is quite similar to the holotype of the species (IGO, 1957, pl. 1, fig. 1). The shells of three to four volutions should be considered to be of the immature stage of the species, because they are quite agreeable to the shell of the immature stage of the holotype in the internal biocharacteristic and the measured values.

Therefore all the specimens illustrated here are referrable to *Eostaffella kanmerai* from the Ichinotani formation of Hida Massif (IGO, 1957), the *Eostaffella kanmerai-Millerella bigemmicula* zone of the Atetsu Limestone (SADA, 1964) and the *Millerella* zone of the Taishaku Limestone (SADA, 1967) in West Japan.

Occurrence.—Rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Millerella* ? sp. A, *Mediocris* sp. A, *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *E.* spp., *Quasiendothyra japonica* SADA, sp. nov., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Brunsia* ? sp., *Climacammina* sp., *Tetrataxis* sp. and *Archaediscus* sp.

Genus *Mediocris* ROSOVSKAYA, 1961

Type-species.-Eostaffella mediocris VISSARINOVA, 1948

Mediocris sp. A

Pl. 12, fig. 14

Descriptive remarks.—The shell of *Mediocris* sp. A is fairly large and discoidal. The shell of five volutions is 150 microns in length and 590 microns in width, having a form ratio of 0.25. The spirotheca is finely granular. The inner four volutions are involute but the last one is completely evolute. The present specimen is somewhat allied to

Mediocris evolutis grandiosa ROZOVSKAYA (1963, p. 107-108, pl. 19, figs. 11-13) but it differs from *M. evolutis grandiosa* in its larger size and the shape of the shell. In the shape of the shell, *Mediocris* sp. A resembles "*Millerella*" *komatsui* IGO (1957, p. 174, pl. 1, figs. 10-12; pl. 2, figs. 4-5) from the Ichinotani formation in Central Japan. However, the final specific identification will be postponed until the sufficient materials are available.

Occurrence.—Very rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *E.* spp., *Quasiendothyra japonica* SADA, sp. nov., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Brunsia* ? sp., *Climacammina* sp. and *Archaediscus* sp.

Family Endothyridae BRADY, 1884

Subfamily Endothyrinae BRADY, 1884

Genus *Endothyra* PHILLIPS, 1846

Type-species.—*Endothyra bowmani* PHILLIPS, 1846

Endothyra kibiensis SADA, sp. nov.

Pl. 12, figs. 15-18

1967. *Millerella* sp. A SADA. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 67, p. 146, pl. 13, fig. 12.

Description.—The shell of *Endothyra* sp. A is minute. The shell of four volutions illustrated as fig. 16 on Pl. 12. is 142 microns long and 389 microns wide, having a form ratio of 0.36. The other specimen (Pl. 12, fig. 17) is 97 microns long and 380 microns wide, possesses a form ratio of 0.25. The inner one to two volutions have the plectogyral coiling and the 3rd is involute. The last one is completely evolute.

The outside diameter of the proloculus is 28 microns in a specimen (Rg. No. A72301-1a: Pl. 12, fig. 16). The shell expands very slowly in the inner volutions but expands rapidly in the outer ones. The spirotheca is composed of a tectum and the inner and outer dense layers in the inner volutions. In the outer ones it consists of a tectum and a fibrous inner layer. The thickness of the spirotheca of the 1st to the 4th volution of a specimen (Pl. 12, fig. 16) is 10, 11, 9 and 11 microns, respectively.

Remarks.—The present species was

Table 2. Measurements of *Endothyra kibiensis* SADA, sp. nov.
Specimen A72301-1a: Pl. 12, fig. 16

Length	Width	Form ratio	Prol.
0.142	0.389	0.36	0.028

Radius vector Vol.		Thickness of spirotheca Vol.	
1	0.048	0	0.076
2	0.080	1	0.010
3	0.134	2	0.011
4	0.218	3	0.009
		4	0.011

(Measurements in millimeters)

illustrated without description as *Millerella* sp. A in my preceding paper (1967). However, the species shows a plectogyral coiling in its inner volutions and has some characteristics which are similar to those of genus *Endothyra*. Therefore, I have reached the conclusion that the species may be referred to genus *Endothyra*.

Occurrence.—Common in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Mediocris* sp. A, *Endothyra* sp. A, *E.* spp., *Quasiendothyra japonica* SADA, sp. nov., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Brunsia* ? sp., *Climacammina* sp., *Tetrataxis* sp. and *Archaediscus* sp.

Endothyra sp. A

Pl. 13, figs. 3-7

Description.—The shell of *Endothyra* sp. A is small. The shell of four and half a volution (Pl. 13, fig. 3, Rg. No. A72301-35a) is 73 microns in length and 365 microns in width. The form ratio is 0.20. The plane of coiling turns gradually as in plectogyral coiling in the inner volutions. The outer volutions are evolute.

The outside diameter of the proloculus is 35 microns in a specimen (Pl. 13, fig. 3). The radius vectors of the 2nd to the 4th volution of the same specimen are 55, 95 and 163 microns, respectively. The spirotheca is composed of a tectum and a fibrous inner layer. The thickness of the spirotheca in a specimen (Pl. 13, fig. 3) is about 7 microns. The thickness of the wall of the proloculus is 12 microns in a specimen.

Remarks.—In the general shape of the shell, the present species somewhat resembles *Endothyra shamordini* (RAUSER) from the Viséan of Russia. However, the present material is not sufficient for the final identification of the species.

Occurrence.—Abundant in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are the same as those of *Endothyra kibiensis* SADA, sp. nov.

Genus *Quasiendothyra* RAUSER-CHERNOUSSOVA, 1948

Type-species.-*Endothyra kobeitusana* RAUSER-CHERNOUSSOVA, 1948

Table 3. Measurements of *Endothyra* sp. A
Specimen A72301-35a: Pl. 13, fig. 3

Length	Width	Form ratio	Prol.
0.073	0.365	0.20	0.035

Radius vector Vol.		Thickness of spirotheca Vol.	
1	0.038	0	0.012
2	0.055	1	0.007
3	0.095	2	0.007
4	0.163	3	0.007
5	0.210	4	0.009
		5	0.009

(Measurements in millimeters)

Table 4. Measurements of *Quasiendothyra japonica* SADA, sp. nov.
Specimen A72301-18b: Pl. 13, fig. 21

Length	Width	Form ratio	Prol.
0.172	0.536	0.32	0.035

Radius vector Vol.		Thickness of spirotheca Vol.	
1	0.072	0	0.014
2	0.118	1	0.016
3	0.177	2	0.009
4	0.294	3	0.015
		4	0.016

(Measurements in millimeters)

Quasiendothyra japonica SADA, sp. nov.

Pl. 13, figs. 20-23

1967. *Quasiendothyra* sp. SADA. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 67, pl. 13, fig. 10.

Description.—The shell of *Quasiendothyra japonica* SADA, sp. nov. is fairly large. The shell of the inner volutions has the plectogyral coiling but the outer ones become planispiral, having a rounded periphery. The last volution is partially evolute to completely evolute. The shell illustrated as fig. 21 on Pl. 13 (Rg. No. A72301-18b) is 172 microns long and 536 microns wide, giving a form ratio of 0.32.

The proloculus is small and its outside diameter is 35 microns in a specimen. The spirotheca is composed of a discontinuous tectum and a fibrous inner layer. The thickness of the spirotheca of the outer two volutions in a specimen is about 15 microns. The chomata in the outer volutions are low and asymmetrical.

Remarks.—The present species somewhat resembles *Quasiendothyra aljutovica* (REYTLINGER) from the Moscovian of Russia. However, the former differs from the latter in having larger size of the shell and higher chambers for corresponding volutions.

Occurrence.—Common in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Millerella* ? sp. A, *Mediocris* sp. A, *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *E.* spp., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Brunsia* ? sp., *Climacammina* sp., *Tetrataxis* sp. and *Archaediscus* sp.

Family Tournayellidae DAIN, 1953

Genus *Tournayella* DAIN, 1953

Type-species.-Tournayella discoidea DAIN, 1953

Tournayella hiroshimana SADA, sp. nov.

Pl. 13, figs. 17-18

Description.—The shell of *Tournayella hiroshimana* SADA, sp. nov. is small and discoidal with the rounded periphery. The shell of five volutions illustrated as fig. 17 on Pl. 13 (A72301-33f) is 57 microns

Table 5. Measurements of *Tournayella hiroshimana* SADA, sp. nov.
Specimen A72301-33f: Pl. 13, fig. 17

Length	Width	Form ratio	Prol.
0.057	0.475	0.12	0.055

Radius vector Vol.		Thickness of spirotheca Vol.	
		0	0.009
1	0.051	1	0.010
2	0.076	2	0.010
3	0.109	3	0.014
4	0.175	4	0.012
5	0.267	5	0.011

(Measurements in millimeters)

in length and 475 microns in width. The form ratio is 0.12.

The proloculus is spherical and its outside diameter is 55 microns. The radius vectors of the 1st to the 5th volution of a specimen (Pl. 13, fig. 17) are 51, 76, 109, 175 and 267 microns, respectively. The spirotheca is composed of a dark, granular to fibrous layer and its thickness is about 10 to 14 microns. The chomata are absent.

Remarks.—In the shell-shape, the measured values and some internal characters, the present species bears a resemblance to the species described by IGO (1957) under the name of "*Millerella*" *discoidea* (p. 177-178, pl. 2, figs. 1-3) from the Ichinotani formation in Central Japan. However, the latter species differs from the former in its spirothecal structure.

Occurrence.—Rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Mediocris* sp. A, *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *E.* spp., *Quasiendothyra japonica* SADA, sp. nov., *Tournayella* sp. A, *T.* sp. B, *Monotaxinoides* sp., *Brunsia* ? sp., *Climacammina* sp., *Tetrataxis* sp. and *Archaediscus* sp.

Tournayella sp. A

Pl. 13, fig. 16

Description.—The shell of *Tournayella* sp. A is small, discoidal and entirely evolute, having the broadly rounded periphery and umbilicated poles. The shell of three volutions illustrated as fig. 16 on Pl. 13 (Rg. No. A72301-33b) is 60 microns in length and 430 microns in width, showing a form ratio of 0.14.

The proloculus is spherical and large. Its outside diameter measures 52 microns. The radius vectors of the 1st to the 3rd volution of a specimen (Rg. No. A72301-33b) are 88, 143 and 220 microns, respectively. The spirotheca is fairly thick and granular to fibrous. The thickness of the spirotheca of the 1st to the 3rd volution of a specimen is 10, 16 and 16 microns, respectively. The thickness of the proloculus wall is 10 microns in the illustrated specimen. The secondary fillings are present in the corners of the chambers.

Remarks.—The present species is simi-

Table 6. Measurements of *Tournayella* sp. A
Specimen A72301-33b: Pl. 13, fig. 16

Length	Width	Form ratio	Prol.
0.060	0.430	0.14	0.052

Radius vector Vol.		Thickness of spirotheca Vol.	
		0	0.006
1	0.088	1	0.010
2	0.143	2	0.016
3	0.220	3	0.016

(Measurements in millimeters)

lar to *Tournayella discoidea* by DAIN from the Donets basin and by SKIPP, HOLCOMB and GUTSCHICK (1966) from the Cordilleran region of North America. However, the latter form has a larger shell and larger number of volutions.

Occurrence.—Rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are the same as those of *Tournayella hiroshimana* SADA, sp. nov.

Tournayella sp. B

Pl. 12, fig. 19

Descriptive remarks.—The shell of *Tournayella* sp. B is discoidal, evolute, and broadly umbilicate on both sides.

The shell of five volutions illustrated as fig. 19 on Pl. 12 (Rg. No. A72301-37a) is 101 microns long and 479 microns wide, giving a form ratio of 0.21.

The proloculus is spherical and its outside diameter is 38 microns. The radius vectors of the 1st to the 5th

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Explanation of Plate 12

All ×100 except fig. 16

Figs. 1-13. *Eostaffella kanmerai* (IGO)
1-10, 13? Axial sections: Rg. No. A72301-20a, A72301-60a, A72301-56a, A72301-62a, A72301-55a, A72301-46a, A72301-21a, A72301-71a, A72301-74a, A72301-21f and A72301-29b, respectively. (See also Pl. 13, figs. 1 and 2). Figs. 1-6 are mature individuals and Figs. 7-10 are immature individuals.
11-12. Sagittal section: Rg. No. A72301-18d and A72301-57a, respectively.

Fig. 14. *Mediocris* sp. Axial section: Rg. No. A72301-55c.

Figs. 15-18. *Endothyra kibiensis* SADA, sp. nov.
15. Axial section of holotype: Rg. No. A72301-39a.
16-17. Axial sections of paratype: A72301-1a (×102) and A72301-1c, respectively.
18. Equatorial section: Rg. No. A72301-31b.

Fig. 19. *Tournayella* sp. B. Axial section: Rg. No. A72301-37a.

Figs. 20-21. *Millerella*? sp.
20. Axial section: Rg. No. A72302-11a.
21. Sagittal section: Rg. No. A72302-6a.

