Fusulines from the Ryukyu Islands Pt. 2, Iheya-jima 1 : Paleontological Study of the Ryukyu Islands-IX

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Fusulines from the Ryukyu Islands Pt. 2, Iheya-jima 1 (Paleontological Study of the Ryukyu Islands-IX)

Takeshi ISHIBASHI

Abstract

The present paper deals only with the systematic paleontology of the Carboniferous and Permian fusulines collected from the Iheya Formation and the Maedake Formation of Iheya-jima, the Ryukyu Islands. The fusuline faunas of these formations in this paper contains 18 species of 12 genera and all of them have been already known from the Japanese Islands and other districts of Tethys.

Introduction and Acknowledgements

Since HANAZAWA (1933) described the Permian fusulines from the Motobu Peninsula of Okinawa-jima, some occurrences of the Permian fusulines have been reported from the Ryukyu Islands (FLINT et al., 1959; KONISHI, 1964: ISHIBASHI, 1968, 1969, 1983). This paper describes paleontologically the Carboniferous and Permian fusulines from the Iheya Formation and a part of the Permian sections of the Maedake Formation of Iheya-jima as follows;

Iheya Formation

Fusulinella cf. *itadorigawensis* ISHII
Beedeina higoensis (KANMERA)
Protriticites sp.
Pseudofusulinella sp.
Triticites samaricus RAUSER-CERNOSSOVA
Hemifusulina ? sp.
Pseudofusulina regularis (SCHELLWIEN)
Pseudofusulina aganoensis FUJIMOTO
Schwagerina cf. *krotowi* (SCHELLWIEN)
Parafusulina gruperaensis (THOMPSON and MILLER)

Maedake Formation

Pseudofusulina sp.
Pseudofusulina vulgaris (SCHELLWIEN)
Pseudofusulina aff. *leavicula* MORIKAWA
Parafusulina gruperaensis (THOMPSON and MILLER)
Parafusulina cf. *kaerimizensis* (OZAWA)
Parafusulina sp.
Nagatoella kobayashii THOMPSON
Misellina (*Misellina*) *claudiae* (DEPRAT)
Maklaya pamirica (LEVEN)

Manuscript received July 9, 1984.

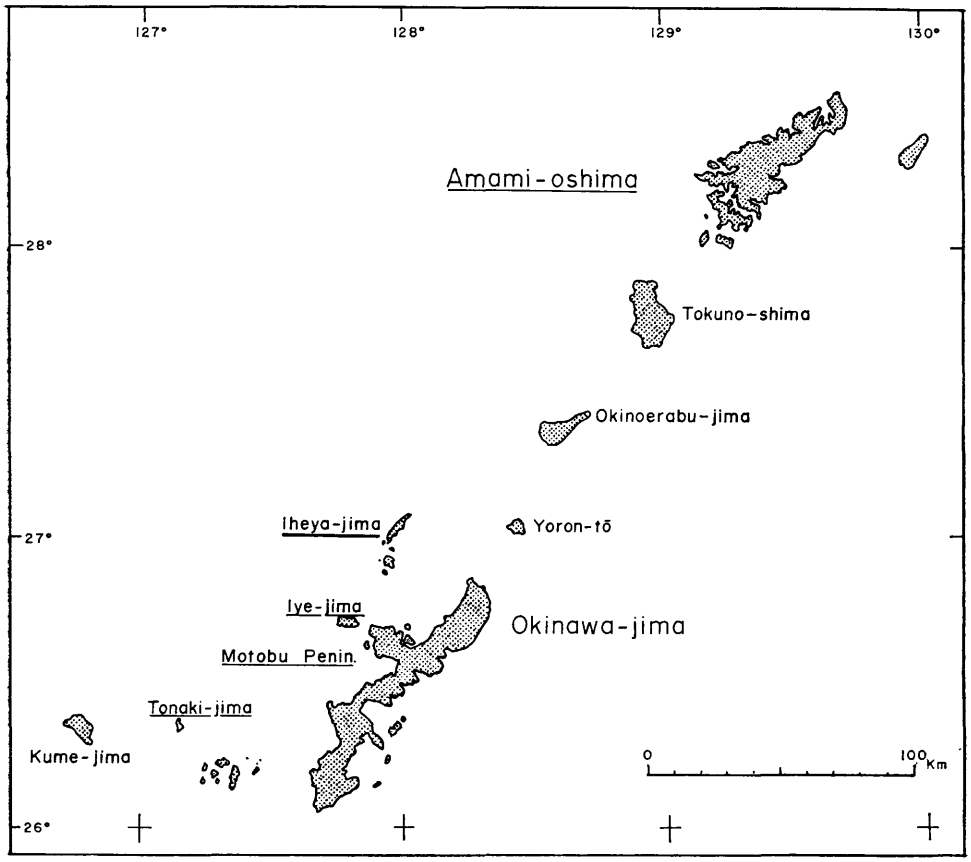


Fig. 1. Map showing the fusuline localities (underlined) in Ryukyu Islands.

These fusuline faunas bear typical Tethyan aspects as a whole.

The Carboniferous evidence in the Ryukyu Islands is furnished for the first time in the lenticular limestone layer intercalated in shale of the Iheya Formation. The geological age of the Iheya Formation is considered to be the Lower Permain on the basis of occurrences of fusuline assemblage (ISHIBASHI, 1968). The Maedake Formation consists of sandstone, bedded chert, and some layers of lenticular limestone which yields the fusulines of Lower and Middle Permian ages. Further systematic study on the Permian fusulines of the Maedake Formation and detail occurrences of fusulines of the Iheya Formation will be given in the next paper.

I am much indebted Professor Ryuzo Toriyama of Fukuoka University for his warm and continuous encouragement since I was a graduate student of Kyushu University and for his reading of manuscript. I gratifully acknowledge Professor Tsugio SHUTO of Kyushu University for his valuable suggestions and encouragement on the sirial study of paleontology of the Ryukyu Islands after my graduate course at Kyushu University. This paper is dedicated to Professor Tsugio SHUTO on the occasion of his retirement in 1985.

My deep appreciation extends to Professor Kametoshi KANMERA and Associate Professor Juichi YANAGIDA of Kyushu University for their helpful advices. I should like to express my appreciation to Professor Kenji KONISHI of Kanazawa University for his continuous encouragement during field survey of Iheya-jima.

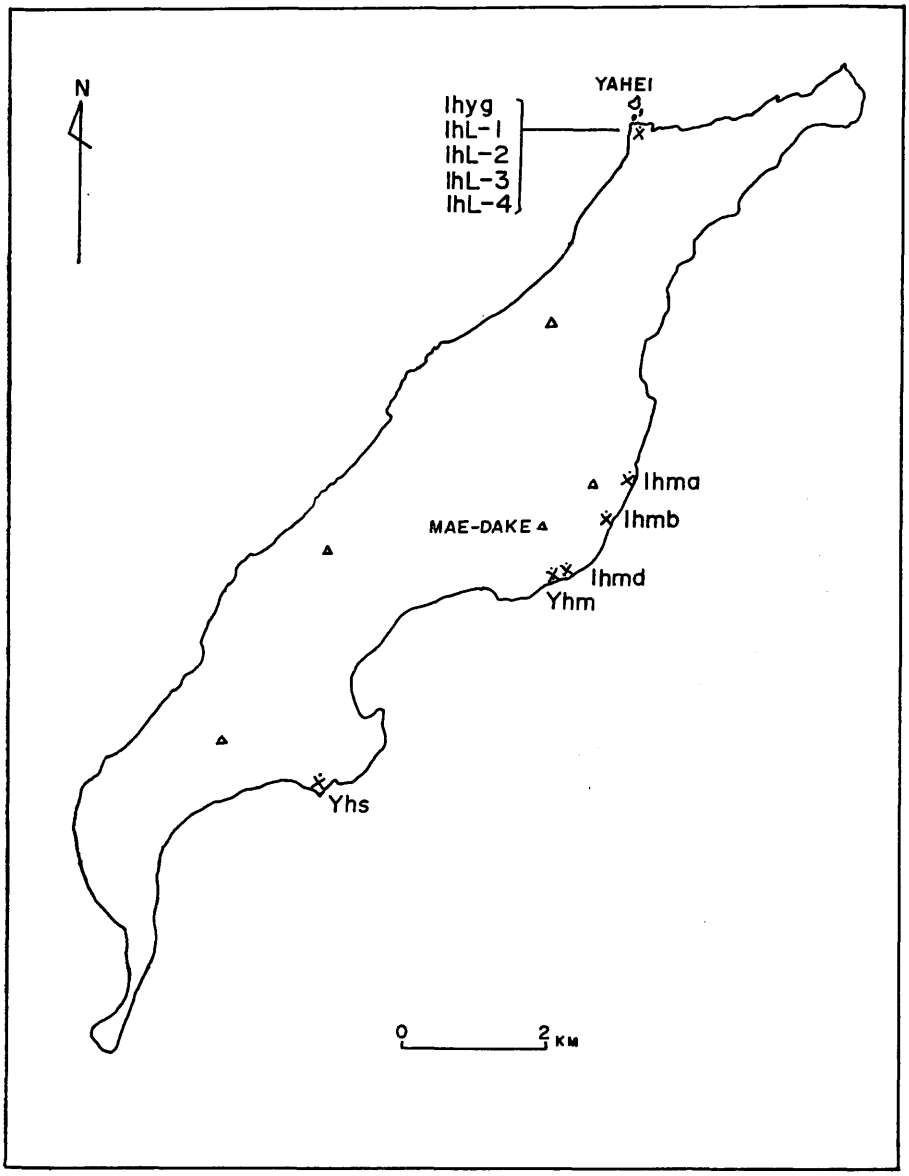


Fig. 2. Location map of fusulines in Iheya-jima

Systematic Paleontology

Family Fusulinidae von MÖLLER, 1878
Subfamily Fusulinininae MÖLLER, 1878
Genus *Fusulinella* MÖLLER, 1877
Type-species.—Fusulinella bocki MÖLLER, 1878
Fusulinella cf. *itadorigawensis* ISHII
Pl. 22, Figs. 1–10; Pl. 23, Figs. 1–6

1956. *Fusulinella itadorigawensis*, ISHII (listed), *Jour. Geol. Soc. Japan*, **62**, (724), p. 23.
1962. *Fusulinella itadorigawensis*, ISHII, *Jour. Geosci. Osaka City Univ.*, **6**, (1), p. 11, pl. 8, figs. 7–25.

Material.—Thirteen axial (or slightly tangential) sections, three sagittal (or slightly excentric) sections and many other sectioned specimens are referred to this species.