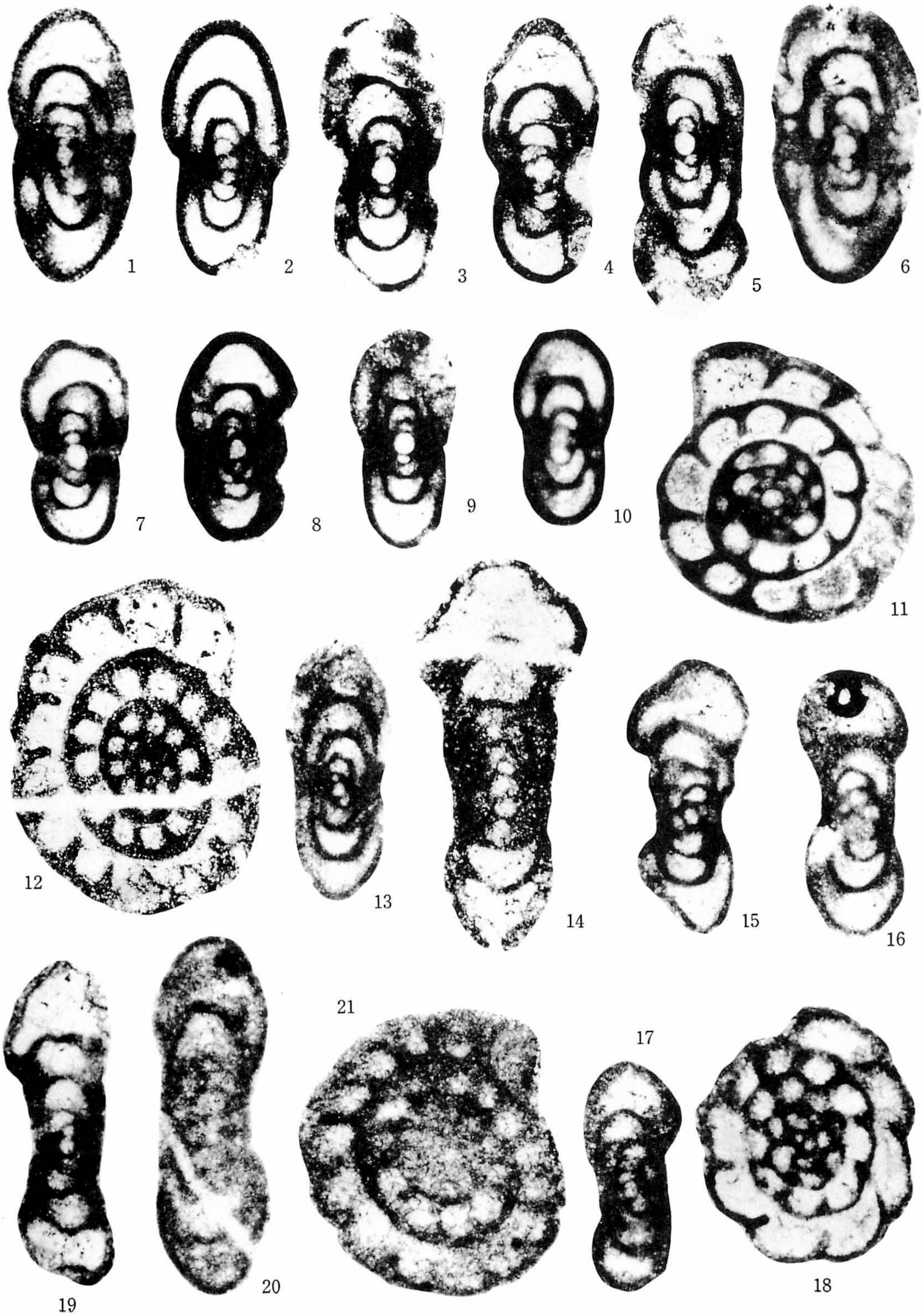
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Table 7. Measurements of *Tournayella* sp. B
Specimen A72301-37a: Pl. 12, fig. 19

Length	Width	Form ratio	Prol.
0.101	0.479	0.21	0.038

Radius vector Vol.		Thickness of spirotheca Vol.	
		0	0.011
1	0.040	1	0.010
2	0.063	2	0.009
3	0.112	3	0.016
4	0.173	4	0.016
5	0.285	5	0.018

(Measurements in millimeters)

volution of a specimen are 40, 63, 112, 173 and 285 microns, respectively. The spirotheca is dark, calcareous and fine to coarsely granular. The thickness of the spirotheca of the 1st to the 5th volution of the illustrated specimen is ranging from 9 to 18 microns.

The specimen referred to *Tournayella* sp. B has similarity to *Tournayella* sp. A in some respects. However, the latter species has fewer volutions and more deeply umbilicated poles.

Occurrence.—Rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are the same as those of *Tournayella hiroshimana* SADA, sp. nov.

Family Lasiodiscidae REYTLINGER, 1956

Genus *Monotaxinoides* BRAZHNIKOVA & YARTSEVA, 1956

Type-species.—*Monotaxinoides transitorius* BRAZHNIKOVA & YARTSEVA, 1956

Monotaxinoides sp.

Pl. 13, fig. 19

Descriptive remarks.—The shell of *Monotaxinoides* sp. is discoidal and planispiral in the coiling. Its diameter is 340 microns. The spirotheca is composed of outer dark dense and inner fibrous layers. The aperture opens at the end of the tube.

The present specimen is very rare at the basal part of the Taishaku Limestone and only one equatorial section of this species has been obtained.

The specimen illustrated here reveals several characters of Genus *Monotaxinoides*. Therefore it may be ascribable to this genus.

Occurrence.—Rare in the *Eostaffella* zone of the Taishaku Limestone. Associated fossils are *Eostaffella kanmerai* (IGO), *Mediocris* sp. A, *Endothyra kibiensis* SADA, sp. nov., *E.* sp. A, *E.* spp., *Quasiendothyra japonica* SADA, sp. nov., *Tournayella hiroshimana* SADA, sp. nov., *T.* sp. A, *T.* sp. B, *Brunsia* ? sp., *Climacammina* sp., *Tetrataxis* sp. and *Archaediscus* sp.

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(See also the references cited in the preceding paper (SADA, 1967))

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Explanation of Plate 13

All ×100 except Fig. 20

Figs. 1–2. *Eostaffella kanmerai* (IGO)
- 1–2. Axial sections: Rg. No. A72301-74b and A72302-21a, respectively. Figs. 1–2 are mature individuals.

Figs. 3–7. *Endothyra* sp. A.
- 3–7. Axial sections: Rg. No. A72301-35a, A72301-59b, A72301-61a, A72301-21b and A72301-2b, respectively.

Fig. 8. *Brunsia?* sp. Equatorial section: Rg. No. A72302-4a.

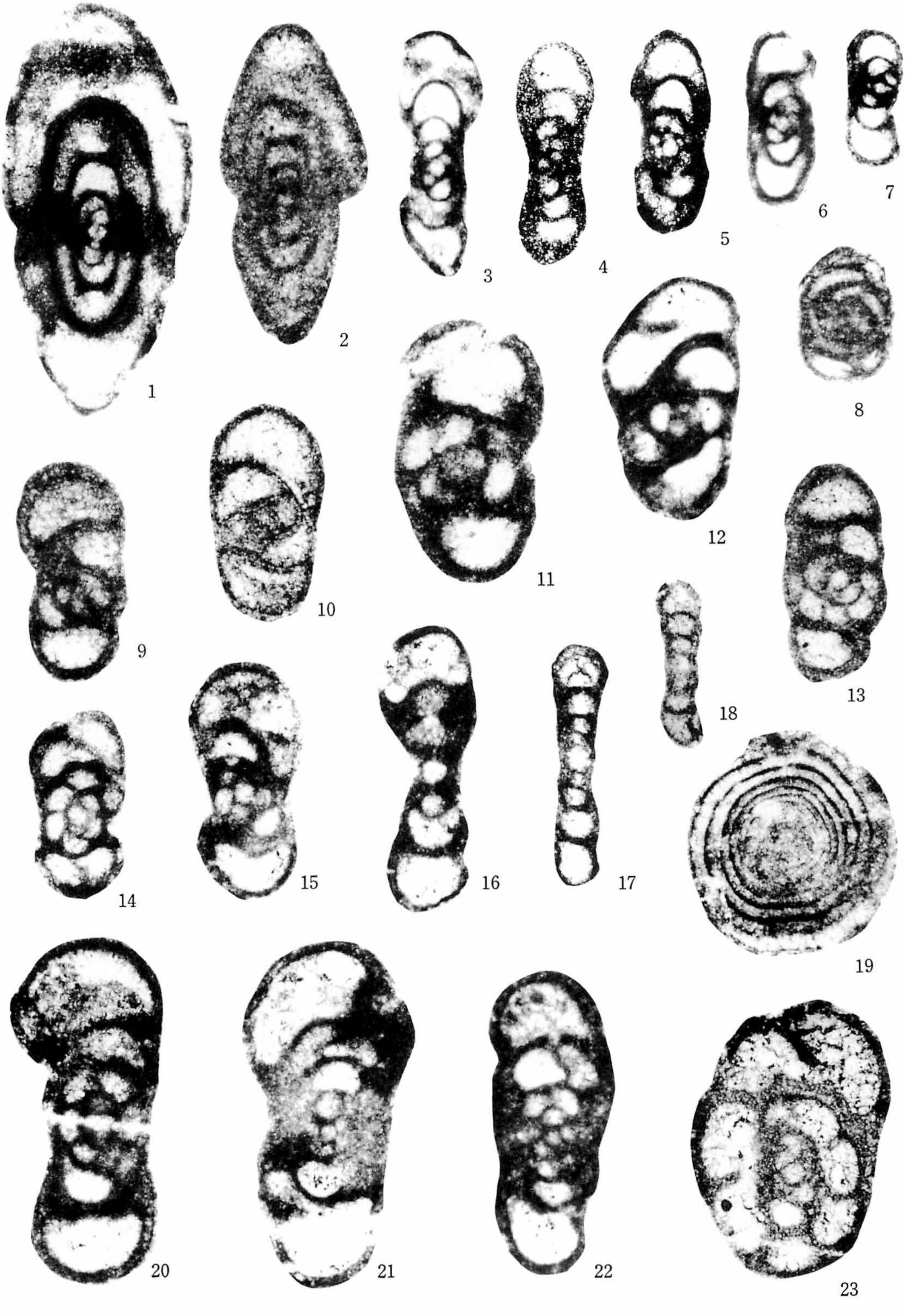
Figs. 9–15. *Endothyra* spp. Axial sections: Rg. No. A72302-10b, A72302-5a, A72302-8a, A72301-30a, A72302-4a, A72301-20c and A72301-25a, respectively.

Fig. 16. *Tournayella* sp. A. Axial section: Rg. No. A72301-33b.

Figs. 17–18. *Tournayella hiroshimana* SADA, sp. nov.
- 17. Axial section of holotype: Rg. No. A72301-33f.
- 18. Axial section of paratype: Rg. No. A72302-15d.

Fig. 19. *Monotaxinoides* sp. Equatorial section: Rg. No. A72301-23b.

Figs. 20–23. *Quasiendothyra japonica* SADA, sp. nov.
- 21. Axial section of holotype: Rg. No. A72301-18b.
- 20, 22. Axial sections of paratype: A72302-2b (×102) and A72301-35b, respectively.
- 23. Equatorial section: Rg. No. A72301-16a.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Atetsu Limestone	阿哲石灰岩	Ichinotani	一の谷
Hida Massif	飛驒山地	Taishaku Limestone	帝釈石灰岩

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 75, pp. 130-135, pl. 14, Sept. 30, 1969

556. PLIOCENE BORING SHELLS AND THEIR BURROWS FROM THE ENVIRONS OF SENDAI, JAPAN*

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and

HIROSHI NODA

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仙台付近の鮮新世穿孔貝とその巣穴： 仙台市付近に分布する鮮新世竜ノ口層，および八木山層最上部から採集した穿孔貝とその巣穴（サンドパイプ）を記載し，その地質学的意義について考察した。さらに，竜ノ口層の安山岩礫中から採集した穿孔貝は *Zirfaea* の新種であることが判ったので *Zirfaea hataii* と命名した。 増田孝一郎・野田浩司

Introduction and Acknowledgements

It is well known that the Tatsunokuchi Formation distributed in the environs of Sendai City has yielded many kinds of fossils such as molluscs, brachiopods, crabs, foraminifers, fishes, whales, elephant teeth, diatoms, drift woods, plant leaves, etc., many of which have already been published.

Recently the senior writer collected some interesting sandpipes containing the original boring shells from a basaltic andesite boulder of the Tatsunokuchi Formation. It is interesting that the rock boring bivalves were found in the igneous rocks, because they usually occur in sedimentary rocks (mostly of Tertiary) such as sandstone, siltstone, etc. (MASUDA, 1968). On the other hand, the junior writer found some boring bivalves from a sandstone of the Tatsunokuchi Gorge in the western part of Sendai City. To date no rock boring bivalves have been reported from the Tatsunokuchi Formation, though numerous molluscan shells were described by many authors since NOMURA and HATAI (1936) first described *Arca tatunokutiensis*, n. sp. from the formation.

Several sandpipes containing the rock boring bivalves were also collected by the junior writer from the upper part of the Yagiyama Formation at Shishiochi, Sendai City.

As the burrows made by the marine bivalves are important and interesting with regard to interpretation of the paleoenvironmental conditions of the area, their characteristics and their sandpipes are described and their geological significances discussed in this article.

Deep appreciation is expressed to Professor Kotora HATAI of the Institute of Geology and Paleontology, Faculty of

* Received January 25, 1969; read January 25, 1969.

Science, Tohoku University, for his contiguous encouragement and reading the manuscript. Thanks are also due to Messrs. Morihiro AOKI of the Department of Geology, Miyagi University of Education and Isao HINO of the Department of Geology, Faculty of Arts and Sciences, Tohoku University for their help in various ways.

Occurrence of Sandpipe

The sandpipes were found in the weathered basaltic andesite boulders embedded in the fossil shell bed of coarse- to very coarse-grained sandstone making the Gôroku cliff in the western border of Sendai City (text-fig. 1). At that locality the conglomerate of the

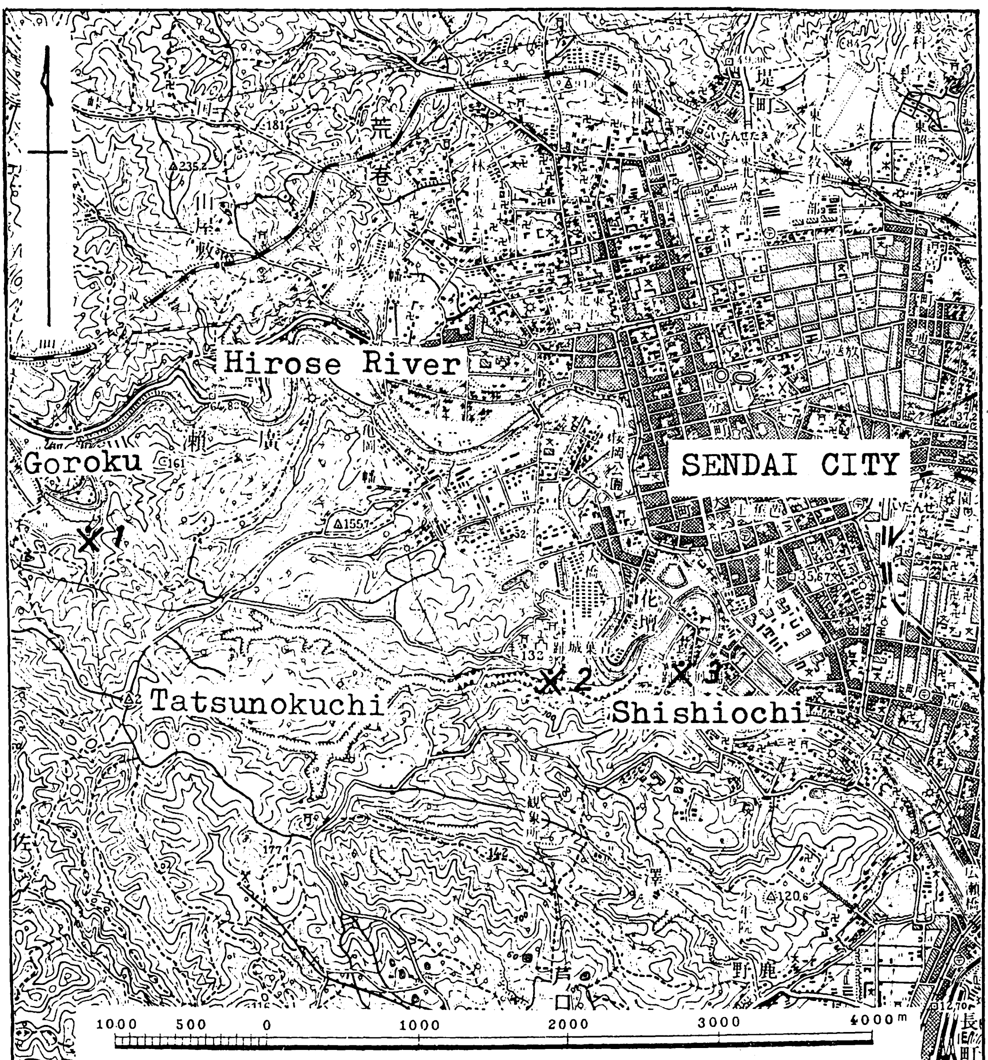

Fig. 1. Map showing the fossil localities.

Tatsunokuchi Formation overlies the pisolite bearing tuffaceous siltstone of the upper part of the Kameoka Formation. The fossil shell bed including the boulders lies above the conglomerate mentioned above.

The sandpipes with the well preserved boring bivalves occur in almost upright position with the upper surface of the boulder, open at the top and broadly and regularly rounded at the lower part. None were found on the lower surface of the boulder.

Numerous molluscan species (NOMURA, 1938) are known from the same locality as the boring shells. The common and characteristic molluscan species are *Anadara tatunokutiensis* (NOMURA and HATAI), *Glycymeris gorokuensis* NOMURA, *Fortipecten takahashii* (YOKOYAMA), *Ostrea gigas* THUNBERG, *Anomia cytaeum* GRAY, *Joannisiella cumingi* (HANLEY), *Pitar sendaica* NOMURA, *Dosinia tatunokutiensis* NOMURA, *Meretrix parameretrix* NOMURA, *Macoma tokyoensis* MAKIYAMA, *Panope japonica* (A. ADAMS), *Mya japonica* JAY, *Littorina brevicula* PHILIPPI, *Tegula yabei* NOMURA, *Neverita kiritaniana gorokuensis* (NOMURA), etc. Among the listed species the rocky bottom dwelling ones are such as *Ostrea*, *Anomia*, *Littorina*, *Tegula*, etc.

The sandpipes with the boring bivalves were found in the siltstone of the uppermost part of the Yagiyama Formation exposed in a roadside cutting near the Shishiochi Mineral Spring (Text-fig. 1). The upper parts of the sandpipes are irregular because of the loading by the overlying Dainenji Formation and occur in almost upright position, open at the top and broadly rounded at the lower.

Description of Sandpipe

A few sandpipe specimens from the Gôroku cliff were examined. The length of the sandpipes measures about 25 mm. The upper end of the sandpipes is open and continuous to the overlying layer. It tends to expand regularly towards the lower part and attains about 13 mm in maximum diameter. The lower end is regularly rounded and subcircular in profile. The longitudinal axis is nearly straight.

The contents of the sandpipes are of rather poorly sorted medium-grained sandstone, generally coarser in the inner part and finer outwards. These differences of grain size in the sandpipes of the boring bivalves have been observed in the sandpipes of *Barnea* (*Umitakea*) *japonica* (YOKOYAMA) from the Pliocene Yagiyama Formation (MASUDA and TAKEZAWA, 1961) and the sandpipes of *Pholadidea* sp. in the volcanic rocks of the Miocene Takadate Andesite (MASUDA, 1968).

The present sandpipes differ from the ones of *Zirfaea subconstricta* (YOKOYAMA) in having shorter length of burrow, and also from the ones of *Pholadidea* sp. penetrating volcanic rocks in having rather straight longitudinal axis and bluntly pointed basal end.

The sandpipes from the Yagiyama Formation are long flask-like in shape, and measure about 30 mm in length. The upper end measures about 4 mm in diameter and is subcircular in profile, whereas downwards it tends to expand gradually and attains about 23 mm in diameter. The lower end is blunt and subcircular in profile. The longitudinal axis is usually somewhat bent. Comparing with the sandpipes of *Zirfaea* described by ITOIGAWA (1963a, b) from the Miocene Mizunami Group in Gifu Prefecture, the present sandpipes are usually of smaller size.

Description of the Boring Shell

Family Pholadidae

Genus *Zirfaea* GRAY, 1847

Zirfaea hataii MASUDA and NODA, n. sp.

Pl. 14, fig. 3

Holotype.—IGPS*, coll. cat. no. 86742.

Description.—Shell small, rather thick, moderately inflated; separated into two parts by distinct, narrow, nearly straight, oblique furrow running from beak to ventral margin; furrow sculptured with numerous, transverse, fine incremental lines; anterior part somewhat shorter than posterior, triangular in shape, sculptured with fine but distinct, close-set, undulated concentric lines and about 10, rather stout, low radiating riblets, making file-like texture, bluntly pointed at end; posterior part sculptured with broad, flat-topped concentric lines, rounded at end; umbonal reflection distinct.

Dimensions (in mm).—Height 9.8, length 14, depth ca. 5.

Remarks.—Only one left valve is at hand and it may represent a young shell. This species is named in honor of Professor Kotora HATAI of the Tohoku University.

The present new species resembles *Zirfaea subconstricta* (YOKOYAMA) (YOKOYAMA, 1924), a Pleistocene and Recent species of Japan, but it can be distinguished from YOKOYAMA's species by its rather thick shell and by the anterior part being sculptured with conspicuous concentric lines and about 10, rather stout radiating riblets. *Zirfaea subconstricta kotorai* OTUKA (1934) described from the Miocene Kadonosawa Formation of Iwate Prefecture, can be distinguished from the present one by its rude concentric structure and faint radiating riblets.

Type locality, geological formation and age.—Gôroku cliff along the right bank of the Hirose-gawa, near the waterway tunnel of the Sankyozawa Electric Plant, in the western border of Sendai City (Lat. 38°16′N., Long. 140°49′E.). Tatsunokuchi Formation. Early Pliocene.

Occurrence.—Rare.

Zirfaea sp.

Pl. 14, figs. 5, 6

Remarks.—The specimens are represented by more or less deformed cast and mold. They are characterized by: Shell medium in size, oblong, inequilateral; rather distinctly separated into two parts by low, rather faint furrow running from beak to ventral margin; anterior part sculptured with rather low, oblique concentric lines having undulated tubercles; tubercles distinct at anterior half but tend to become obscure towards posterior; obtusely pointed at end; posterior part sculptured with regularly spaced, fine, low concentric lines and faint, fine internal concentric lines.

Zirfaea subconstricta (YOKOYAMA) differs from the present one in having large shell, file-like sculpture at anterior part and close-set, fine concentric lines. *Zirfaea hataii* MASUDA and NODA described in earlier lines is also distinguishable from the present one by the surface sculpture. However, the naming is held until better preserved specimens are obtained.

The present specimens were found in the silty very fine-grained sandstone of the upper part of the Tatsunokuchi Formation. They occur rarely in association with some molluscs such as *Macoma*

* —Abbreviation for Institute of Geology and Paleontology, Tohoku University, Sendai.

tokyoensis MAKIYAMA, *Lucinoma annulata* (REEVE), etc. crabs, plant fragments, etc.

Dimensions (in mm).—Height 20.5, length ca. 35, depth ca. 5.

Locality, geological formation and age. —Left river cliff of the Tatsunokuchi stream, near the entrance of the Tatsunokuchi Gorge, Oimawashi, Sendai City (Lat. 38°14′48″N., Long. 140°51′36″E.). Tatsunokuchi Formation. Early Pliocene.

Remarks

As pointed out in earlier lines the basaltic andesite boulders with bore-holes of the boring bivalves were found in the fossil shell bed in the lower part of the Tatsunokuchi Formation exposed in the Gôroku cliff. The fossil molluscs from that locality are composed of sandy bottom dwelling molluscs in association with some rocky bottom dwelling ones. However, these rocky bottom dwellers are unknown from any other localities of the Tatsunokuchi Formation in the environs of Sendai City. According to SHIBATA (1960) the thickness of the Tatsunokuchi Formation is less in the western or northwestern regions than in the eastern or southeastern regions and the western margin of the formation is near Gôroku. From the lithologic characteristics it may be considered that the basaltic andesite boulders with bore-holes may have been derived from the Mitaki Andesite. Therefore, it is expected that the basement rocks or the boulders with bore-holes of the boring shells may also be found in the western or northwestern regions in the environs of Sendai. That is to say, it is thought that rocky shore bottoms may have been developed in the western or northwestern regions prior the deposition of the Tatsunokuchi Formation. However, further study is necessary to clarify the detailed stratigraphic relations between the Tatsunokuchi Formation and the older formations.

Two types of sandpipes are known from the uppermost part of the Yagiyama Formation. That is to say, the sandpipes made by *Barnea* (*Umitakea*) *japonica* (YOKOYAMA) (MASUDA and TAKEZAWA, 1961) are found at the northern end of Koeji, Sendai City and those of *Zirfaea* at Shishiochi, about 1 km northeast of the locality mentioned above. From the accounts mentioned above the environmental conditions may have been different between the two localities.

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Explanation of Plate 14

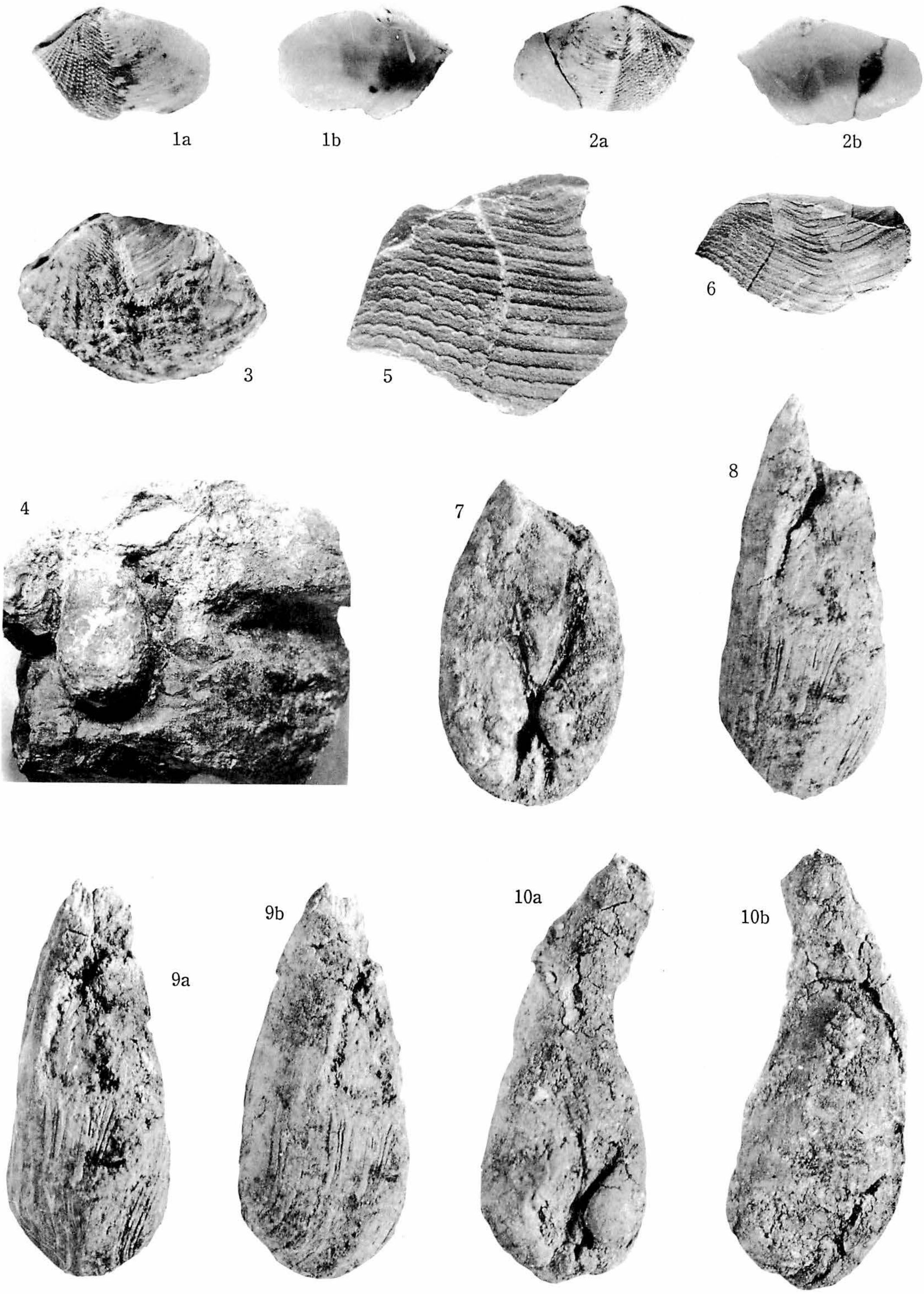
Figs. 1–2b. *Zirfaea subconstricta* (YOKOYAMA), ×3. Locality: Isohama, Miyagi Prefecture, Recent.

Fig. 3. *Zirfaea hataii* MASUDA and NODA, n. sp., ×3. Holotype, IGPS coll. cat. no. 86742, Tatsunokuchi Formation, Early Pliocene, Locality no. 1.

Fig. 4. Sand-pipe of *Zirfaea hataii* MASUDA and NODA, n. sp., IGPS coll. cat. no. 86742, Tatsunokuchi Formation, Early Pliocene, Locality no. 1.

Figs. 5, 6. *Zirfaea* sp., Fig. 5, ×5, Fig. 6, ×1. Tatsunokuchi Formation, Early Pliocene, Locality no. 2.

Figs. 7–10b. Sandpipes found in the tuffaceous siltstone of the uppermost part of the Yagiyama Formation, Pliocene, ×2. IGPS coll. cat. no. 86799, Locality no. 3.