Description.—Shell large in size for the genus, short fusiform, with gently convex lateral slopes and bluntly pointed poles. Mature specimens having 7 to 7½ volutions 5.4 to 3.5 mm long and 2.4 to 1.9 mm wide. Form ratio ranging from 2.3 to 1.8. Shell coils tightly in the first three volutions and gradually increasing its height.

Ratios of half length to radius vector of first to seventh volution for 5 specimens average 1.47 1.77 1.90, 1.84, 1.84, 1.99, and 1.81, respectively. Proloculus spherical, small in size and its outside diameter ranging from 133 to 101 microns averaging 115 microns in four specimens.

Spirotheca thin, composed of a tectum, a diaphanotheca, and upper and lower tectoria. Diaphanotheca appears from third ? to last volution and thickness of diaphanotheca of third to seventh volution for 2 specimens averages 25, 25, 26, 27, and 28 microns, respectively. Upper and lower tectoria well developed. Tunnel comparatively narrow and becomes gradually wide outward. Averages of tunnel angles of second to seventh 16.7, 18.9, 30.7, 32, 39 and 34.5 degrees respectively. Chomata well developed, gradually increases its height outward, sometimes reach almost to top of chamber. Tunnel side of chomata usually steep, sometimes overhanging, but poleward slopes very gentle.

Remarks.—Fusulinella itadorigawensis was originally described by ISHII (1962) from Itadorigawa, Kurosegawa-village, Higashiuwa-gun, Ehime Prefecture. In addition to *F. Itadorigawensis* ISHII (1961) described some species or subspecies of *Fusulinella* from the It_1 zone. One of them, *fusulinella iyoensis* resembles the present species in the shell size and septal count, but the former is distinguishable from the latter in having larger shel and not well developed chomata in the outer volutions. As a Fusulinella the present specimens have very large shell and a number of volution. The largest one is 5.4 mm in length. Nevertheless they are reasonably referable to *Fusulinella* on the basis of features mentioned above. The present species is identical with *Fusulinella itadorigawensis* described by ISHII from the It_1 fossil zone of the Itadorigawa Group, except for only shell size, number of volution and secondary deposits

Table 1. Measurements of *Fusulinella* cf. *itadorigawensis* ISHII (in mm. unless otherwise stated)

Specimen	Reg. no. GK. D	No. vol.	L.	W.	Fr.	Prol. ( )	Radius vector							
							1	2	3	4	5	6	7	8
1	20031	7	4.1	2.1	1.95	110.8	0.098	0.170	0.302	0.542	0.804	1.102	1.372	
2	20033	7	2.7*	1.2*	2.23	101	0.097	0.162	0.232	0.402	0.571	0.833	1.212	
3	20035	6	3.52+	1.92+		133	0.101	0.183	0.294	0.452	0.661	0.960		
4	20032	6	3.19	1.62	1.97		0.129	0.228	0.361	0.488	0.649	0.887		
5	20042	7	3.26+	2.27+			0.138	0.137	0.236	0.373	0.553	0.793	1.106	
6	20039	6	1.65			115	0.101	0.165	0.265	0.395	0.612	0.906		
7														
8														

Specimen	Ratio of half length to radius vector							Thickness of spirotheca (in micron)							Pl. Fig.	Pl. Fig.
	1	2	3	4	5	6	7	1	2	3	4	5	6	7		
1	1.37	1.91	2.26	2.26	2.21	2.20	1.71								22 1	
2	1.86	2.13	2.74	2.20	2.65	2.44	2.23	14	22	28	35	53	47	32	22 3	
3	1.33	1.78	1.73	1.58	1.32	1.95									22 5	
4	1.39	1.48	1.33	1.67	1.62	1.82				29	47	45	26		22 2	
5	1.40	1.55	1.46	1.49	1.42	1.55	1.48		19	32	28	49	61	37	23 2	
6															22 9	
7																

Specimen	Tunnel angle/Septal count ( )						
	1	2	3	4	5	6	7
2		17.5	18.7	31.3	32	?	34.5
4		15.9	20.7	33.3			
5		16.7	17.3	27.4	32	39	
6	(11)	(14)	(16)	(18)	(21)	(19)	

on spirotheca. No species of fusuline associate with the present one in the same limestone material in the Iheya Formation.

Occurrence.—*Fusulinella* cf. *itadorigawensis* occurs in the limestone distributed at Yahei (IhL-4), northern part of Iheya-jima and is associated with chaetitid coral.

Genus *Beedeina* GALLOWAY, 1933, emend. ISHII, 1958

Type-species.—*Fusulina girtyi* DUNBAR and CONDRA, 1927

Beedeina higoensis (KANMERA)

Pl. 23, Figs. 7–11; Pl. 24, Figs. 1–8; Pl. 25, Figs. 1–4

1954. *Fusulina higoensis* KANMERA, *Japan. Jour. Geol. Geogr.*, **25**, (1–2), p. 133–136, pl. 14, figs. 1–11.
1958. *Beedeina higoensis*, ISHII, *Jour. Inst. Polytech., Osaka City Univ.*, [G] **4**. p. 41, (listed).
1962. *Beedeina higoensis*, SUYARI, *Jour. Gakugei, Tokushima Univ.*, [Nat. Sci.], **12**, p. 8, pl. 4, figs. 6, 7.

Material.—Twelve axial sections, five tangential sections, and many other sectioned specimens are here examined.

Description.—Shell large for the genus, highly inflated fusiform having straight axis of coiling with weak axial fillings in inner volutions. Lateral slopes gently concave in early volutions and convex in outer volutions with bluntly pointed poles. Mature shell of 7 to 10 volutions 3.48 to 5.14 mm in length and 1.91 to 2.84 mm in width, giving a form ratio of 1.57 to 2.32. First to third volutions nearly spherical to subspherical. Outer volutions typically fusiform. Ratios of half length to radius vector in the second to ninth volutions in one axial section (Pl. 23, Fig. 7) 2.44, 2.21, 2.32, 2.46, 2.44, 2.29, 1.99 and 1.84, respectively.

Proloculus spherical. Outside diameter averaging of 159 microns for 9 specimens. Proloculus wall 21 microns thick in average. Shell expands slowly in the early volutions with gently concave slopes and almost uniformly in succeeding volutions. Spirotheca thin, consisting of a tectum, a thin diaphanotheca, upper and lower tectoria. Diaphanotheca visible in outer volutions but indistinguishable in inner ones. Average thickness of spirotheca in first to eighth volution of specimens 17, 22, 29, 30, 31, 38, 32 and 39 microns, respectively. Septa highly and narrowly fluted throughout length of shell, especially in both polar regions. Closed chamberlets extend almost to tops chamber. Septa counts in five volutions ? 18, 21, 25, 28 and 30. Tunnel very narrow and its path irregular, gradually increasing its width in outer volutions. Average tunnel angles in first to seventh volution for 3 specimens 15.2, 14.8, 16.0, 15.0, 16.4, 19.7 and 22.6 degrees, respectively.

Remarks.—The genus *Beedeina* was established by GALLOWAY (1933) based on the type-species *Fusulinella girtyi* DNUBAR and CONDRA, 1927, but this genus has not been accepted for the long time. ISHII (1958) restudied the phylogeny, morphology, and distribution of *Fusulina*, *Beedeina* and allied fusuline genera. He emended the genus *Beedeina* to which some Japanese species of *"Fusulina"*,

Table 2. Measurements of *Beedeina higoensis* (KANMERA) (in mm. unless otherwise stated)

Specimen	Reg. no. GK. D	No. vol.	L.	W.	Fr.	Prol.	Radius vector 1	2	3	4	5	6	7	8	9
1	20047	10	5.14	2.84	1.74	154		0.137	0.222	0.294	0.405	0.584	0.849	1.128	1.393
2	20054	8	4.17	2.32	1.79	152		0.132	0.210	0.288	0.451	0.633	0.862	1.161	
3	20055	8	4.43	2.83	1.57	194	0.203	0.293	0.395	0.543	0.731	0.940	1.197	1.438	
4	20060	7	3.48	1.91	1.82	177	0.192	0.263	0.342	0.471	0.644	0.856	1.056		
5	20061	7	4.75	2.05	2.32	126		0.158	0.262	0.415	0.592	0.807	1.556		
6	20062	7	4.50	2.32	1.94	174	0.133	0.214	0.321	0.493	0.707	0.946	1.218		
7	20051	7		2.51		155		0.308	0.441	0.588	0.775	1.066	1.335		
8	20058	6.5		1.76		130	0.178	0.248	0.343	0.465	0.657	0.889			
9	20059	7		2.19		171	0.147	0.288	0.362	0.519	0.715	0.929	1.189		
10	20063	5		1.42		259/224×	0.210	0.315	0.444	0.609	0.750				

Specimen	Ratio of half length to radius vector 1	2	3	4	5	6	7	8	9	Thickness of spirotheca (in micron) 1	2	3	4	5	6	7	8	9	Pl. Fig.
1		2.44	2.21	2.32	2.46	2.44	2.29	1.99	1.84			29	26	26	28	34	39		23 7
2		1.97	1.99	3.19	2.75	2.47	2.42			14	21	25	33	34	43	55			24 3
3	0.99	1.08	1.37	1.51	1.58	1.60	1.62	1.63					36	33	46	48	38		24 4
4		1.67	1.70	1.77	1.75	1.87	1.83					36	31	32	40	25			25 1
5		2.38	2.16	2.12	2.06	2.05	1.47						32	34	32	26			25 2
6	1.49	2.16	2.17	1.94	1.82	1.79	1.92					28	39	34	40	19			25 3
7														26	43	22			23 11
8										20	24	31	26	37	31				24 7
9													27	33	41	27			24 8
10											21	24	22	16					25 4

Specimen	Tunnel angle/Septal count ( ) 1	2	3	4	5	6	7	8	9
2	17.8	23.3	19.4	14	17.8	21.4	22.6		
4		11.1	17.6	18.5	15.2				
6	12.6	10	10.9	12.4	16.1	18			
7				(25)?	(28)	(33)	(38)?		
10		(16)	(21)	(29)	(30)				

such as *Fusulina akiyoshiensis,* (TORIYAMA 1958), *F. higoensis* (KANMERA, 1954), *F. ichinotaniensis* (IGO, 1957) and *F. cheni* (IGO, 1957), were included.

Beedeina higoensis described by KANMERA from the Yayamadake Limestone, Kumamoto has a large shell of 6.4 to 7.7 mm long, seven to eight volutions and form ratio of 2.1 to 2.9. The present species has similar characteristics with those of *B. higoensis.* One mature specimen of the Ryukyu Islands has a shell of 7.5 mm long.

Beedeina ichinotaniensis described from Ichinotani, Hida Massif, Gifu Prefecture is somewhat similar to the present species, the former is different from the latter in having smaller shell, less number of volution, thinner spirotheca and larger radius victor of inner volutions.