K. KUMAGAI, photo.

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YOKOYAMA, M. (1924) : Mollusca from the Coral-Bed of Awa. *Jour. Coll. Sci., Imp. Univ. Tokyo*, Vol. 45, Art. 1, pp. 1-62, pls. 1-5.

Gôroku	郷 六
Oimawashi	追 廻
Shishiochi	鹿 落
Koeji	越 路
Sankyozawa	三居沢
Tatsunokuchi	竜ノ口

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 75, pp. 136-152, pls. 15-17, Sept. 30, 1969

557. NANNOFOSSILS FROM JAPAN I. MIOCENE DISCOASTERS FROM NOTO

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日本産超微化石 I. 能登半島の中新世ディスコースター： 能登半島の中新統中の石灰質超微化石のうちディスコースターについて報告した。西黒沢階から船川階に及ぶとされている輪島互層，赤神頁岩層，法住寺含珪藻泥岩層，輪島石灰質砂岩層，飯田含珪藻泥岩層，南志見泥岩層から21種のディスコースターを光学顕微鏡および電子顕微鏡によって識別し，そのうち4種を新種として記載した。また今までに報告されたディスコースターの産出層準との比較を試みたが確定したものとは言い難い。ディスコースターの出現の時期についてはほゞ明らかにされたようであるが消滅期については問題を残す。石灰質超微化石のプレパレーションテクニックも併せて報告した。

西　田　史　朗

Introduction

This investigation was initiated during the ordinary and electronmicroscopic examination of the calcareous sediments from the Noto Peninsula, Central Japan. Micropaleontological studies of this region has been done by ICHIKAWA and others. ICHIKAWA *et al.* (1950, 1956, 1963, 1964 and 1967) dealt mainly with diatoms, pollen, spores and silicoflagellata, and ASANO (1953) studied Miocene foraminifera. Occurrence of calcareous nannofossils was reported by NISHIDA and SHIMAKURA (1967). In this paper present author treats only discoasters. Coccoliths and other nannofossils will be reported in the near future.

Since the stratigraphic value of discoasters was recognized by BRAMLETTE and RIEDEL (1954), an increasing number of papers has been published on the calcareous remains of the nannofossils in recent years, but the reports from Japan are meager. Most papers of them have been devoted to the description of the variety of discoasters from the early Tertiary, and few published have been devoted to the occurrence of these tiny fossils in the late Tertiary. Present study clarified a part of the Miocene discoaster assembrage from the district along the Sea of Japan.

Star-shaped, minute, calcareous, skeletal remains are included in the "form genus" named *Discoaster*. These organisms are supposed not to be living at present, and so there is no certainty of its relationship to the other calcareous nannofossils. In spite of the obscurity in taxonomical position of this nannofossils, discoasters are recognized as excellent guide fossils in the Cenozoic period.

In this paper, twenty-one species of Discoasters are presented with ordinary and electronmicroscopical investigations. Four new species of Discoasters are described. They are named *Dis-*

* Received March 4, 1969; read Sept. 22, 1968 at Kanazawa.

coaster gladiatus, *D. japonicus*, *D. notoensis* and *D. trifurcatus*. Type specimen will be preserved in the Department of Earth Science, Nara University of Education.

Acknowledgements

A part of the samples was collected by Assistant Professor Shiro ISHIDA of Kyoto University. Mr. Kazumi MATSUOKA and Mr. Hisashi OKUDA of Nara University of Education helped the present author for the sampling in the field. The writer wishes to express his sincer thanks to them. He received valuable suggestions from Dr. Toshiaki TAKAYAMA of Tohoku University. The writer wishes to express his thanks to Professor Misaburo SHIMAKURA of Nara University of Education for his constant encouragement and valuable suggestions. Thanks are also due to Assistant Professor Tsutomu HONJO of Hokkaido University for his hearty encouragement. The authors grateful thanks due to Professor George DEFLANDRE of Paris and to Professor William W. HAY of Illinois University for the literatures.

Previous investigations

The studies of discoasters was initiated by EHRENBERG (1854) in his "Mikrogeologie", but he considered it to be of inorganic origin. JUKES-BROWN and HARRISON (1892) figured several calcareous "Stellate bodies" from the Oceanic formation of Barbados. The first systematic work was done by TAN SIN HOK (1927), who applied the name "*Discoaster*" to the group from the late Tertiary of Indonesia. A few forms were described by SUJIKOWSKI (1930) from Poland, DEFLANDRE (1934), BERSIER (1939) from the Molasse of the northern Alps and by COLOM and GAMUNDI (1951) from the Middle Tertiary of Majorca. DEFLANDRE also vigorously studied from 1934 and summarized with his views on their systematic agreement in the "Traité de Paléontologie" (1952a) and more complately in the "Traité de Zoologie" (1952b).

Recent investigations of discoasters are as follows: BLACK and BARNES (1961), BOUCHÉ (1962), BRAMLETTE and RIEDEL (1954), BRAMLETTE (1957), BRAMLETTE and SULLIVAN (1961), BRÖNNIMANN and STRADNER (1960), BRÖNNIMANN and RIGASSI (1963), COHEN (1964 and 1965), DEFLANDRE and FERT (1954), HAY and SCHAUB (1960), HAY (1964), HAY and TOWE (1962 and 1966), HAY *et al.* (1967), HONJO *et al.* (1967), LEVIN (1965), LEVIN and JOERGER (1967), MAIER (1959), MARTINI (1958, 1960, 1961 and 1962), MARTINI and BRAMLETTE (1963), MARTINI *et al.* (1967), STRADNER (1959a, 1959b and 1961), STRADNER and PAPP (1961), SULLIVAN (1964 and 1965) and others. In these studies, BLACK and BARNES, DEFLANDRE and FERT, HAY and TOWE, and HONJO *et al.* dealt discoasters with electronmicroscope.

From the Neogene of Japan, Discoasters are first reported by TAKAYAMA (1966, Oral presentation at the annual meeting of the Geological Society of Japan, at Kanazawa) from the upper Miocene of Chōshi, HONJO *et al.* (1967) and MINOURA *et al.* (1967, Oral presentation at the annual meeting of the Geological Society of Japan, at Nagoya) from the Neogene of Bōsō, and by NISHIDA and SHIMAKURA (1967, Oral presentation at the above mensioned meeting) from the Middle Miocene of Noto.

Samples studied and their stratigraphic relationship

The Noto Peninsula belonging geologically to a part of the Miocene Green Tuff region consists of the Neogene strata covering the basement of the Hida Complex. Calcareous nannofossil-bearing beds restricted to the Miocene beds. No pre-Neogene sediments exist under these Neogene beds and in the vicinity of these sedimentary basins.

Recent stratigraphical studies of the northeastern region of this peninsula were done by NAGAHAMA (1951), KUBO (1953), MASUDA (1954), ISHIDA and MASUDA (1956), MASUDA and ISHIDA (1956), and ISHIDA (1959). Geology of this peninsula was compiled comprehensively by KASENO (1965). HOSONO *et al.* (1949) and SUZUKI (1950) investigated the historical geology of the province of Noto. Researches for diatomite were done by ICHIKAWA and KASENO (1963) and the Foundamental Session of the Ishikawa Prefectural Society for the Study of Utilization of Diatomite (1966).

According to ISHIDA (1959), the stratigraphic succession of the Miocene Noto Group in this region is established as follows:

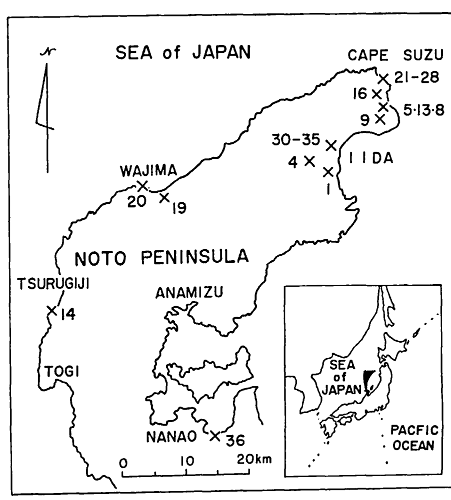
Suzu formation
- Najimi black mudstone, with a glauconite-bearing flinty bed and partly diatomaceous beds.
- Iwakurayama liparite and Awagura tuff.
- Akagami hard shale, in part diatomaceous.
- Higashiinnai alternation, with the Middle Miocene fauna.

Yanagida formation
- Basalts and dacitic sediments with the Middle Miocene flora and *Bunolophodon annectens*.

Anamizu formation
- Andesites, andesitic ryoclastics and clastic sediments derived from them.

Calcareous nannofossils have been discovered from the Najimi mudstone, the Iida diatomaceous mudstone, the Akagami shale, the Hōjūji diatomaceous mudstone, the Wajima calcareous sandstone and the Wajima alternation. The Iida diatomaceous mudstone is named for the diatomaceous part of the Awagura tuff. The Hōjūji diatomaceous mudstone is also the name given to the diatomaceous part of the Akagami shale. The Wajima calcareous sandstone is correlated to the Iwakurayama liparite and the Awagura tuff horizon, and the Wajima alternation is correlated to the Higashiinnai alternation. These discoasters occurring strata are regarded as the Middle or Upper Miocene in age. Their stratigraphic range extends from the Nishikurosawa to the Funakawa stage of the standard division in Japan, and it also corresponds to that from the late Kurosedani to the early Otogawa stage of the standard division in Hokuriku region, Central Japan.

Locality map of samples is shown in



Text-fig. 1. Sample locality map. Inset: Map of a part of the Far East showing the position of the Noto Peninsula.

text-fig. 1. The stratigraphic unit, location and the lithology for each sample are given below.

NC-8. Najimi mudstone. Awazu, Suzu City. Gray mudstone.
NC-21-28. Najimi mudstone. Rokugōsaki, Noroshi-Chō, Suzu City. White to light gray mudstone.
NC-9. Iida diatomaceous mudstone. Morikoshi, Suzu City. Gray diatomaceous mudstone.
NC-30-35. Iida diatomaceous mudstone. Iida-Chō, Suzu City. Gray diatomaceous mudstone.
NC-19. Wajima calcareous sandstone. Kamogaura, Wajima City. Hard white calcareous sandstone.
NC-1. Hōjūji diatomaceous mudstone. Uwado-Chō, Suzu City. Gray diatomaceous mudstone.
NC-4. Hōjūji diatomaceous mudstone. Hōjūji, Uwado-Chō, Suzu City. White to gray diatomaceous mudstone.
NC-5 & 13. Akagami shale. Awazu, Suzu City. Gray hard shale.
NC-16. Akagami shale. Jike, Suzu City. Gray hard shale.
NC-20. Wajima alternation. Kawai-Chō, Wajima City. Shell-bearing medium grained sandstone.

Method of the study

At the field, samples were collected taking care to eliminate the contamination. In the laboratory, after crushing the massive sample, the pulverized and shieved one under 100 mesh in size was used for the study. The shieved sample was soaked in about 5 percent solution of potassium hydroxide for more than a day for dispersion. Sometimes sodium hexametaphosphate was added to a concentration of about 1 percent in this dispersing procedure. Next, calcareous nannofossils were concentrated by the hydraulic procedure, repeatedly washing them to become so clean and pure as to be from any fine colloidal material. After all the finer material was eliminated, the sample was shieved to be under 250 mesh and then set upon the centrifugal separation at 1500 rpm. for 30 seconds. Next, the equal volume of sodium hypochloride solution was added, and boiled in water bath for 10 minutes to eliminate organic matter and silicious microfossils. Again, the process of centrifugal separation and the washing with water was repeated alternately. Through these procedure, specimens for ordinary and electron microscopy were prepared. For the optical microscopy, a drop of water with suspending nannofossils was spread on a slide glass, which was allowed to dry up, and the remained fossils were sealed in Pleurax. Carbon replica for the electron microscopy was made by the following procedures. Usually it is made by simply dropping the sample on a piece of thin glass and allowing it to dry up. Present author commonly used optical microscopic cover glass for this purpose. In the bell jar where the air was evacuated to about 1×10^{-4} torr., evaporated carbon was attached on the surface of the specimen so that it attained a suitable thickness. The carbon coated specimen was then taken out of the jar and sectioned to squares of about 2×2 milimeters and floated on 5 percent hydrofluoric acid solution in a polyetylen dish till the glass was resolved out or separated. After being washed with water sufficiently, replicated carbon films were transferred to the bath of 10 percent hydrochloric acid, and kept for about 1 hour, and then washed again with water repeatedly. Fluorite which replaced the calcareous nannofossils was dissolved out or separated within about 1 hour. Replicated carbon film was scooped up by a 150 mesh copper net. Obtained carbon replica was examined and its electronmicrographs was taken using the Japan Electron Optics Laboratory JEM-SS electronmicroscope. Prints made directly from the original negative reproduce the appearance of the nannofossils as seen on the fluorescent screen of the microscope with clear shadows which appear white on the print. Serial numbers were given to electronmicrographed negative film. In the following descriptions, type specimens used for observations are those electronmicrographed negative films for electronmicrographs, and preparates for opticalmicrographs. Besides these, concentrated and refined samples and preparats for optical microscopy are preserved.

Discoaster assembrage and discussion

It has been pointed out by many investigators, namely, HAY and MOHLER (1967), COHEN (1965) and others, that some prosperous reappearance of nannofossils in younger strata through the reworking of original sources. In the Noto Peninsula the basement of the Noto Group consists of plutonic and metamorphic rocks belonging to the Hida metamorphic belt. No pre-Miocene strata are observed in this region. The lowest part of this group is the volcanic Anamizu formation derived from the Green Tuff earth movements. The succeeding Yanagida formation yields many plant fossils showing the Daishima type flora and the Higashiinnai alternation produces abundant molluscan fossils showing the Yatsuo-Kadonosawa type fauna. These Yanagida formation and the Higashiinnai alternation have been accepted as shallow sea deposits. Also, no Paleogence strata are known in the hinterlend of this peninsula. From above reasons, any possibility of the secondary derivation of the nannofossils may be denied.

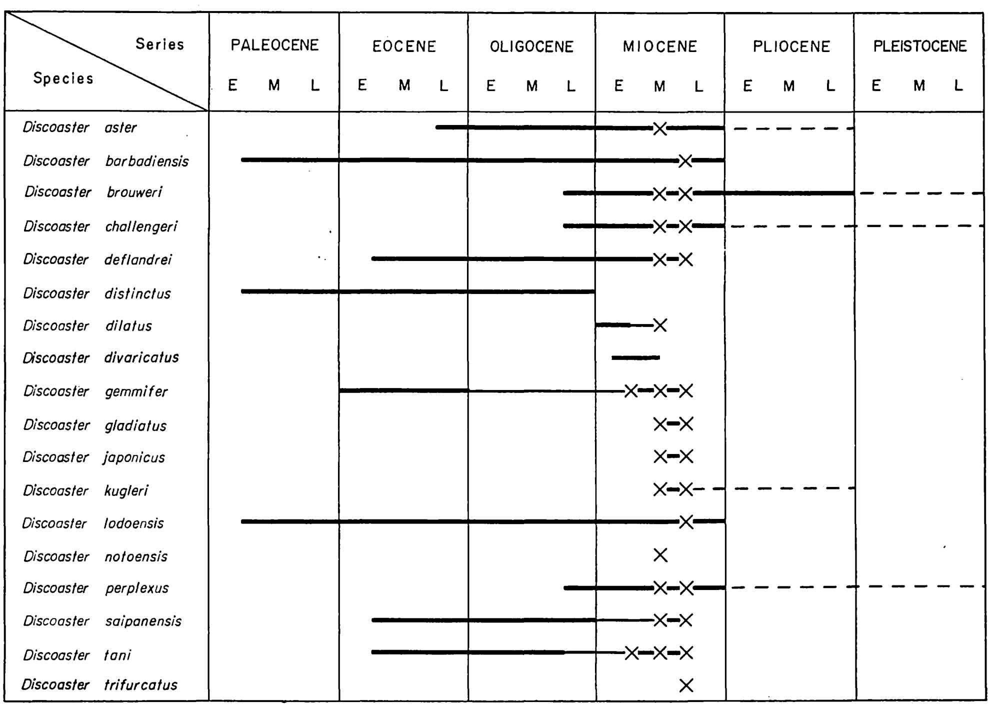
Occurrence of Discoaster in each sample is shown in text-figure 2. This figure does not show any numerical presenta-

Lithologic unit	WAJIMA alt.	AKAGAMI sh.			HOJUJI diat. ms.		WAJIMA ca. s.	SEKINOHANA ca. s.	NANAO ca. s.	IIDA diat. ms.							NAJIMI ms.								
Location	WAJIMA	AWAZU		JIKE	UWADO CHO	HOJUJI	KAMOGA URA	SEKINO HANA	NANAO	MORI KOSHI	IIDA						AWAZU	ROKUGOSAKI							
Species / Sample No. NC-	20	5	13	16	1	4	19	14	36	9	30	31	32	33	34	35	8	21	22	23	24	25	26	27	28
Discoaster aster					+																				
Discoaster barbadiensis																	+								
Discoaster brouweri		+	+		+					+	+	+			+	+	+	+				+			
Discoaster challengeri		+								+	+			+			+		+	+		+			+
Discoaster aff. *D. challengeri*										+															
Discoaster cf. *D. challengeri*		+	+	+	+					+					+	+	+	+	+						
Discoaster deflandrei		+	+	+	+	+					+				+	+		+				+			
Discoaster dilatus											+														
Discoaster aff. *D. distinctus*		+	+		+	+				+	+			+	+	+	+			+					
Discoaster cf. *D. distinctus*		+	+								+				+										
Discoaster cf. *D. divaricatus*					+																				
Discoaster gemmifer	+	+	+	+		+					+			+	+	+	+	+	+	+	+				+
Discoaster gladiatus		+	+		+	+	+			+				+	+	+									
Discoaster japonicus			+			+	+							+	+										
Discoaster kugleri		+	+	+							+				+	+				+	+			+	
Discoaster lodoensis																	+								
Discoaster notoensis			+	+		+																			
Discoaster perplexus					+									+											
Discoaster saipanensis		+		+	+					+	+	+			+			+	+	+		+			+
Discoaster tani	+	+	+	+	+	+				+	+				+	+	+		+			+			+
Discoaster trifurcatus										+															
Other calcarous nannofossils	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Text-fig. 2. Distribution of the Miocene Discoasters in the Noto Pentnisula.

tion. Throughout all samples, predominant species are *Discoaster brouweri, D. challengeri, D. deflandrei, D. gemmifer, D. saipanensis, D. tani* and almost all species have six rays. Very rarely five or four rayed *D. brouweri* and five rayed *D. deflandrei* were observed. Occurrences of *D. aster, D. barbadiensis, D. dilatus, D. lodoensis* and *D. trifurcatus* are restricted in a certain member of formations in this region, e. g., *D. aster* in the Hōjūji diatomaceous mudstone, *D. barbadiensis* and *D. lodoensis* in the Najimi mudstone, and *D. dilatus* and *D. trifurcatus* in the Iida diatomaceous mudstone. Discoasters are meager in the Wajima alternation. In the Sekinohana and the Nanao calcareous sandstone, coccoliths appear commonly but no discoasters are recognized.

According to MARTINI and BRAMLETTE, (1963), *Discoaster kugleri, D. exilis* and *D.* aff. *D. deflandrei* are particularly significant species in the Middle Miocene (Helvetian ?) cut by the experimental Mohole Drilling. *D. exilis* did not occur but *D. kugleri* and *D. deflandrei* are common throughout the Onnagawa and the Funakawa stage in Noto region. The Onnagawa stage is regarded as the Middle Miocene and the Funakawa as the Middle to Upper Miocene in Japan. *D. hamatus, D. brouweri, D. pentaradiatus* and *D. bolli* are reported from the Middle Miocene (Tortonian ?) of the above drilling. Among them, *D. brouweri* only occurred from Noto peninsula. MARTINI and BRAMLETTE (loc. cit.) also say that *D. brouweri* and *D. pentaradiatus* have their lower limits near the base of



Text-fig. 3. Stratigraphic range chart of Discoasters. Solid line: Reported range by many investigators of the world. Cross symbol: Present occurrence.

this unit in the above mentioned drill-core. But *D. brouweri* occurs throughout the Onnagawa and the Funakawa stage in Noto.

On the other hand, WRAY and ELLIS (1965) have reported that the time of extinction of Discoasters, such as *Discoaster exilis, D. hamatus, D. pentaradiatus, D. surculus, D. variabilis, D. brouweri, D. bolli, D. kegleri* and *D. challengeri*, are approximately the Plio-Pleistocene boundary in the Gulf Coast Area on the basis of their examination of about 600 samples of drill cuttings.

Text-figure 3 shows the tentative stratigraphic range chart of Discoasters. Thick lines represent the stratigraphic ranges of discosters reported by many investigators in the world. Cross symbols show the occurrence from this peninsula. *Discoaster gemmifer, D. saipanensis* and *D. tani* were still living in Noto in the Middle Miocene time. Extinction of these species seem to be somewhat delayed in our region as compared with Europe and America.

KAMPTNER (1967) reported the occurrence of *D. aster, D. brouweri, D. challengeri* and *D. perplexus* from the Challenger deep-sea sample collected at the Station 338 (lat. 21°15′N, long. 14°02′W, depth 1990 fathoms). Earlier, BLACK and BARNES (1961) described *D. perplexus* from the same sample. MC-INTYRE *et al.* (1967) found *D. brouweri* and *D. challengeri* from Atlantic deep-sea core V16-23 (lat. 13°15′N, long. 40° 40′W, depth 4885 m) taken by the Vema, research vessel of the Lamont Geological Observatory. COHEN (1964) also reported the occurrence of *D. perplexus* from Caribbean core samples A-240-M1 (lat. 15°26′N, long. 68°30′W, depth 4180 m) and A-254-BR-C (lat. 15°17′N, long. 72° 53.5′W, depth 2968 m), taken by the Woods Hole Laboratory research vessel Atlantis in 1959 and 1960 respectivly. From the Pacific Ocean, present author (unpublished) found the occurrence of *D. brouweri* from the deep-sea sample of St. 21 (lat. 0°39.6′S, long. 160°36.7′E, depth 2940 m) taken by the Oceanographical Raboratory of University of Tokyo research vessel Hakuhō-Maru in 1968. From these deep-sea occurrences, present author supposes that *D. brouweri, D. challengeri* and *D. perplexus* have possibly extended their stratigraphic range to the Pleistocene.

Systematic description

Genus Discoaster TAN SIN HOK, 1927.

Discoaster aster BRAMLETTE & RIEDEL, 1954.

Pl. 15, fig. 1

Discoaster stella (EHRENBERG), COLOM & GAMUNDI, 1951, pl. 25, fig. 6.
Discoaster aster BRAMLETTE & RIEDEL, 1954, p. 400, pl. 39, fig. 4; BRAMLETTE, 1957, p. 249, pl. 61, fig. 4; STRADNER, 1959a, p. 8, fig. 29; LEVIN, 1962, p. 270, pl. 43, fig. 3; LEVIN & JOERGER, 1967, p. 171, pl. 3, figs. 14–15; KAMPTNER, 1967, pl. 24, fig. 127.

Remarks.—This asterolith has six bluntly pointed rays varying in width and degree of separation. Outline are somewhat irregular. Total diameter 13 microns.

Hypotype.—NC-1P-1. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle Miocene (Onnagawa) of Noto, Japan.

Reported stratigraphic range.—Upper Eocene to Upper Miocene.

Discoaster barbadiensis TAN SIN HOK, 1927.

Pl. 15, fig. 2.

Discoaster Barbadiensis TAN SIN HOK, 1927, text-fig. II-4.
"coccolithe" DEFLANDRE, 1934, fig. 12.
Heliodiscoaster barbadiensis TAN SIN HOK, DEFLANDRE, 1934, figs. 22 & 23.
Hemidiscoaster barbadiensis TAN SIN HOK, COLOM & GAMUNDI, 1951, pl. 25.
Discoaster barbadiensis TAN SIN HOK, *sens emend.*, BRAMLETTE & RIEDEL, 1954, pp. 398–399, pl. 39, fig. 5a–b; GARDET, 1955, p. 526, pl. 7, fig. 68a–b; BRAMLETTE, 1957, p. 249, pl. 61, fig. 10; MARTINI, 1958, p. 366, pl. 5, fig. 24a–c; MANIVIT, 1959, p. 369, pl. 10, figs. 1–5; STRADNER, 1959a, pp. 2–3, fig. 2; STRADNER & PAPP, 1961, pp. 95–96, pl. 28, figs. 1–2; BRAMLETTE & SULLIVAN, 1961, p. 158, pl. 11, fig. 2; BOUCHÉ, 1962, p. 89, pl. 3, figs. 1–4; HAY & TOWE, 1962, p. 515, pl. 10, figs. 3 & 5; SULLIVAN, 1964, p. 189, pl. 10, figs. 1–2; HONJO *et al.*, 1967, text-figs. 3–4; TAKAYAMA, 1967, pl. 8, fig. 3; LEVIN & JOERGER, 1967, p. 172, pl. 3, figs. 17a–b; HAY *et al.*, 1967, pl. 1, figs. 9–11.

Remarks.—Asterolith, consisting of ten rays, bearing a prominent stem on its surface. Rays joined throughout their length with rounded tips forming serrate margin to the disc. Stem is short, conical and rounded distally. Total diameter 13 microns.

Hypotype.—NC-8P-2. Najimi mudstone.

Present occurrence.—Upper middle Miocene (late Funakawan) of Noto, Japan.

Reported stratigraphic range.—Middle Paleocene to Upper Miocene.

Discoaster brouweri TAN SIN HOK, 1927.

Pl. 15, fig. 3; Pl. 16, figs. 5, 6.

Discoaster Brouweri TAN SIN HOK, 1927, text-fig. II-8a, b.
? *Discoaster* aff. *D. brouweri* TAN SIN HOK, DEFLANDRE, 1934, p. 66, text-figs. 15–19.
Discoaster cf. *brouweri* TAN SIN HOK, DEFLANDRE, 1952a, text-figs. 69–70.
Discoaster brouweri TAN SIN HOK, DEFLANDRE, 1952b, fig. 34n–o.
Discoaster brouweri TAN SIN HOK, *sens emend.*, BRAMLETTE & RIEDEL, 1954, p. 402, pl. 39, fig. 12; BRAMLETTE, 1957, p. 248, pl. 61, fig. 1; STRADNER & PAPP, 1961, pp. 85–87, pl. 20, figs. 1–6; MARTINI & BRAMLETTE, 1963, p. 851, pl. 102, figs. 9–10; TAKAYAMA, 1967, p. 194, pl. 4, figs. 1–4 & pl. 6, figs. 1–5; HAY *et al.*, 1967, pl. 5, figs. 1–4; MCINTYRE *et al.*, 1967, pl. 3, fig. c; KAMPTNER, 1967, p. 164, pl. 24, fig. 133.

Remarks.—This asterolith has usually six rays which are thin, elongated, bluntly pointed and not bifurcated. Total diameter 12 microns.

Hypotype.—NC-13P-1. Akagami shale.

Present occurrence.—Middle (Onnagawan) and Upper Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range.—Upper Oligocene to Upper Pliocene.

Discoaster challengeri BRAMLETTE, & RIEDEL, 1954.

Pl. 15, fig. 5.

Discoaster Mohlengraaffi TAN SIN HOK, var. γ, text-fig. II-11.
Hemidiscoaster Mohlengraaffi Variété à bras plus maigres, DEFLANDRE, 1934, text-fig. 11.
Hemidiscoaster mohlengraaffi TAN SIN HOK, DEFLANDRE, 1952a, text-fig. 66; DEFLANDRE, 1952b, text-fig. 362u.
Discoaster challengeri BRAMLETTE & RIEDEL, 1954, p. 401, pl. 39, fig. 10; BRAMLETTE, 1957, p. 248, pl. 61, fig. 2; MARTINI & BRAMLETTE, 1963, p. 851, pl. 103, figs. 11–12; HAY *et al.*, 1967, pl. 4, figs. 9–10; MCINTYRE *et al.*, 1967, pl. 3, fig. d; KAMPTNER, 1967, p. 164, pl. 24, fig. 130.

Remarks.—Asterolith with six rays which are subcylindrical, distally bifurcated into short, round termination. Widening of rays in central area is not pronounced. In the central area, there is a small, circular knob. Total diameter 12 microns.

Hypotype.—NC-9P-1. Iida diatomaceous mudstone.

Present occurrence.—Middle (Onnagawan) to Upper middle Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range.—Upper Oligocene to Lower Pliocene.

Discoaster aff. *D. challengeri* BRAMLETTE & RIEDEL, 1954.

Pl. 15, fig. 4.

Discoaster challengeri BRAMLETTE & RIEDEL, 1954, p. 401, pl. 39, fig. 10.

Remarks.—Asterolith, with six rays which are subcylindrical, distally bifurcated into long, round termination. Rays typically thin and long. Angle of bifurcation is less than that of *D. challengeri*. Total diameter 20 microns.