Fusulinella girtyi, the type-species of *Beedeina,* described by DUNBAR and CONDRA (1927) from Greece country, Illinois, U.S.A. somewhat resembles the present species in shell form, rate of expansion of outer volution, but the former is distinguished from the latter by having a stouter fusiform and smaller form ratio.

SAFONOVA (in RAUSER-CHERNOSSOVA et al., 1951) described *Fusulina nytrica* based on a single axial section from the Mjatschkov of the Russian Platform. This species somewhat resembles the present species of the Ryukyu in shell characteristics, but the latter is different from the former in stronger septal fluting and the presence of axial fillings in the inner volutions and larger proloculus.

Occurrence.—Beedeina higoensis occurs along with a lot of calcareous algae, *Eugonophyllum* sp. in the limestone (IhL-1) exposed at Yahei, Iheya-jima.

Genus *Pseudofusulinella* THOMPSON, 1951

Type-species.—Neofusulinella occidentlis THOMPSON and WHEELER, 1946

Pseudofusulinella sp. indet.

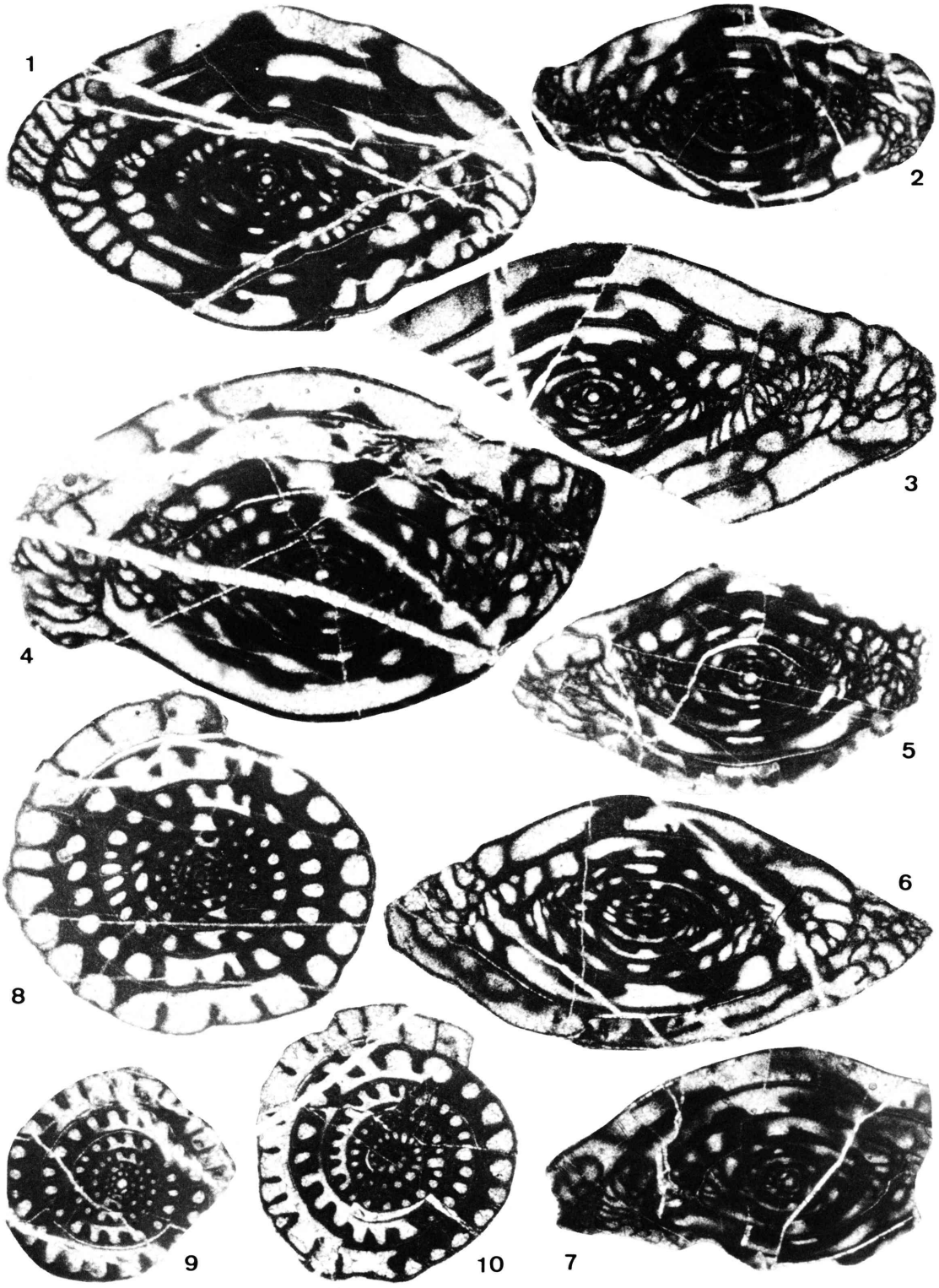
Pl. 26, Figs. 1–16

Material.—Ten axial sections three tangential sections, two sagittal section and an oblique section are examined.

Descriptive remarks.—The present specimens were collected from the dolomitic brecciated limestone exposed at Yahei, Iheya-jima. The present specimens have a small shel and elongated and inflated fusiform with slightly concave lateral slopes, blunted pointed poles. The spirotheca consists of a tectum, a thin diaphanotheca, and lower and upper tectoria like in *Fusulinella,* but in sixth volution of almost all specimens it is composed of a tectum and a dense layer

Explanation of Plate 22

Figs. 1–10. *Fusulinella* cf. *itadorigawensis* ISHII .....Page 202
1. Axial (slightly oblique) section (GK.D 20031): 2–5 and 7. Axial sections (GK.D 20032–GK.D 20035, and GK.D 20037: 6. Tangential section (GK.D 20036): 8 and 10. Excentric sections (GK.D 20038 and GK.D 20040): 9. Sagittal section (GK.D 20039) ×20. (See also Pl. 23, Figs. 1–6)



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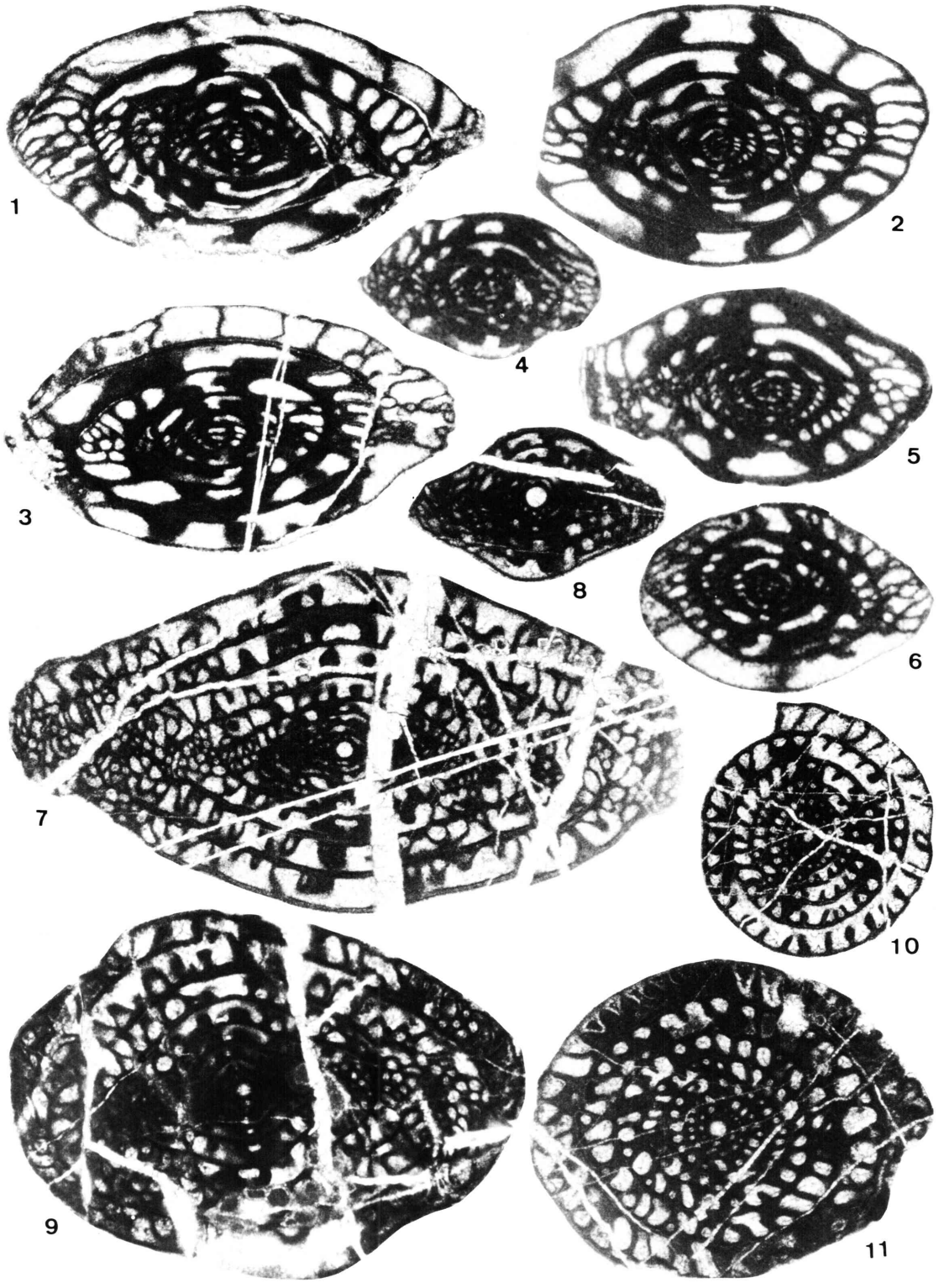

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(Pl. 26, Figs. 10, 12). The mature specimens with six volutions are measured in 2.4 mm long (Pl. 26, Fig. 1) and 0.92 mm wide. The proloculus is small, averaging 110 microns in outer diameter. The one specimen (Pl. 26, Fig. 3) has larger proloculus, attaining 280 microns in diameter.

Septa are irregularly folded in polar regions. Chomata are massive and asymmetrical and tunnel is narrow.

Pseudofusulinella utahensis was reported by KANUMA (1958) from Mino Mountainland, Gifu. OZAWA (1967) restudied the genus *Pseudofusulinella* of North America and Japan, and he divided it into two subgenera, *Pseudofusulinella* (s. str.) and a new subgenus, *Kanmeraia* with description of a new species, *Pseudofusulinella japonica.*

The present species is very similar to *P. Kanmeraia japonica* in important diagnostic shell characteristics, but differs from the latter in having smaller shell, being about a half in length. The detail structures of spirotheca in earlier volutions can not be observable in the Ryukyu specimens.