Hypotype.—NC-9P-1. Iida diatomaceous mudstone.

Present occurrence.—Middle Miocene (early Funakewan) of Noto, Japan.

Discoaster cf. *D. challengeri* BRAMLETTE & RIEDEL, 1954.

Pl. 16, fig. 8.

Discoaster challengeri BRAMLETTE & RIEDEL, 1954, p. 401, pl. 39, fig. 10.

Remarks.—This specimen differs from *D. challengeri* in its rather thick rays. Total diameter 10 microns.

Hypotype.—NC-1P-1. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle (Onnagawan) to Upper middle Miocene (Funakawan) of Noto, Japan.

Discoaster deflandrei BRAMLETTE & LIEDEL, 1954

Pl. 15, fig. 6; Pl. 17, figs. 2, 3.

Discoaster deflandrei BRAMLETTE & RIEDEL, 1954, pp. 399–400, pl. 39, fig. 6, text-fig. 1a–c; BRAMLETTE, 1957, p. 249, pl. 61, fig. 6; MARTINI, 1958, pp. 363–364, pl. 5, fig. 23a–c; MANIVIT, 1959, p. 367, pl. 9, fig. 4; STRADNER, 1959a, p. 7, fig. 25; MARTINI, 1961, p. 13, pl. 3, fig. 27; STRADNER & PAPP, 1961, pp. 71–72, pl. 10, figs. 1–6; SULLIVAN, 1964, p. 189, pl. 11, figs. 8–9; LEVIN & JOERGER, 1967, p. 172, pl. 4, figs. 1–2; TAKAYAMA, 1967, pl. 8, fig. 2; HAY *et al.*, 1967, pl. 2, figs. 6–9.

Remarks.—Asterolith, consisting of a central disc with six broard, bifurcated rays which are generally as long as, or a little longer than, the radius of the central disc. Outline of the widened, bifurcated parts of the rays is rounded or somewhat angular. Terminal notches are angular, rather than rounded. Spaces between the rays are subcircular, approximately as broad as the narrowest part of the rays and half as broad as the widest part of them. Total diameter 15 microns.

Hypotype.—NC-13P-1. Akagami shale. NC-13R-26 & NC-1R-44.

Present occurrence.—Middle (Onnagawan) to Upper middle Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range.—Middle Eocene to Middle Miocene.

Discoaster dilatus HAY, 1967.

Pl. 16, fig. 7.

Discoaster dilatus HAY, 1967, pp. 450–451, pl. 4, figs. 3–4.

Remarks.—Asterolith, with six rays, widened towards ends that are linear or slightly concave. Inter-ray notches are deep. Total diameter 7 microns.

Hypotype.—NC-30P-1. Iida diatomaceous mudstone.

Present occurrence.—Middle Miocene

(early Funakawan) of Noto, Japan.

Reported stratigraphic range.—Lower Miocene.

Discoaster aff. *D. distinctus* MARTINI, 1958.

Pl. 15, fig. 9.

Discoaster distinctus MARTINI, 1958, p. 363, pl. 4, figs. 17a-b.

Remarks.—Paired nodes toward the tips of the rays are conspicuous. But, present specimen differs from the holotype in the width of the rays. The rays expand gradually towards periphery and broaden at the end. Total diameter 20 microns.

Hypotype.—NC-13P-1. Akagami shale.

Present occurrence.—Middle (Onnagawan) to upper middle Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range of D. distinctus.—Middle Paleocene to Upper Oligocene.

Discoaster cf. *D. distinctus* MARTINI, 1958.

Pl. 15, fig. 8.

Discoaster distinctus MARTINI, 1958, p. 363, pl. 4, fig. 17a-b.

Remarks.—The paired nodes that tent towards the tips of the rays are conspicuous. A conical and circular knob, in central part. Present specimen has rather wide and thick rays, and wider central area compaired with the holotype. Total diameter 20 microns.

Hypotype.—NC-13P-1. Akagami shale.

Present occurrence.—Middle (Onnagawan) to the Upper middle Miocene (early Funakawan) of Noto, Japan.

Discoaster cf. *D. divaricatus* HAY, 1967.

Pl. 15, fig. 7.

Discoaster divaricatus HAY, 1967, p. 451, pl. 3, figs. 7-9.

Remarks.—Six rayed asterolith with broad, bifurcating tips having a distinct notch. Inter-ray spaces subangular. Present specimen differs from the holotype in the wide central disc. Total diameter 13 microns.

Hypotype.—NC-1P-1. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle Miocene (Onnagawan) of Noto, Japan.

Reported stratigraphic range of D. divaricatus.—Lower to Middle Miocene.

Discoaster gemmifer STRADNER & PAPP, 1961.

Pl. 15, fig. 10.

Discoaster gemmifer STRADNER & PAPP, 1961, pp. 69-71, pl. 8, fig. 5 & pl. 9, figs. 1-2; STRADNER, 1961, text-fig. 83; BOUCHÉ, 1962, p. 90, pl. 3, figs. 17 & 21, text-figs. 28-29; LEVIN, 1965, p. 270, pl. 43, fig. 4.

Remarks.—Asterolith has six rays which bifurcate into two tips, and bluntly terminated. Central area is wide. Total diameter 17 microns.

Hypotype.—NC-13P-1. Akagami shale.

Present occurrence.—Middle lower (Nishikurokawan) to Upper middle Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range.-Throughout the Eocene.

Discoaster gladiatus NISHIDA, sp. nov.

Pl. 17, fig. 4.

Discoaster cf. *Brouweri* (LICATA), DEFLANDRE, 1934, text-fig. 26.

Diagnosis.—Broad central area. Ray is wide in basal part and narrow at the tip suddenly. Distinct central ridge in rays.

Description.—Asterolith, with six rays having short, pointed termination. Central area is wide and on the center of the surface, there is a knob. Ray is wide at the proximal part and become narrower outward, and its shape is rather triangular with pointed corners. Central ridge of the ray is distinct, but it does not extend into the central area. Total diameter 8 microns.

Remarks.—Short, pointed, triangular rays and broad central area are conspicuous features in this species.

Holotype.—NC-13R-30. Akagami shale.

Present occurrence.—Middle (Onnagawan) to Upper middle (early Funakawan) Miocene of Noto, Japan.

Other occurrence from Japan.—Mr. Hisatake OKADA of Hokkaido University reported of this species from the Miocene of Boso peninsula, Japan, as *Discoaster* sp. at the 75th autumnal meeting of the Geological Society of Japan.

Discoaster japonicus NISHIDA, sp. nov.

Pl. 17, fig. 5.

Diagnosis.—Broad central area. Short rays with rounded termination.

Description.—Asterolith, consisting of a broad central disc with six short, broad, roundly terminated rays whicn are about one third of the radius of the central disc in length. Spaces between rays are wide, shallow and circular. Large stellate knob in the central disc. Total diameter 8 microns.

Remarks.—Broad central disc and short, broad, roundly terminated rays are remarkable. Differs from *Discoaster gladiatus* in the width and length of the rays, and the shape of the central knob.

Holotype.—NC-4R-111. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle (Onnagawan) to Upper middle (early Funakawan) Miocene of Noto, Japan.

Discoaster kugleri MARTINI & BRAMLETTE, 1963.

Pl. 15, fig. 11; Pl. 16, figs. 1, 2.

Discoaster kugleri MARTINI & BRAMLETTE, 1963, p. 853, pl. 102, figs. 11-13.

Remarks.—This asterolith has six thick rays and large, flat central area. A small knob in the central area. Total diameter 16 microns.

Hypotype.—NC-13P-1. Akagami shale.

Present occurrence.—Middle (Onnagawan) to Upper middle (early Funakawan) Miocene of Noto, Japan.

Reported stratigraphic range.—Middle Miocene (Helvetian).

Discoaster lodoensis BRAMLETTE & RIEDEL, 1954.

Pl. 15, fig. 12.

Discoaster lodoensis BRAMLETTE & RIEDEL, 1954, p. 398, pl. 39, fig. 3; MARTINI, 1958, pp. 366-367, pl. 6, fig. 28; STRADNER, 1959a, p. 3, fig. 5; MANIVIT, 1959, p. 361, pl. 6, figs. 4-5; STRADNER, 1961, p. 86, text-figs. 84-85; STRADNER & PAPP, 1961, pp. 92-93, pl. 25, figs. 3 & 5; BRAMLETTE & SULLIVAN, 1961, p. 161, pl. 12, figs. 4-5; HAY & TOWE, 1962, p. 514, pl. 10, figs. 2, 4 & 6; BRÖNNIMANN & RIGASSI, 1963, pl. 11, fig. 2; SULLIVAN, 1964, p. 191, pl. 11, fig. 14; SULLIVAN, 1965, p. 42, pl. 10, fig. 14; TAKAYAMA, 1967, pl. 8, fig. 4.

Remarks.—Stellate asterolith, consisting of six rays joined together at their proximal half or one third portion. Furcating distal portion of the rays is tapering gradually to a sharp point, and curves. A rays are similar in the plane of the asterolith. In the central portion, a knob projects from one surface. Total diameter 12 microns.

Hypotype.—NC-8P-2. Najimi mudstone.

Present occurrence.—Upper middle Miocene (late Funakawan) of Noto, Japan.

Reported stratigraphic range.—Middle Paleocene to Upper Miocene.

Discoaster notoensis NISHIDA, sp. nov.

Pl. 17, fig. 6.

Diagnosis.—Brunt-shaped ray with blunt, arcuated termination.

Description.—Asterolith, with six brunt-shaped rays with bluntly arcuated termination. Rays are joined together at the proximal three fourth portion of their length and the proximity is inconspicuous. Total diameter 7.8 microns.

Remarks.—Rays show narrow sector-shaped with somewhat angular distal margin.

Holotype.—NC-13R-36. Akagami shale.

Present occurrence.—Middle Miocene (Onnagawan) of Noto, Japan.

Discoaster perplexus BRAMLETTE & RIEDEL, 1954.

Pl. 16, fig. 9.

Discoaster perplexus BRAMLETTE & RIEDEL, 1954, pp. 400-401, pl. 39, fig. 9; BLACK & BERNES, 1961, p. 144, pl. 24, fig. 1; STRADNER & PAPP, 1961, p. 100, pl. 30, figs. 1-7; COHEN, 1964, p. 246, pl. 5, figs. 4a-c & pl. 6, figs. 4a-b; TAKAYAMA, 1967, p. 195, pl. 4, fig. 9; HAY *et al.*, 1967, pl. 5, figs. 10-12; KAMPTNER, 1967, p. 165, pl. 23, figs. 118-119 & pl. 24, fig. 125.

Remarks.—This asterolith is small, thin, discoidal, with circular outline characterized by the straight distal margins of the rays. Twelve, very elongated triangular rays, joined together with their whole length. Total diameter 6 microns.

Hypotype.—NC-1P-1. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle (Onnagawan) Miocene to Upper middle (early Funakawan) Miocene of Noto, Japan.

Reported stratigraphic range.—Upper Oligocene to Upper Miocene, and Recent deep-sea deposit.

Discoaster saipanensis BRAMLETTE & RIEDEL, 1954.

Pl. 16, fig. 10.

Discoaster saipanensis BRAMLETTE & RIEEEL, 1954, p. 398, pl. 39, fig. 4; BRAMLETTE, 1957, p. 249, pl. 61, fig. 7; MARTINI, 1958, p. 367, pl. 6, figs. 29a-b; STRADNER, 1959a, p. 3, fig. 3; MANIVIT, 1959, pp. 359-361, pl. 6, figs. 1-3; STRADNER & PAPP, 1961, pp. 90-91, pl. 22, figs. 5-7; LEVIN, 1965, p. 270, pl. 43, figs. 2a-b; HAY *et al.*, 1966, pl. 11, figs. 8-9 & pl. 13, fig. 1; HAY *et al.*, 1967, pl. 1, figs. 4-6; LEVIN & JOERGER, 1967, p. 172, pl. 3, fig. 16.

Remarks.—Stellate asterolith, with six straight rays, joined together at the portion approximately half of their length to the proximity and taper to sharp points. A stem project from central disc. Total diameter 9 microns.

Hypotype.—NC-22P-1. Najimi mudstone.

Present occurrence.—Middle (Onnagawan) to Upper middle (Funakawan) Miocene of Noto, Japan.

Reported stratigraphic range.—Middle Eocene to Upper Oligocene.

Discoaster tani BRAMLETTE & RIEDEL, 1954.

Pl. 16, figs. 3, 11, 12.

Discoaster tani BRAMLETTE & RIEDEL, 1954, p. 397, pl. 39, fig. 1; DEFLANDRE & FERT, 1954, pl. 11, figs. 13-17; BRAMLETTE, 1957, p. 250, pl. 61, fig. 8; MARTINI, 1958, pp. 359-360, pl. 3, fig. 13a-b; STRADNER, 1959a, p. 5, fig. 16; STRADNER, 1959b, p. 479, text-figs. 43-44; STRADNER & PAPP, 1961, pp. 82-83, pl. 16, figs. 3-4; LEVIN, 1965, p. 171, pl. 43, fig. 6; HAY *et al.*, 1966, p. 396, pl. 11, fig. 6; HAY *et al.*, 1967, pl. 1, fig. 1; LEVIN & JOERGER, 1967, p. 172, pl. 4, fig. 3a-b.

Remarks.—Asterolith, with six or five rays. Rays rather heavy and of almost uniform width, abruptly truncated. Total diameter 8 microns.

Hypotype.—NC-4R-96. Hōjūji diatomaceous mudstone.

Present occurrence.—Middle lower (Nishikurokawan) to Upper middle Miocene (Funakawan) of Noto, Japan.

Reported stratigraphic range.—Middle Eocene to Upper Oligocene.

Discoaster trifucatus NISHIDA, sp. nov.

Pl. 16, fig. 4.

Diagnosis.—Trifurcated termination of the rays.

Description.—Asterolith, with six rather thin rays which are subcylindrical, distally trifurcated into short, rounded terminations. As the present figure is the electronmicroscopical shadowgraph, surface details are not observable. Total diameter 10 microns.