Occurrence.—The material occurs in the dolomitic limestone layer (IhL-2) distributing at Yahei.

Genus *Protriticites* PUTRJA, 1948

Type-species.—Protriticites globulus PUTRJA, 1948

Protriticites sp. indet.

Pl. 26, Figs. 17, 18

Material.—Only two tangential sections (GK.D 20089, 20090) are here examined.

Descriptive remarks.—The shell is small in length with inflated fusiform and 2.6 mm and 2.1 mm in length and 1.3 mm and 1.2 mm in width. The spirotheca is relatively thick, consisting of a tectum and a thick transparent layer. A fine alveolar structure is only recognized in the last volution. The chomata develop distinctly and is asymmetrial. The tunnel is narrow, with angle of 27 degrees in fourth volution. The septa are only fluted at polar regions.

The present species is referred to *Protriticites* although sufficient information is not available from the present material. Many species of *Protriticites* have been known from Russia and China. *Protriticites nakahataensis* described by ISHIZAKI (1963) is somewhat similar to the present species in shell size and structure of spirotheca. ISHIZAKI stated that *Triticites matsumotoi* described by KANMERA (1955) and some specimens reported from Japan, *i.e. Triticites pseu-*

Explanation of Plate 23

Figs. 1–6. *Fusulinella* cf. *itadorigawensis* ISHII .....Page 202
1. Axial (slightly oblique) section (GK.D 20041) : 2–6. Axial (slightly oblique tangential) sections (GK.D 20042–GK.D 20046) ×20. (See also Pl. 22, Figs. 1–10

Figs. 7–11. *Beedeina higoensis* (KANMERA) .....Page 204
7–9. Axial sections (GK.D 20047–GK.D 20049) : 10. Sagittal section (GK.D 20050) : 11. Sagittal (slightly oblique) section (GK.D 20051) ×20. (See Pl. 24, Figs. 1–8: Pl. 25, Figs. 1–4)

dobocki should be referred to *Protriticites*. The present specimens are so poor in number and in preservation that detailed comparison with these species is not advisable until more sufficient material comes to hand.

Occurrence.—The material at hand from boulder of limestone in shale exposed at Yahei (IhL-4).

Genus *Hemifusulina* MÖLLER, 1878

Type-species.—*Hemifusulina bocki* MÖLLER, 1878

Hemifusulina ? sp. indet

Pl. 26, Fig. 19

Material.—One incomplete axial section (GK.D 20091) is examined.

Descriptive remarks.—The present material is poorly preserved, but except shape and length of shell some characteristics are observed. It is presumable that the shell form is probably cyrindrical with rounded polar regions. The spirotheca is composed of tectum, dense layer and lower tectorium. The dense layer is not clear as diaphanotheca. The septa are narrowly fluted thoughout length of shell. The tunnel is low and broad. The secondary deposits are not observed in the present specimen.

The present specimen clearly belongs to Fusulinidae and resembles *Hemifusulina bocki* described by MÖLLER (1878, pl. 5, fig. 2) from the Moscow basin, having the ovoid shape of shell and the similar characteristics of spirotheca, septal fluting, but the former has larger proloculus, less number of volutions. RAUSER-CHERNOSSOVA (1951) described a lot of species of *Hemifusulina*, one of which (pl. 42, figs. 9, 10) is somewhat similar to the present species, but the latter is different from the former in having larger shell and proloculus.

Occurrence.—The material was obtained from the dolomitic limestone (IhL-2) in which *Protriticites* sp. occured at Iheya.

Family Schwagerinidae DUNBAR and HENBEST, 1930

Genus *Triticites* GIRTY, 1904

Type-species.—*Miliolites secalius* SAY, 1923

Triticites samaricus RAUSER-CHERNOSSOVA

Pl. 27, Figs. 6–13

1938. *Triticites secalicus* var. *samaricus* RAUSER-CHERNOSSOVA, *Acad. Sci., U.S.S.R., Work Geol. Inst.*, **7**, p. 156, pl. 4, figs. 1, 2.

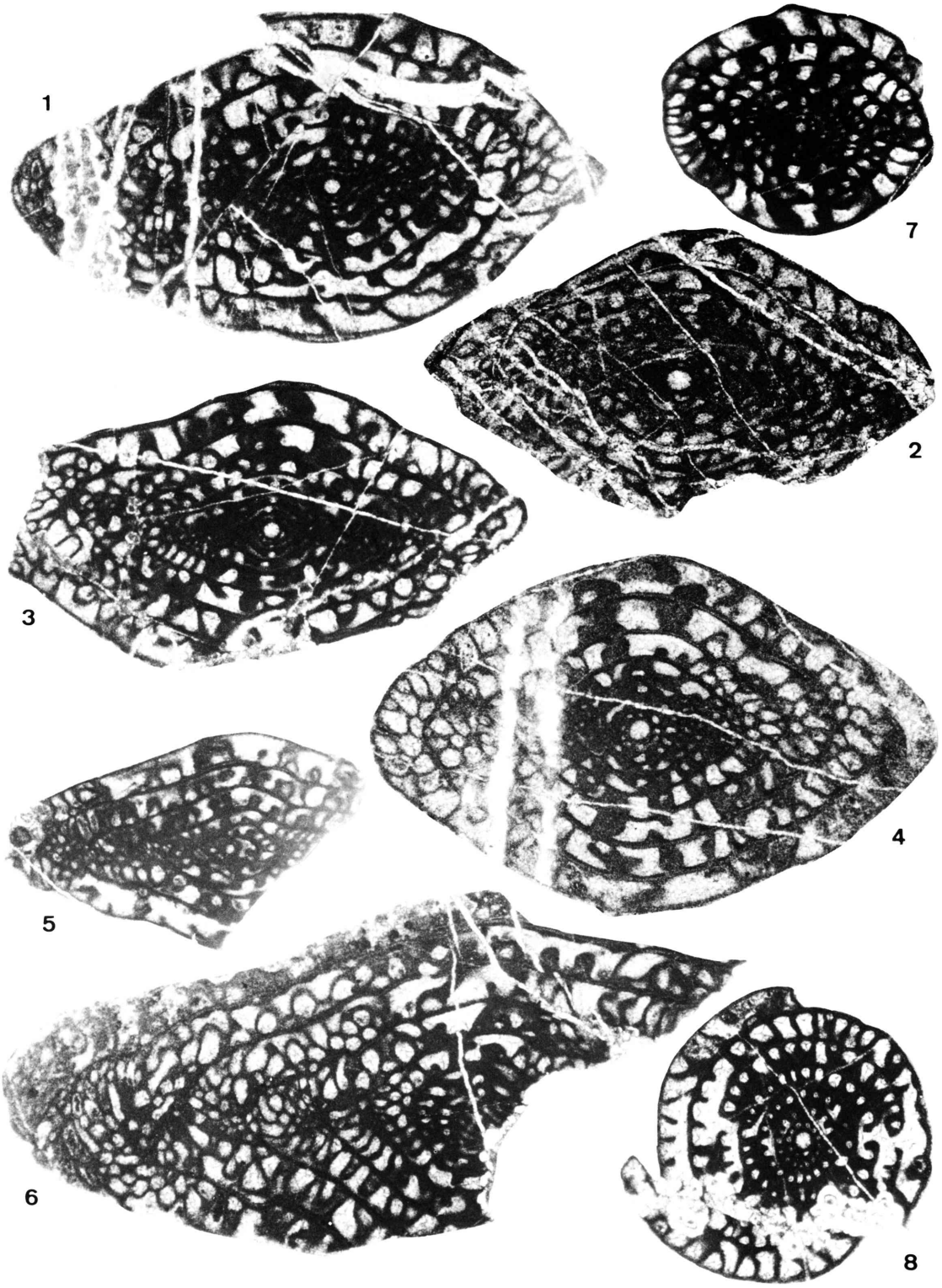
1958. *Triticites samarica*, KANMERA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **6**, (3), p. 168, pl. 26, figs. 1–13.

1958. *Triticites* (*T.*) *secalicus samarica*, ROSOVSKAYA, *Akad. Nank, SSSR, Trudy Paleont. Inst.*, **13**, p. 83, pl. 2, figs. 7–8.

Explanation of Plate 24

Figs. 1–8. *Beedeina higoensis* (KANMERA) .....Page 204

1–4. Axial sections (GK.D 20052–GK.D 20055): 5 and 6. Tangential sections (GK.D 20056–GK.D 20057): 7 and 8. Sagittal sections (GK.D 20058–GK.D 20059) ×20. (See Pl. 23, Figs. 7–11: Pl. 25, Figs. 1–4)



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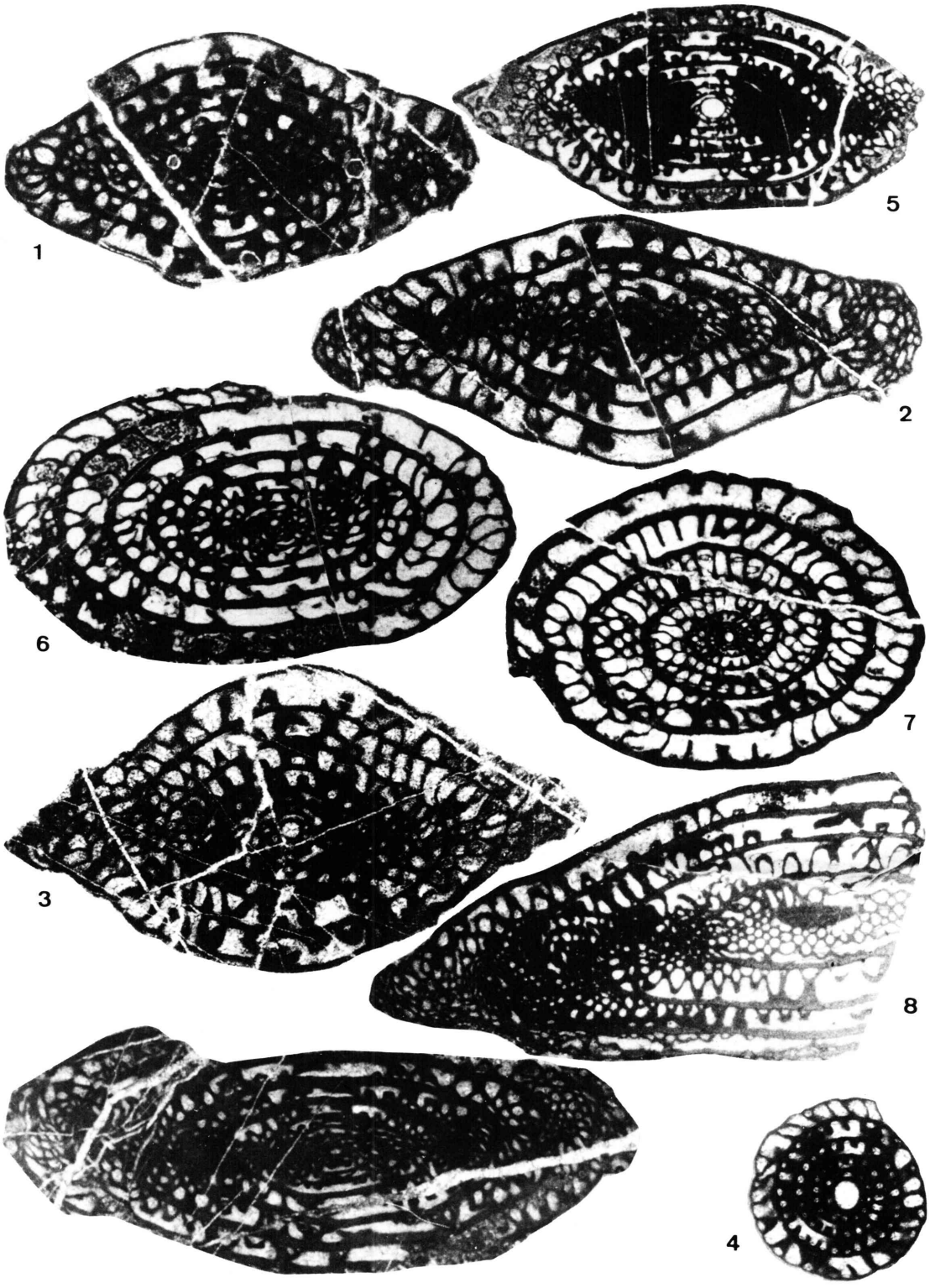


T. ISHIBASHI: Iheya fusulines

1983. *Triticites secalicus samaricus*, CHEN and WANG, *Palaeont. Sinica*, **164**, N.S., [B], (19), p. 71, pl. 11, fig. 15.

Material.—Five axial sections, three tangential sections and two sagittal sections, are examined.

Description—Shell medium, elongated and cylindrical, with straight axis of coiling, flat to slightly irregularly wavy lateral slops and bluntly rounded poles. Typical specimens of six volutions attain a length of 10.5 mm and a width of 2.92 mm. Form ratios, 3.46–2.54, averaging 2.93 in four specimens. Inner two volutions short fusiform and from third volution axial length increases rapidly with growth. Proloculus moderate in size with spherical shape. Outside diameter varies from 255, 235, 209, and 203 with an average of 226 microns for four specimens.

Spirotheca rather thin for the size of shell, consists of a tectum and a keriotheca with fine alveoli. Septa narrowly and regularly fluted throughout length of shell. Septal flutings much intense in the end zones, expanding more nearly to the tops of the chambers. Tunnel low and narrow. Chomata occur at least in inner volutions. Dense secondarly deposits coat the outer two or three volutions. Axial fillings not developed.

Remarks.—This species was originally established by RAUSER-CHERNOSSOVA as a variety of *Triticites secalicus* (SAY) from the Samara Bend region of Russia. KANMERA (1958) discussed this variety along with the specimens of Yayamadake, Hikawa Valley, Kyushu, and regarded RAUSER-CHERNOSSOVA's *samaricus* as a distinct species from *T. secalicus* of Nebraska, U.S.A. I agree with KANMERA's opinion. *Triticites secalicus samaricus*, recently described by CHEN and WANG (1983) from the Maping limestone of Yishan, Guanfixi, China, well agrees in shell characteristics with KANMERA's description.

The Ryukyu's specimens have been coated by the dense secondary deposits in outer volutions, but the important diagnostic characteristics have been preserved.

Occurrence.—The material occurs in the öolitic sparite limestone of Yahei (IhL-3), Iheya-jima.

Genus *Schwagerina* MÖLLER, 1877

Type-species.—Borelis princeps EHRENBERG, 1842

Schwagerina cf. *krotowi* (SCHELLWIEN)

Pl. 27, Figs. 15–19

Explanation of Plate 25

Figs. 1–4. *Beedeina higoensis* (KANMERA) .....Page 204
1–3. Axial sections (GK.D 20060–GK.D 20062): 4. Sagittal section (GK.D 20063) ×20. (See also Pl. 23, Figs. 7–11: Pl. 24, Figs. 1–8)

Fig. 5. *Parafusulina gruperaensis* (THOMPSON and MILLER) .....Page 217
Axial section (GK.D 20064) ×10. (See also Pl. 7, Figs. 6–9)

Figs. 6–9. *Pseudofusulina aganoensis* FUJIMOTO .....Page 212
6 and 7. Centered oblique sections (GK.D 20069–GK.D 20070): 8. Tangential section (GK.D 20071): 9. Axial section (GK.D 20072) ×10

1908. *Fusulina krotowi* SCHELLWIEN, *Palaeontographica*, **55**, p. 190–192, pl. 20, figs. 1–10.
1925. *Schellwienian krotowi*, OZAWA, *Jour. Coll. Sci. Imp. Univ. Tokyo*, **45**, art 6, p. 27, 28, pl. 7, figs. 5, 6.
1936. *Pseudofusulina krotowi*, HUJIMOTO, *Sci. Repts. Tokyo Bunrika Daigaku*, sec. C, **1**, (2), p. 82–84, pl. 15, figs. 1–5, 9–15.
1938. *Pseudofusulina krotowi*, RAUSER-CHERNOSSOVA, *Travaux l'Inst. Géol. Acad. Sci., U.S.S.R.*, tome 7, p. 143, 144, pl. 9, figs. 1, 2.
1955. *Pseudofusulina krotowi*, MORIKAWA, *Sci. Rept., Saitama Univ.*, (B), **2**, (1), p. 8, 9, pl. 14, figs. 5, 6.
1958. *Schwagerina krotowi*, KANMERA, *Mem. Fac. Sci., Kyushu Univ.*, (D, Geol.), **6**, (3), p. 193, 194, pl. 24, fig. 20; pl. 35, figs. 13, 14.
1958. *Schwagerina krotowi*, KAWANO, *Bull. Fac. Educ. Yamaguchi Univ.*, Math. & Sci., **11**, Spec. No., p. 84, 85, pl. 4, fig. 28; pl. 5, figs. 1–4.
1961. *Pseudofusulina krotowi*, MORIKAWA and ISOMI, *Repts. Geol. Surv. Japan*, (191), p. 18, 19, pl. 8, figs. 1–11.

Material.—One axial section (GK.D 20106), two tangential sections (GK.D 20107, 20108) and two excentric sections (GK.D 20109, GK.D 20110).

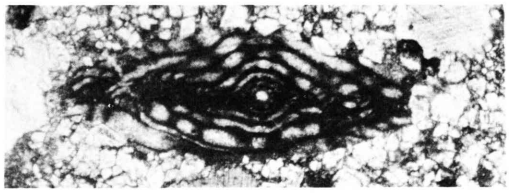
Description.—Shell moderate in size and thickly fusiform, with almost straight axis of coiling, bluntly pointed poles and convex lateral slopes. Mature shells of six to seven volutions 7.83 to 7.06 mm long and 2.59 to 2.0 mm wide, giving average form ratio of 2.1 in three specimens. Proloculus seems to be small, but accurate diameter not obtained. Shell tightly coils in first two volutions and expands nearly uniform in outer volutions. Average radius vectors of first to seventh volutions in two specimens 148, 257, 421, 656, 951, 1343, and 1781 microns, respectively.

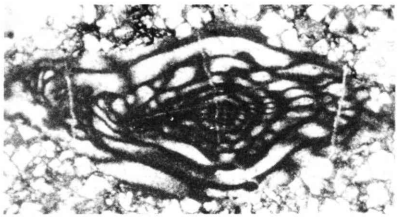
Spirotheca consists of a tectum and a coarsely alveolar keriotheca, relatively thin in inner three to four volutions, but thicker in outer volutions. Septa thin and considerably closely spaced in inner volutions, and rather widely in outer volutions. Septa narrowly fluted throughout length of shell. Chamberlets more than two-thirds as high as chambers. Tunnel low and narrow throughout growth with irregular path. Chomata asymmetrical and relatively well developed throughout shell.

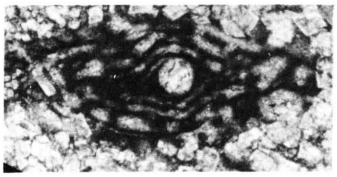
Remarks.—*Schwagerina krotowi* has been known from U.S.S.R. and many districts of Japan. The present species are almostly identical with *Schwagerina krotowi* in the general shape of the shell, expansion of volution and other characters. The present specimens have more slender shape and smaller proloculus

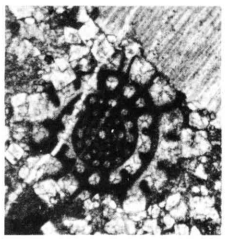
Explanation of Plate 26

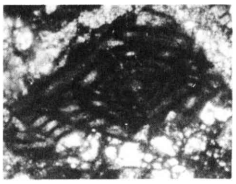
Figs. 1–16. *Pseudofusulinella* sp. indet ..... Page 206
Figs. 1, 3, 5–12. Axial (slightly oblique) sections (GK.D 20073, GK.D 20074 and GK.D 20077–GK.D 20084): 2, 4, and 13. Oblique tangential sections (GK.D 20074, GK.D 20076 and GK.D 20085): 14 and 16. Sagittal sections (GK. 20086 and GK.D 20088): 15. Excentric section (GK.D 20087) ×20
Figs. 17–18. *Protriticites* sp. indet ..... Page 207
17. Oblique tangential section (GK.D 20089): 18. Tangential section (GK.D 20090) ×20
Fig. 19. *Hemifusulina* ? sp. indet ..... Page 208
Axial section (GK.D 20091) ×20