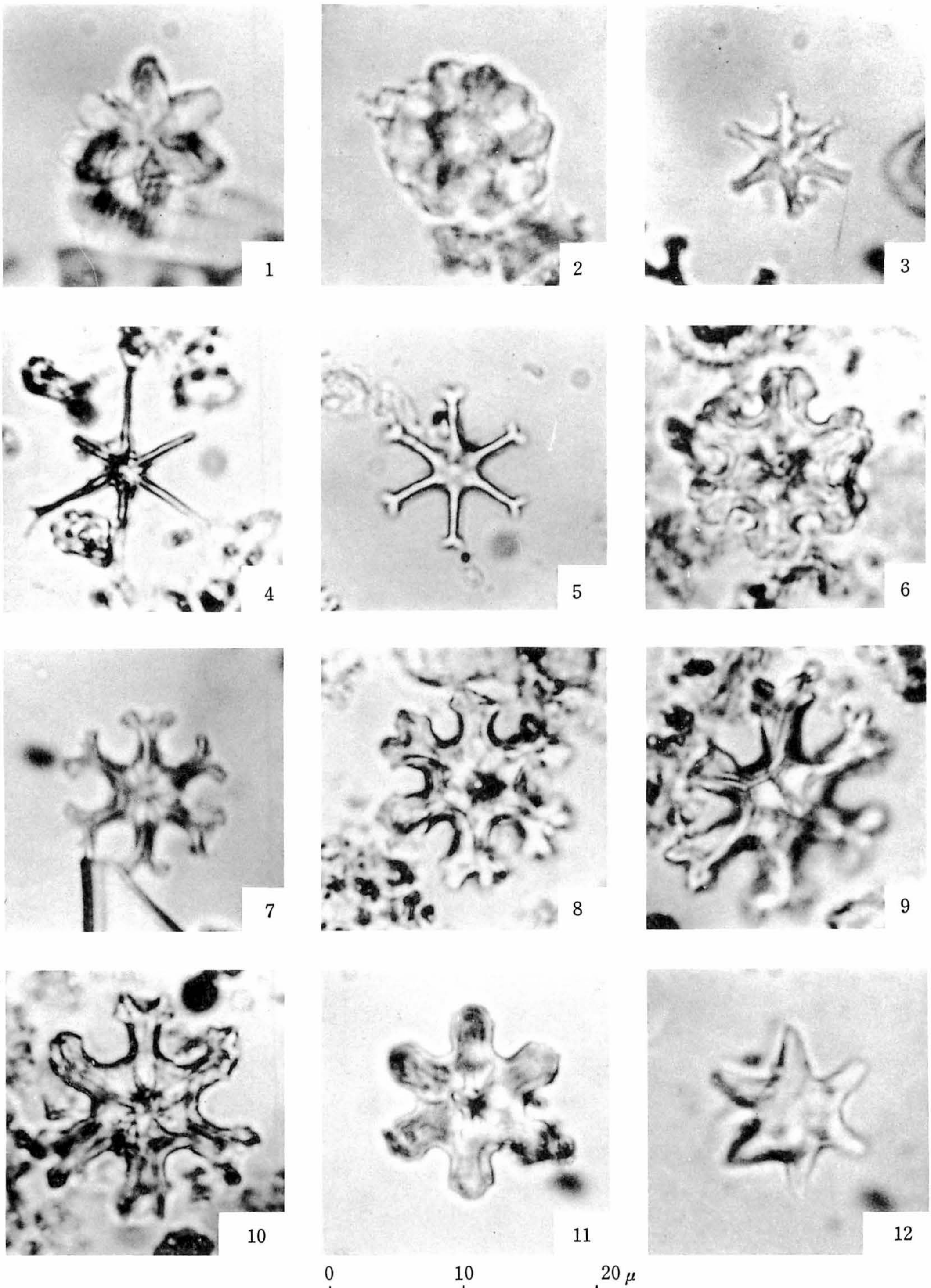
Holotype.—NC-9S. Iida diatomaceous mudstone.

Present occurrence.—Middle (early Funakawan) Miocene of Noto, Japan.

Explanation of Plate 15

Light micrographs, 2000×.

Fig. 1. *Discoaster aster* BRAMLETTE & RIEDEL.
Hypotype NC-1P-1. Hōjūji diatomaceous mudstone. Mishima, Uwado-cho, Suzu City.
Fig. 2. *Discoaster barbadiensis* TAN SIN HOK.
Hypotype NC-8P-2. Najimi mudstone. Awazu, Suzu City.
Fig. 3. *Discoaster brouweri* TAN SIN HOK.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 4. *Discoaster* aff. *D. challengeri* BRAMLETTE & RIEDEL.
Hypotype NC-9P-1. Iida diatomaceous mudstone. Morikoshi, Suzu City.
Fig. 5. *Discoaster challengeri* BRAMLETTE & RIEDEL.
Hypotype NC-9P-1. Iida diatomaceous mudstone. Morikoshi, Suzu City.
Fig. 6. *Discoaster deflandrei* BRAMLETTE & RIEDEL.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 7. *Discoaster divaricatus* HAY.
Hypotype NC-1P-1. Hōjūji diatomaceous mudstone. Morikoshi, Suzu City.
Fig. 8. *Discoaster* cf. *D. distinctus* MARTINI.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 9. *Discoaster* aff. *D. distinctus* MARTINI.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 10. *Discoaster gemmifer* STRADNER & PAPP.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 11. *Discoaster kugleri* MARTINI & BRAMLETTE.
Hypotype NC-13P-1. Akagami shale. Awazu, Suzu City.
Fig. 12. *Discoaster lodoensis* BRAMLETTE & RIEDEL.
Hypotype NC-8P-2. Najimi mudstone. Awazu, Suzu City.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Explanation of Plate 16

Figs. 1–3. Electromicrographs of carbon replica.
Fig. 4. Electronmicroscopical shadowgraph of intact Discoaster. Magnification of Figs. 1–4 are not 2000×.
Figs. 5–12. Lightmicrographs. 2000×.

Figs. 1–2. *Discoaster kugleri* MARTINI & BRAMLETTE.
Akagami shale. Awazu, Suzu City.
1: Hypotype NC–13R–60. Carbon replica. 5000:1.
2: Hypotype NC–13R–28. Carbon replica. 6000:1.

Fig. 3. *Discoaster tani* BRAMLETTE & RIEDEL.
Hypotype NC–4R–96. Hōjūji diatomaceous mudstone. Hōjūji, Uwado-chō, Suzu City. Carbon replica. 7000:1.

Fig. 4. *Discoaster trifurcatus* NISHIDA, sp. nov.
Holotype NC–9S. Iida diatomaceous mudstone. Morikoshi, Suzu City. Intact. 6000:1.

Figs. 5–6. *Discoaster brouweri* TAN SIN HOK.
5: Hypotype NC–1P–1. Hōjūji diatomaceous mudstone. Uwado-chō, Suzu City.
6: Hypotype NC–8P–1. Najimi mudstone. Awazu, Suzu City.

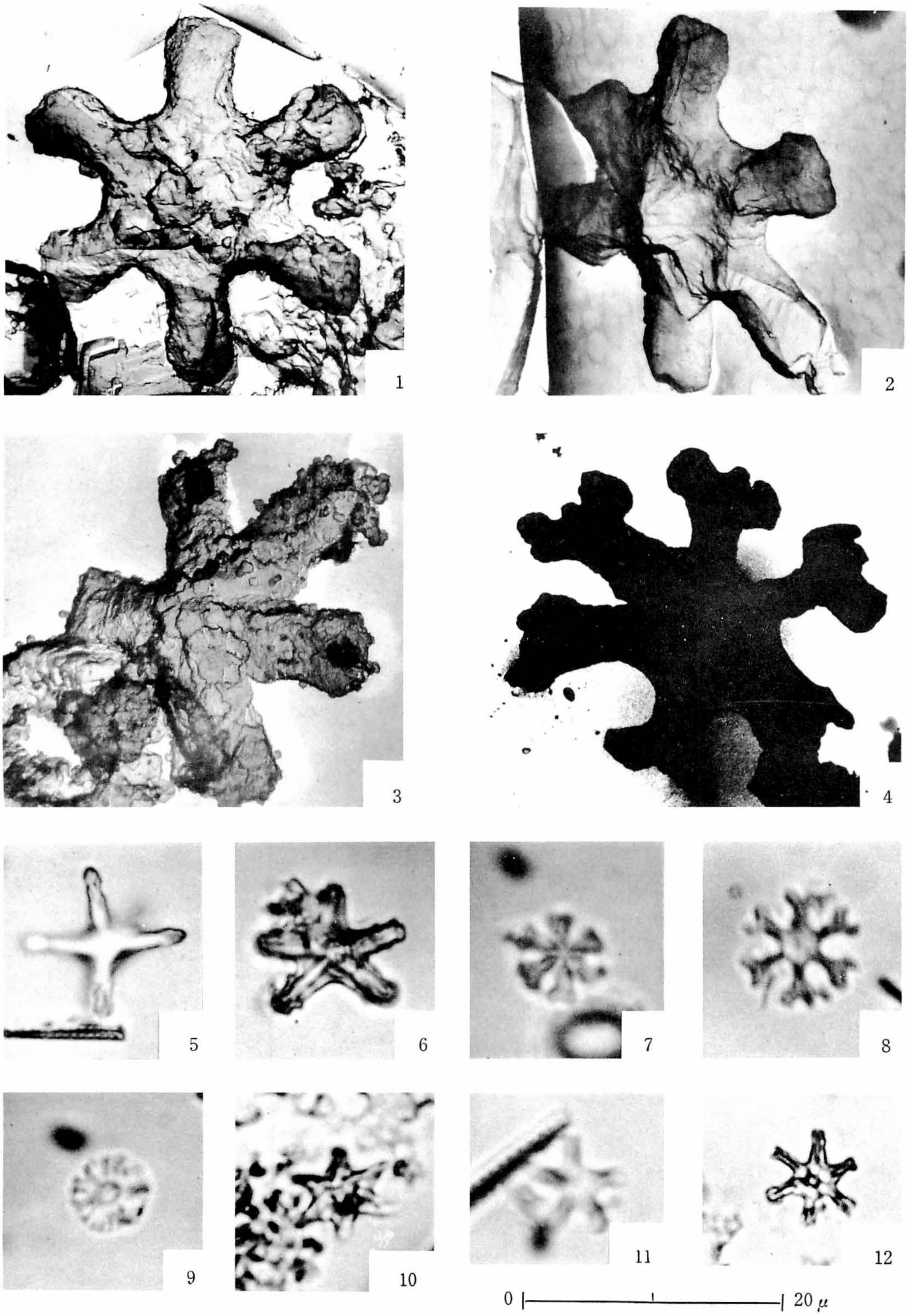
Fig. 7. *Discoaster dilatus* HAY.
Hypotype NC–30P–1. Iida diatomaceous mudstone. Iida-chō, Suzu City.

Fig. 8. *Discoaster* cf. *D. challengeri* BRAMLETTE & RIEDEL.
Hypotype NC–1P–1. Hōjūji diatomaceous mudstone. Mishima, Uwado-chō, Suzu City.

Fig. 9. *Discoaster perplexus* BRAMLETTE & RIEDEL.
Hypotype NC–1P–1. Hōjūji diatomaceous mudstone. Morikoshi, Uwado-chō, Suzu City.

Fig. 10. *Discoaster saipanensis* BRAMLETTE & RIEDEL.
Hypotype NC–22P–1. Najimi mudstone. Rokugōsaki, Noroshi-chō, Suzu City.

Figs. 11–12. *Discoaster tani* BRAMLETTE & RIEDEL.
11: Hypotype NC–1P–1. Hōjūji diatomaceous mudstone. Morikoshi, Uwado-chō, Suzu City.
12: NC–13P–1. Akagami shale. Awazu, Suzu City.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Akagami	赤 神	Kawai-chō	河井町
Anamizu	穴 水	Morikoshi	森 腰
Awagura	粟 蔵	Najimi	南志見
Awazu	粟 津	Nanao	七 尾
Bōsō	房 総	Nishikurosawa	西黒沢
Chōshi	銚 子	Noroshi	狼 煙
Daishima	台 島	Noto	能 登
Funakawa	船 川	Onnagawa	女 川
Hida	飛 弾	Otogawa	音 川
Higashiinnai	東印内	Rokugōsaki	祿剛崎
Hōjūji	法住寺	Sekinohana	関ノ鼻
Hokuriku	北 陸	Suzu	珠 州
Iida	飯 田	Togi	富 来
Ishikawa	石 川	Tsurugiji	劔 地
Iwakurayama	岩倉山	Uwado-chō	上戸町
Jike	寺 家	Wajima	輪 島
Kadonosawa	門 沢	Yanagida	柳 田
Kamogaura	鴨ケ浦	Yatsuo	八 尾

Explanation of Plate 17

Electronmicrographs of carbon replica

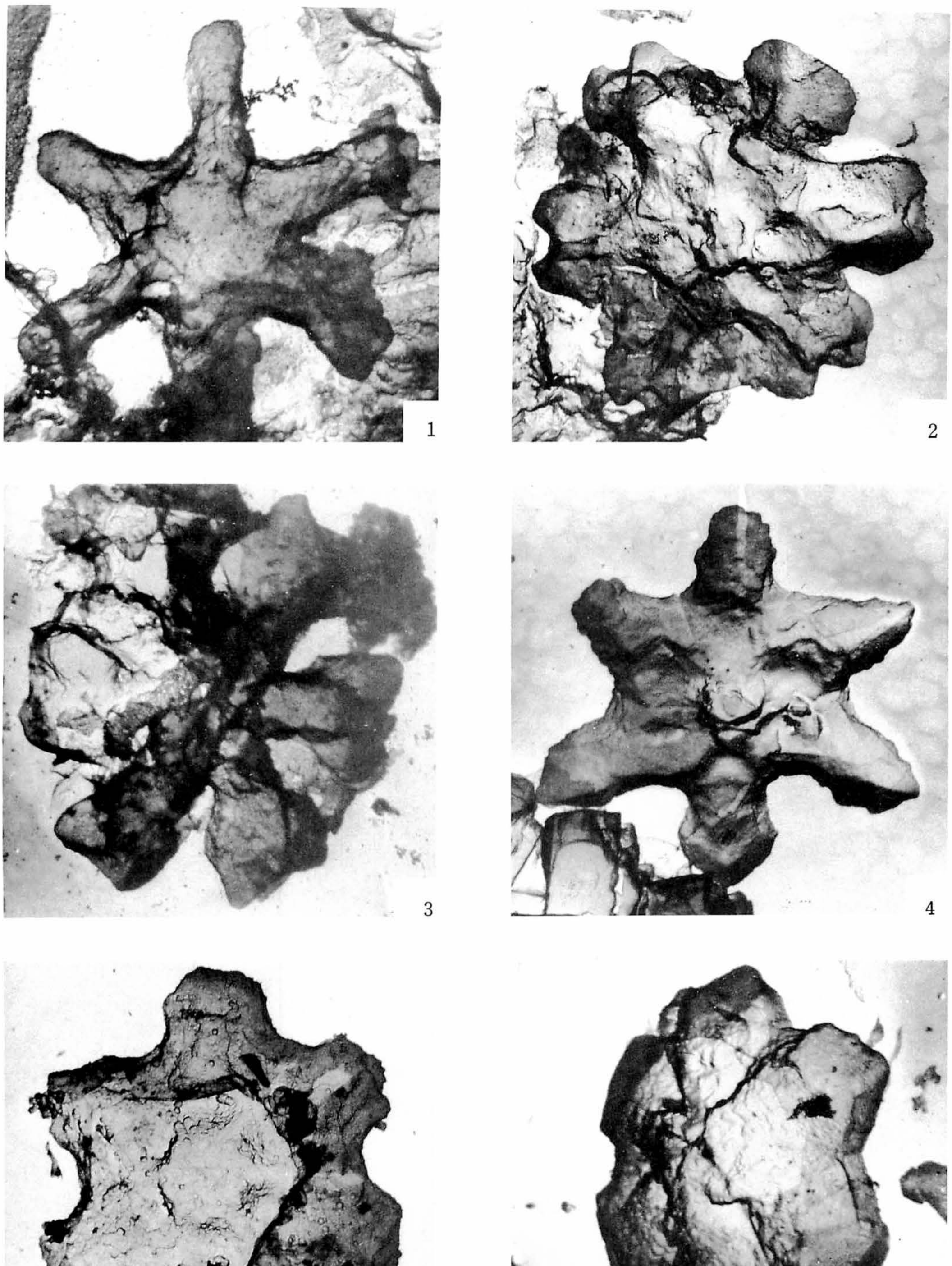
Fig. 1. *Discoaster brouweri* TAN SIN HOK.
Hypotype NC-1R-15. Hōjūji diatomaceous mudstone. Mishima, Uwado-chō, Suzu City. 8000:1.