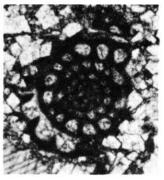


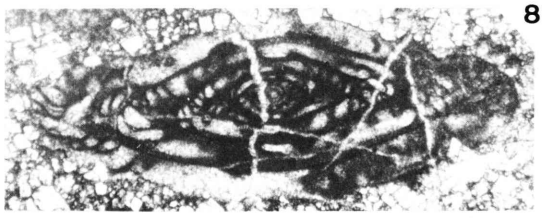


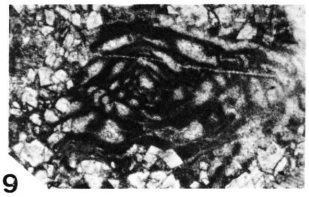


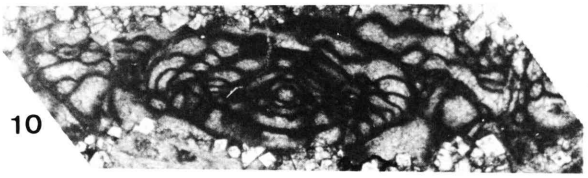


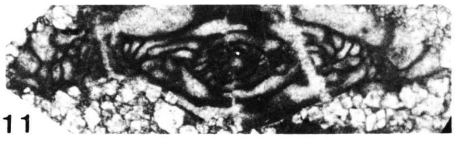


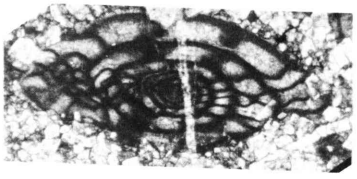


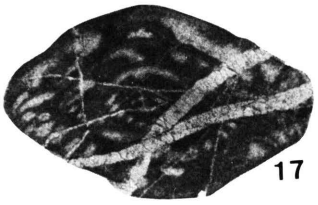


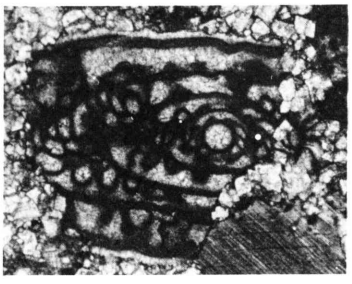


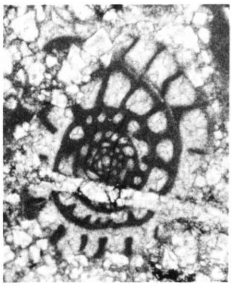


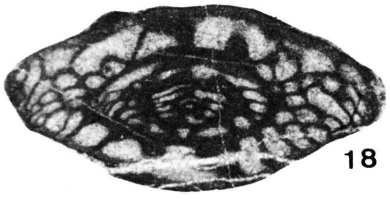












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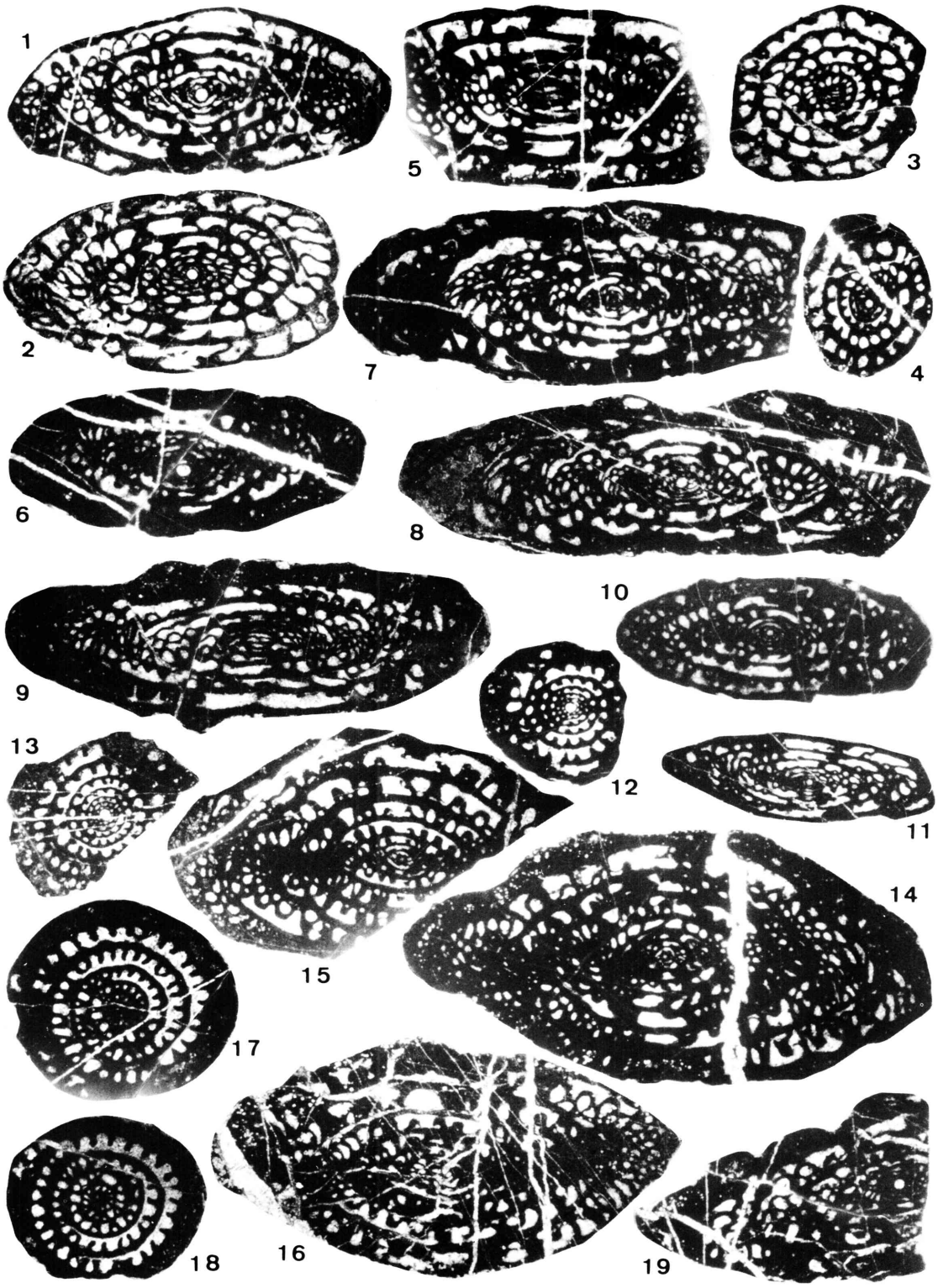

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than the species described by the previous authors.

Occurrence.—The present species is occured with *Pseudofusulina regularis*, and *Triticites samarcus* in the limestone (IhL-3) at Yahei.

Genus *Pseudofusulina* DUNBAR and SKINNER, 1931

Pseudofusulina regularis (SCHELLWIEN)

Pl. 27, Figs. 1–4

1898. *Fusulina regularis* SCHELLWIEN, *Palaeontographica*, **44**, p. 250, pl. 19, figs. 1–6.
1912. *Fusulina regularis*, DEPRAT, *Mém. Serv. Géol. l'Indochina*, **1**, fasc. III, p. 28, pl. 7, figs. 14, 15.
1927. *Schellwienia regularis*, LEE, *Palaeont. Sinica*, [B], **4**, fasc. 1, p. 50, pl. 7, figs. 8–10.
1936. *Pseudofusulina regularis*, HUJIMOTO, *Sci. Repts., Tokyo Bunrika Daigaku*, [C], **1**, (2), p. 94, pl. 10, figs. 9–11; pl. 18, fig. 1.
1958. *Pseudofusulina regularis*, KANMERA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **6**, (3), p. 194, pl. 33, figs. 1–10.
1958. *Schwagerina regularis*, TORIYAMA, *Ibid.*, **7**, p. 140, pl. 16, figs. 8–15.
1959. *Schwagerina regularis*, KOCHANSKY-DEVIDÉ, *Jugosl. Akad. Znanosti i Umjet.*, p. 50, pl. 2, figs. 7–11.
1960. *Pseudofusulina regularis*, SAURIN and LÉ-THI-VIÉN, *Ann. Fac. Sci. Saigon*, **191**, p. 396, pl. 1, figs. 16–18.
1961. *Pseudofusulina regularis*, MORIKAWA and ISOMI, *Geol. Surv. Japan, Rept.*, (191), p. 15, pl. 7, figs. 1–10.
1962. *Schwagerina regularis*, SUYARI, *Jour. Gakugei, Tokushima Univ.*, Nat. Sci., **12**, p. 22, pl. 8, fig. 10.
1964. *Pseudofusulina regularis*, SADA, *Jour. Sci., Hiroshima Univ.*, [C], **4**, (3), p. 257, pl. 26, figs. 8–11; pl. 27, figs. 9–10.
1972. *Pseudofusulina (Daixina) regularis*, IGO, *Geol. Palaeont. Southeast Asia*, **10**, p. 105, pl. 16, figs. 10–16.
1975. *Pseudofusulina regularis*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **23**, (1), p. 15, pl. 16, figs. 10–16.
1978. *Pseudofusulina regularis*, LIU, XIAO and DONG, *Palaeont. Atlas Southwest China, Kueichow-2*, Geol. Press, p. 44, pl. 8, fig. 1.

Material.—Each of axial section (GK.D 20092), centered oblique section (GK.D 20093), excentric section (GK.D 20094) and sagittal section (GK.D 20095).

Explanation of Plate 27

Figs. 1–4. *Pseudofusulina regularis* (SCHELLWIEN) .....Page 211
Fig. 1. Axial section (GK.D 20092): 2. Oblique centered section (GK.D 20093): 3. Excentric section (GK.D 20094): 4. Sagittal section (GK.D 20095) ×10

Figs. 5–13 and 19. *Triticites samaricus* RAUSER-CHERNOSSOVA .....Page 209
6, 8, 10, 11 and 19. Axial sections (GK.D 20097, GK.D 20099, GK.D 20101, GK.D 20102 and GK.D 20105, respectively) 5, 7, and 9. Tangential sections (GK.D 20096, GK.D 20098 and GK.D 20100, respectively): 12 and 13. Sagittal sections (GK.D 20103 and GK.D 20104) ×10

Figs. 14–18. *Schwagerina* cf. *krotowi* (SCHELLWIEN) .....Page 210
14. Axial (slightly tangential) section (GK.D 20106): 15, 16. Tangential sections (GK.D 20107 and GK.D 20108) 17, 18. Excentric sections (GK.D 20109 and GK.D 20110) ×10

Description.—Shell moderate in size and fusiform with slightly convex lateral slopes and bluntly pointed poles. Axial section of 6 volutions has a length of 6.06 mm and a width of 2.89 mm, with a form ratio of 2.1. Inner two volutions subspherical, tightly coiled. Axis extends rapidly from third to outer volutions. Proloculus moderate, spherical with 246, 207 and 195 microns of outside diameter in three specimens.

Radius vectors of first to sixth volutions in axial section 196, 311, 433, 668, 1017 and 1420 microns respectively. Spirotheca composed of a tectum and keriotheca. Alveolar structure coarse in outer three volutions, but fine in inner two volutions. Thickness of spirotheca in axial section 91, 110, 99, 48, 29 and 18 microns, respectively. Septa fluted rather regularly throughout length of shell, except tunnel regions. In polar regions fluting extends to height of chamberlets. Chomata poorly developed in inner two or three volutions. Tunnel angles 35.7 degrees in volution. Phrenotheca develops only in outer two volutions.

Occurrence.—*Pseudofusulina regularis* is collected from the limestone (IhL-3) distributed at Yahei.

Pseudofusulina aganoensis HUJIMOTO
Pl. 25, Figs. 6–9

1936. *Pseudofusulina aganoensis* HUJIMOTO, *Sci. Repts., Tokyo Bunrika Daigaku,* [C], **1**, (2), p. 70, 71, pl. 10, figs. 4–8.
1956. *Pseudofusulina aganoensis,* MORIKAWA, *Sci. Rept., Saitama Univ.,* [B], **2**, (1), p. 96, pl. 10, figs. 1–12.
1957. *Pseudofusulina aganoensis,* KOBAYASHI, *Sci. Repts., Tokyo Daigaku,* [C], **5**, (48), p. 269, 270, pl. 4, figs. 9, 10.

Material.—One axial section (GK.D 20072), a tangential section (GK.D 20071) and two centered oblique sections (GK.D 20069, 20070) are available.

Description.—Shell large is size, sylindrical fusiform, with gently convex lateral slops and bluntly pointed polar ends. Mature shell of 6 volutions 8.9 mm in length and 3.7 mm in width, giving form ratio of 2.4. Shell tightly coiled in inner first to second volutions expands almost uniformly in outer volutions. Ratios of half length to radius vector of first to fifth volution in Fig. 9, 1.74, 2.10, 2.14, 2.60, 2.34, 2.11, and 2.20, respectively.

Proloculus small with outside diameter of 182 microns in Fig. 7. Spirotheca moderately thick consisting of a tectum and a keriotheca. Septa thin with many phrenotheca. Septal counts of first to sixth volution in one specimen (Fig. 7) 24, 20, 26, 33, 41 and 43 respectively. Septal fold throughout length of shell except for tunnel regions, especially strongly fluted near polar regions. Tunnel low and wide, with tunnel angles of 39, 42, 42 and 34 in third to sixth volutions in Fig. 9.

Remarks.—*Pseudofusulina aganoensis* was originally described by HUJIMOTO (1936) from the Kwanto Massif, and later described by (MORIKAWA, 1956) from Shomaru pass, Chichibu, Kwanto Massif, and by KOBAYASHI (1957) from Ibukiyama, Gifu. The present specimens well agree with the HUJIMOTO's type in essential diagnostic characteristics.

The present species also well agrees with *P. aganoensis* described by KOBAYASHI (1957) in shell size and form, rate of expansion and septal fluting. *Pseudofusulina duplithecata* established by IGO (1955) from the Osobudani Conglomerate, Hida Massif has outer and inner keriotheca. *P. duplithecata* is very similar with the present species in diagnostic characteristics, except for the duplex structure of spirotheca. SUYARI (1962) described *Schwagerina toyamaensis* as a new species from Onogahara, Shikoku. This species resembles the present species in shel form and size, septal fluting at axis but the former has thicker spirotheca and larger proloculus. The SUYARI's specimens may be identical with this species.

Occurrence.—*Pseudofusulina aganoensis* was collected from the limestone layer (IhL-1) at Yahei and associated with *Parafusulina gruperaensis* (THOMPSON and MILLER).

Pseudofusulina vulgaris (SCHELLWIEN)
Pl. 29, Figs. 3–6; Pl. 30, Figs. 1–6

1909. *Fusulina vulgaris* SCHELLWIEN, *Palaeontographica*, **56**, p. 163, pl. 14, figs. 1, 2.
1925. *Schellwienia vulgaris*, OZAWA, *Jour. Coll. Sci. Imp. Univ. Tokyo*, **45**, art 6, p. 23, 24, pl. 7, fig. 3.
1927. *Schellwienia vulgaris*, LEE, *Palaeont. Sinica*, [B], **4**, fasc. 1, p. 59–64, pl. 8, figs. 6–9, 11, 12; pl. 9, fig. 9.
1934. *Pseudofusulina vulgaris*, CHEN, *Palaeont. Sinica*, [B], **4**, fasc. 2, p. 67, 68, pl. 6, fig. 10.
1936. *Pseudofusulina vulgaris*, HUJIMOTO, *Sci. Repts., Tokyo Bunrika Daigaku*, [C], **1**, (2), p. 75–77, pl. 11, figs. 1–7.
1949. *Pseudofusulina vulgaris*, MIKLOCHO-MAKLAY, *Berchepaliotoiskie Fusulinidi Srendy Azii, Leningrad Gosud. Univ.*, p. 87, 88, pl. 8, figs. 2, 3.
1955. *Pseudofusulina vulgaris*, MORIKAWA, *Sci. Repts., Saitama Univ.*, [B], **2**, (1), p. 89, 90, pl. 9, figs. 1–6.
1958. *Pseudofusulina vulgaris*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **7**, p. 164–168, pl. 20, figs. 12–18; pl. 21, figs. 1–15.
1959. *Pseudofusulina vulgaris*, IGO, *Sci. Repts., Tokyo Daigaku*, sec. C, (56), p. 239, 240, pl. 1, fig. 7.
1961. *Pseudofusulina vulgaris*, KAWANO, *Bull. Fac. Educ. Yamaguchi Univ.*, [Math. & Sci.], **11**, spec. no., p. 92–94, pl. 6, figs. 4–19.
1961. *Pseudofusulina vulgaris*, MORIKAWA and ISOMI, *Rept. Geol. Surv. Japan*, (191), p. 16, 17, pl. 13, figs. 1–4.
1961. *Pseudofusulina vulgaris*, NOGAMI, *Mem. Coll. Sci., Univ., Kyoto*, [B], **27**, (3), p. 210, 211, pl. 9, figs. 1–3.
1962. *Pseudofusulina* aff. *vulgaris*, ISHIZAKI, *Sci. Repts. Tohoku Univ.*, [2nd.], **34**, (2), p. 146, 147, pl. 8, fig. 7.
1963. *Pseudofusulina vulgaris*, SHENG, *Palaeont. Sinica*, N. S., [B], **10**, p. 192, pl. 16, figs. 6–7.
1965. *Pseudofusulina vulgaris vulgaris*, KANMERA and MIKAMI, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **16**, (3), p. 295–297, pl. 15, figs. 1–3.
1978. *Pseudofusulina vulgaris*, LIU, XIAO et DONG, *Palaeont. Atlas Southwest China, Kueichow-2*, Geol. Press., p. 58, pl. 12, fig. 2.
1983. *Pseudofusulina vulgaris*, CHEN et WANG, *Palaeont. Sinica*, W. N., **164**, N. S., [B], (19), p. 106, 107, pl. 21, fig. 12; pl. 22, fig. 1.

Material.—Four axial sections a tangential section and three sagittal sections and two centered oblique sections come to hand at present.

Description.—Shell moderate to large in size and inflated to robustly fusiform in shape, with straight axis of coiling, convex to straight lateral slopes and bluntly pointed poles. Specimens of five or rarely six volutions average 7.9 mm in length and 4.4 mm in width. Proloculus moderate for size of shell and spherical or oval, with 611 × 439 microns in three specimens.

Spirotheca typical in structure for the genus, consisting of a tectum and a alveolar keriotheca. Average thickness of first to sixth volution for three specimens, 56, 73, 77, 84, 100 and 93 microns, respectively. Septa relatively thick, composed of downward deflection of tectum and dense pycnotheca, and not uniform in thickness. Septa tightly and narrowly fluted throughout their length. Fluting extends almostly completely to tops of chambers. Tunnel narrow and irregular. Chomata develop in inner volutions.

Remarks.—Pseudofusulina vulgaris is one of the common and widespread species in the Lower Permian formations in Japan and China though it is originally described by SCHELLWIEN from Darwas, U.S.S.R. A number of variations of *P. vulgaris* was established by SCHELLWIEN (1909), almost al of which are, according to my opinion, should be included in *P. vulgaris* so far as the essential biocharacters are concerned. The present specimens resemble the MORIKAWA's specimens described from the Shomaru Pass, Central Japan in shell size, mode of septal fluting and other essential characteristics.

Occurrence.—Limestone breccia located at Ihmb of the Maedake Formation in Iheya-jima. This species is associated with *Nagatoella kobayashii, Misellina claudiae, Pseudofusulina* aff. *leavicula.*

Pseudofusulina aff. *leavicula* MORIKAWA
Pl. 31, Figs. 1, 2

1955. *Pseudofusulina leavicula* MORIKAWA, *Sci. Rept. Saitama Univ.*, [B], 2, (1), p. 87, 88, pl. 11, figs. 1–11.
1955. *Pseudofusulina leavicula* var. *expansa* MORIKAWA, *Ibid.*, p. 88, 89, pl. 6, figs. 25–27.

Material.—One slightly tangential section (GK.D 20131) and a sagittal (GK.D 20132) section are here examined.