Figs. 2-3. *Discoaster deflandrei* BRAMLETTE & RIEDEL.
2: Hypotype NC-13R-26. Akagami shale. Awazu, Suzu City. 5000:1.
3: Hypotype NC-1R-14. Hōjūji diatomaceous mudstone. Mishima, Uwado-chō, Suzu City. 5000:1.

Fig. 4. *Discoaster gladiatus* NISHIDA, sp. nov.
Holotype NC-13R-30. Akagami shale. Awazu, Suzu City. 7000:1.

Fig. 5. *Discoaster japonicus* NISHIDA, sp. nov.
Holotype NC-4R-111. Hōjūji diatomaceous mudstone. Hōjūji, Uwado-chō, Suzu City. 7000:1.

Fig. 6. *Discoaster notoensis* NISHIDA, sp. nov.
Holotype NC-13R-36. Akagami shale. Awazu, Suzu City. 7000:1.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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 75, pp. 153-155, Sept. 30, 1969

A MEMORIAL TO PROFESSOR HISAKATSU YABE
DEC. 3, 1878—JUNE 23, 1969

ICHIRO HAYASAKA

In the evening of June 23, 1969, our highly esteemed and beloved Professor Hisakatsu YABE, ex-President and honorary President of our Society, passed away very peacefully in his home under the devoted care of Mrs. YABE and his daughters. He was at the age of 90 years and 6 months. His long life was spent almost exclusively for scientific researches in geological sciences. His field of study was extensive; besides paleontology and geology, it covered zoology, oceanography, anthropology, etc. Within the bounds of his paleontological researches, foraminifers, coelenterates, molluscs, brachiopods, crustaceans, several vertebrates and some plants were dealt with. Among his geological papers, those on stratigraphy, historical geology, tectonic geology and geomorphology stand out. The stuff dealt with in these works include materials from abroad, especially from the pacific countries. His works published up to 1939 amount to 390, according to the bibliography compiled by R. AOKI as part of the Jubilee Publication of YABE's 60th Anniversary. Even after he became Professor Emeritus, YABE continued his research works for more than a dozen years in Sendai, and the rest of years in his Tokyo home. Moreover, he was said to have never missed the monthly sessions of the Japan Academy of which he was a member. During the long 30 years since the "Jubilee Publication" the number of his papers must have been immensely enlarged, possibly reaching to about 500. Many of the papers aimed, in reality, at training senior students for their future activities in universities, research institutions, mining and other engineering enterprises, museums and so on.

It may be important to notice here the time when YABE made his appearance on the stage of science in our country. As the geology in a wide sense is a science imported from abroad, it is quite natural that in a less developed country like Japan the science had to be concerned chiefly with economic problems. It was in 1898 that YABE entered the Tokyo Imperial University to start his training in geology. He was graduated in 1901, the 34th year of Meiji Era. In those days, paleontology was not altogether neglected, but Prof. Matajiro YOKOYAMA was the only one in the university who devoted himself to the paleontological works. Generally speaking, geology was applied to the investigations for national economic needs, and no geologists could be spared for other purposes.

Under such circumstances YABE's debut on the stage met with warm-hearted acknowledgement from others, though perhaps not sanctioned by some of his colleagues. Strong volition and prescient confidence in the future of the science in this country must have cost him a good deal of valour. The manifold lines of his research works as referred to above are not unrelated to such situation.

He was graduated from the Tokyo Imperial University in 1901 as stated above, presenting an excellent graduation thesis "Cretaceous Cephalopoda from Hokkaido" (which was published in 1903-4).

About that time the Ministry of Education had a plan to establish a new national university in Sendai within a few years to come. Candidates for professorship at this new university were sent abroad to prepare themselves in various senses, as was the custom of our country in those days. YABE was recommended as one of them. He spent 3 years in Europe and America, and made acquaintance with many of the leading scholars of various countries while earnestly attending to his studies.

Returning home in 1911 he was appointed the professor of geology at the Tohoku Imperial University, Sendai, where the Faculty of Science comprised the chair of geology. From then on the activities in the fields of paleontology and stratigraphy have become very active, as will be easily recognized by a glance at the lists of papers published in the period and in the periods to follow.

Swarms of students gathered around YABE to listen to his lectures. Accordingly, before several years passed, it was agreed that the Institute of Geology (Stratigraphy) and Paleontology should be kept apart from the other divisions of the Geological Department, as it would be more convenient and efficient for teaching and training the students.

In the meantime the Paleontological Society was established in 1935 under the auspices of YABE, so as to maintain international contact and communication with foreign countries. The Society made its start as a branch of the Geological Society of Japan. The first 21 issues of the Transactions were attached to the Journal of the latter. The New Series was first published in January 1951, and is being continued ever since, with increasing contributors. YABE held the post of the President of the Society until April 1959. We can make a boast of the Society's recent development, with members and contributors on the increase and noticeable works accomplished in stratigraphy, geohistory, geotectonics and other fields of the geological sciences. We should not overlook, however, that these branches of learning were based, either directly or indirectly, on the foundation laid by YABE.

YABE was a busy man, as everybody will agree. He left his footmarks not only in this country but also in Korea, China, Indonesia, the Philippines and other parts of the world, often accompanied by certain pupils of his. Perhaps because of his busy life YABE did not appear to be a sociable person. Indeed he had no habit of smoking or drinking. Among the audiences of concerts, art exhibitions, athletic fields and the like, he was seen very seldom if ever, throughout the long period of his intercourse with us. As a matter of fact he remeined unmarried until his early forties. He happened, however, to meet with a lovely, elegant and winsome young lady, not quite twenty years of age. He decided to marry her. She proved to be a very nice and consoling wife and served tenderly until her hushand's last moment. Their married life was blessed with four children, a boy and three daughters.

As an distinguished scholar and excellent teacher YABE served to the world as well as to his own country. On the occasion of his graduation from the university in 1901, he was honored with the Royal prize on account of his outstanding work accomplished for the graduation thesis. It was in 1912 that he was recommended to the degree of D. Sc. by the President of the Tohoku Imperial University. About that time Prof. DIENER from Wien called on YABE, and together they made field trips to southern Kitakami and to Shikoku in order to fulfil DIENER's wishes to observe the Triassic and Permian stratigraphy and paleontology. Soon after DIENER published a paper on the Triassicce phalopods of Japan. In 1914 YABE was recommended to the " Korrespondierendes Mitglied " of the " Kaiserlich-Könichliche Geographische Gessellschaft in Wien ". I happened to be in his room at the moment the License reached him. His face beamed with joy and he told me that " this is the most delightful moment in my life ". In the following years he received various honors from abroad, namely, Foreign Correspondent to the Paleontological Society of America (1931), Honorary member of the California Academy of Science (1932), Honorary Member of the Société Paléontologique de Russie, USSR (1933), Corresponding Member of The Geological Society of China (1915), Correspondent of the Geological Society of America, and Member of the Birbal Sahni Institute of Paleobotany (1966). At home he was a member of the Japan Academy since 1925, and an honorary member of the Paleontological Society, the Geological Society, the Geographical Society and the Association for Quaternary Research.

In 1953 YABE was awarded the Cultural Medal (Bunka-Kunsho) for his distinguished achievements in scientific researches and education.

For his long years' services to the national university and to the Japan Academy YABE was decorated posthumously with the First Class National Order.

He was buried in Sendai where most of his life was dedicated to the science and to the university. The cemetery is on a hill looking down the city to its south.

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会第 102 回例会及びシンポジウムは 1969 年 6 月 14 日（土）・15 日（日）の二日間にわたり神奈川県立博物館講堂（横浜市）において行なわれた。（参加者 70 名）

個　人　講　演

On a new species of *Brasilosaurus*. ....SHIKAMA, T. & H. OZAKI

Mesosaurus skeletons kept in Japan....... ....SHIKAMA, T.

Holocene の *Lynx* および *Sinomegaceros* に関する問題.......................... ....高井冬二・長谷川善和・金子浩昌

最近の古生物学界の動向（アジアーヨーロッパ）ーシルル・デボン系研究での 1 例........ ....浜田隆士

A new ammonite from the Shimantogawa Group of Shikoku. .... MATSUMOTO, T. & M. HIRATA

On the mode of occurrence of ammonites in the Nishinakayama Formation, Toyora Group......................... .... HIRANO, H. & T. SHIKAMA

唐津炭田行合野砂岩のノーチロイド 2 種の産状について.......................西田民雄

Carboniferous pectinaceans from Akiyoshi (Molluscan Paleontology of the Akiyoshi Limestone Group. V)........... ....NISHIDA, T.

On some gastropods from the Lower Permian Sakamotozawa Formation....... ....NISHIDA, T.

銚子白亜紀層の貝化石群 ....鈴木茂樹・鹿間時夫

Freshwater molluscs from the Owada Formation, Southeast Rumoi, Hokkaido, Japan.（代読）................NODA, H.

化石 *Ostrea* の産状 ....鎮西清高

横浜市内沖積層の貝化石群集 ....松島義章

葉山層群より得られた有孔虫化石について ....栗原謙二

北海道黒松内地方の瀬棚層産有孔虫群集について............................池谷仙之

駿河湾底質中のコッコリス ....西田史朗

Nannoplanktons from the deep-sea ooze of the Equatorial Pacific.......NISHIDA, S.

A palynological study of the late Miocene Tsukada Diatomaceous Member in Wajima City, Noto Peninsula.（代読） ....FUJI, N.

琉球列島の化石林について ....前田四郎

三浦半島秋谷の第三紀層からブナの葉化石の発見とその意味...................蟹江康光

A new species of *Sagenopteris* from Nariwa, Southwest Honshu, Japan.（代読） ....HUZIOKA, K.

Nilssoniales of the eastern Asia........... ....KIMURA, T.

シンポジウム「古植物の進化と分布」（世話人・浅間一男・徳永重元）は 15 日（日）の午前・午後にわたって行なわれた。

東亜における中生代植物の分布の特徴 ..木村達明

マレーシア産の *Gigantopteris-Lobatannularia* フローラおよび Dipteridaceae フローラと，他の東亜産のそれらとの比較..今野円蔵

ホモキシロンの分布に関連して ....西田　誠

化石と現生の植物の接点をさぐる ......前川文夫

新植代におけるスギ科について ....松尾秀邦

環太平洋地域の上部白亜系および下部古第三系花粉・胞子の分布と変遷..........高橋　清

北海道の中軸部の中新世海成堆積物の花粉分析 ....佐藤誠司

総合討論

例　会　通　知

	開催地	開催日	講演申込締切日
103回　例　会	鹿児島大学	1969年11月29,30日	1969年10月25日
1970年総会，年会	東　北　大　学	1970年1月19,20日	1969年12月1日

103回例会（鹿児島大）：日本地質学会西日本支部例会と合同。シンポジウム，九州の第四系一九州近海海底ならびに南西諸島地域を含む（世話人：首藤次男，早坂祥三）。

日本古生物学会刊行の「化石」増刊号「化石硬組織内の同位体」特集のお知らせ

昭和43年9月に日本古生物学会第100回例会が金沢大学に於いて開催されましたが，その際に行われたコロキアム「化石硬組織内の同位体」で発表された論文の内，7篇が，「化石」増刊号として出版されました。会員・非会員を問わず，興味をお持ちの方々に御一読をおすすめいたします。

内　容
1. 南西諸島および台湾産二枚貝ならびにサンゴ化石の炭素・酸素同位体比……………………酒井　均・小西健二・中道　修
2. 水温変化と酸素同位体比……………………………堀部純男・大場忠道・新妻信明
3. インド洋深海底コアーの炭酸塩温度計法による古水温………………堀部純男・大場忠道
4. 生物遺骸の示す古水温……………………………堀部純男・新妻信明・酒井忠三郎
5. 古生物に対する放射化学からのアプローチ………………………阪上正信・高木友雄
6. 造礁サンゴの ^{230}Th および ^{231}Pa 年令と ^{14}C 年令………大村明雄・小西健二・浜田達二
7. 骨・貝殻などについての ^{14}C 年代測定………………………………………木越邦彦

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3) 金沢市丸ノ内1（〒920）　金沢大学理学部地学教室　（世話人　小西健二・高柳洋吉）

NEWS

◎ 本会名誉会長　矢部長克君は1969年6月23日逝去された。

◎ 会員　植松健児君は1969年7月24日逝去された。

◎ 会員　鹿間時夫君は米国地質学会主催の Field Symposium（シカゴ）に出席のため出発した。また会員　棚井敏雅君は International Botanical Congress（シアトル）に，会員　土隆一君は INQUA（パリ）に出席した。

◎ 会員　松本達郎君は UNESCO-IUGS (International Union of Geological Sciences) 共催の IGCP (International Geological Correlation Programme)（9月11～16日　ブタペストにて開催）に出席の為，出発した。

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