Descriptive remarks.—The shell is relatively small in size. The exact ex-

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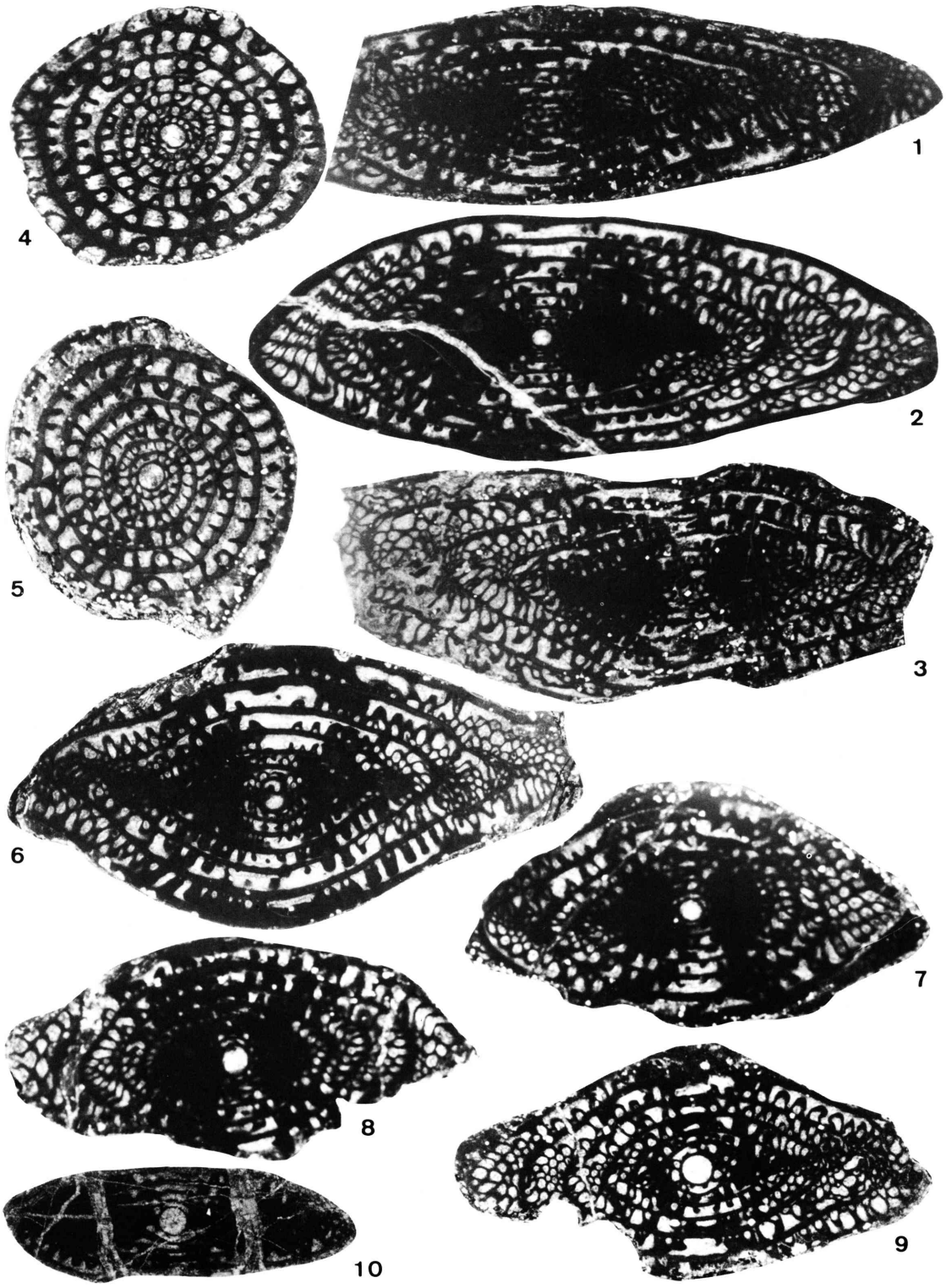
Explanation of Plate 28

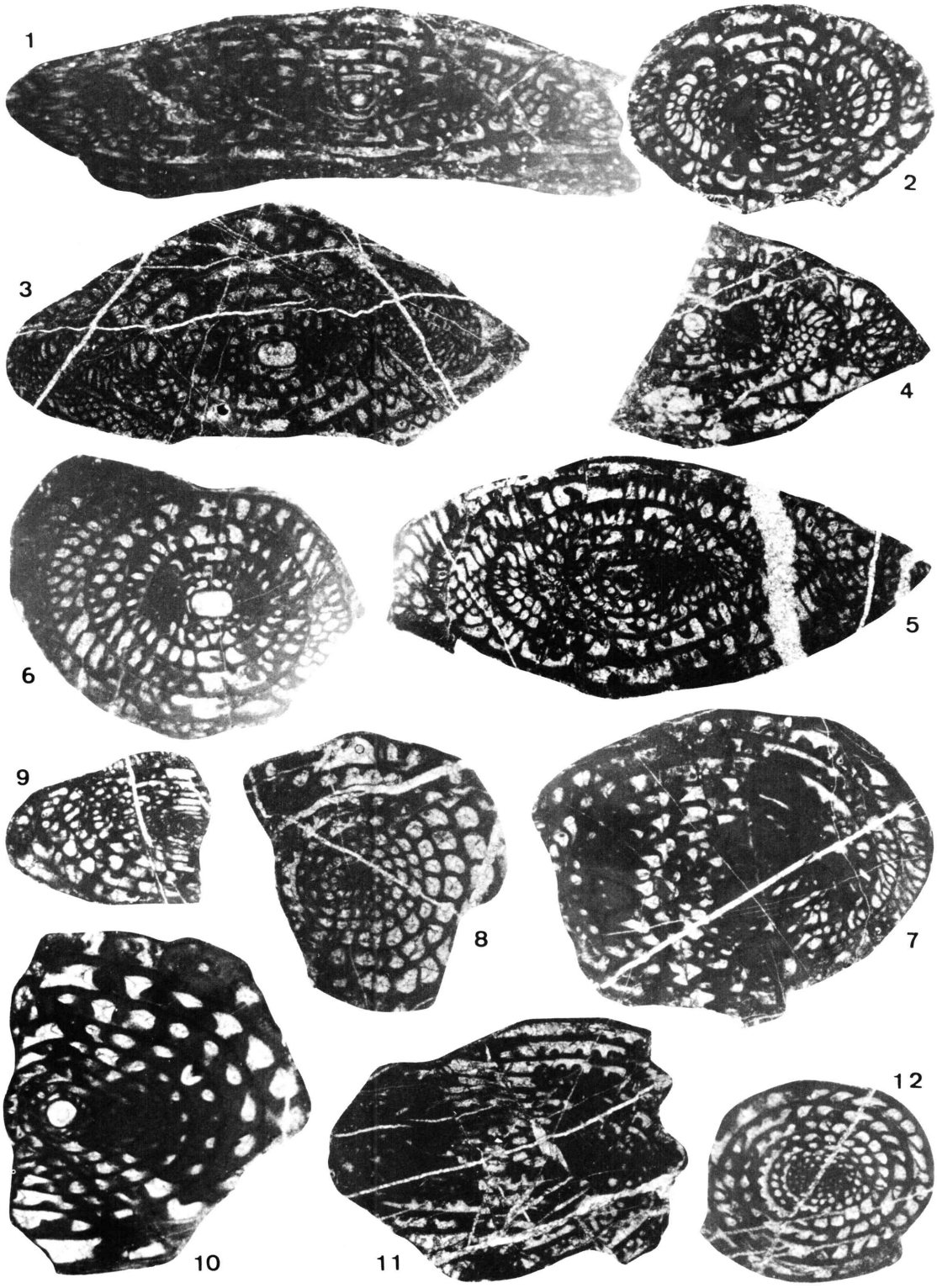
Figs. 1–5. *Parafusulina* cf. *kaerimizensis* (OZAWA) .....Page 216
1 and 3. Tangential sections (GK.D 20111 and GK.D 20113) 2. Axial (slightly oblique) section (GK.D 20112): 4 and 5. Sagittal sections (GK.D 20114 and GK.D 20115) ×10

Figs. 6–9. *Pseudofusulina gruperaensis* (THOMPSON and MILLER) ....Page 217
6–9. Axial sections (GK.D 20065–GK.D 20068) ×10

Fig. 10. *Parafusulina* sp. indet .....Page 219
Axial section (GK.D 20154)



T. ISHIBASHI: Iheya fusulines



T. ISHIBASHI: Iheya fusulines

ternal form of the shell is unknown, but it seemingly has subsylindrical fusiform. The proloculus is small in size and rounded in shape with a diameter of 94 microns. The spirotheca is very thick and coarsely alveolar, especially in the last volution where spirotheca develops nearly a half the height of the chambers. The average thickness of spirotheca measured in the first to eighth volutions in the sagittal section, 16, 16, 17, 24, 30, 47, 100 and 125 microns, respectively.

The septa are thin and fluted thoughout the length of the shell. Although the Ryukyu's material is extremely insufficient to described the species, they are somewhat similar to *Pseudofusulina leavicula* described by MORIKAWA (1955) from Kwanto Mountains, Central Japan in many respects, such as characteristics of spirotheca, number of volution, septal fluting, except the size of proloculus. Further study of this form will be necessary before definite specific assignment is done.

Occurrence.—The material is obtained from the limestone breccia exposed at locality Ihmb, eastern coast of Iheya-jima.

Pseudofusulina sp. indet.
Pl. 29, Figs. 1, 2

Material.—One axial section (GK.D 20115) and a slightly oblique centered section (GK.D 20116) are examined.

Descriptive remarks.—The shell is about 1.12 mm in long and 2.6 mm in wide, and sylindrical fusiform in shape with rounded polar regions, gently convex lateral slopes. The proloculus is small, 373 × 274 microns (Pl. 29, Fig. 1), 333 microns (Pl. 29, Fig. 2) in diameter. The spirotheca is composed of a tectum and a keriotheca. The septa are strongly fluted throughout the volutions. The septal flutings reach near top of chamber except for central part.

The present form is similar to *Pseudofusulina* sp. B, n. sp. ? described by IGO (1959) from Hirayu district, Hida massif Central Japan, but the latter has large proloculus and stronger septal fluting. The present specimens most resemble *Pseudofusulina elleryensis* reported by SKINNER and WILDE (1965) from Shasta Lake area, Northern California in shell characters. The present material

Explanation of Plate 29

Figs. 1–2. *Pseudofusulina* sp. indet .....Page 215
1. Axial section (GK.D 20115): 2. Sagittal (slightly oblique) section (GK.D 20116) ×10

Figs. 3–6. *Pseudofusulina vulgaris* (SCHELLWIEN) .....Page 213
3 and 4. Axial sections (GK.D 20117 and GK.D 20118) 5. Tangential section (GK.D 20119): 6. Sagittal (slightly oblique) section (GK.D 20120) ×10 (See also Pl. 30, Figs. 1–9)

Figs. 7–12. *Nagatoella kobayashii* THOMPSON .....Page 219
7, 9 and 11. Tangential sections (GK.D 20121, GK.D 20123 and GK.D 20125): 8 and 12. Excentric sections (GK.D 20122 and GK.D 20126): 10. Centered oblique section (GK.D 20124) ×10 (See also Pl. 30, Figs. 7–12; Pl. 30, Figs. 3–5)

is too poorly preserved that the specific designation for the present form is not advisable here.

Occurrence.—This specimens occur in the tuffaceous limestone of the locality Ihma, associated with *Parafusulina* cf. *kaerimizensis, Nagatoella kobayashii.*

Genus *Parafusulina* DUNBAR and SKINNER, 1931

Type-species.—*Parafusulina wordensis* DUNBAR and SKINNER, 1931

Parafusulina cf. *kaerimizensis* (OZAWA)

Pl. 28, Figs. 1–5

1925. *Schellwienia kaerimizensis* OZAWA, *Jour. Coll. Sci. Imp. Univ. Tokyo,* **45**, art 6, p. 31–32, pl. 4, figs. 6, 7; pl. 6, fig. 5 (non pl. 4, fig. 5)
1958. *Parafusulina kaerimizensis,* TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.,* [D, Geol.], **7**, p. 194–197, pl. 30, figs. 6–12; pl. 31, figs. 1–8; pl. 32, figs. 1–9.
1959. *Parafusulina kaerimizensis,* TORIYAMA and SUGI, *Mem. Fac. Sci., Kyushu Univ.,* [D, Geol.], **9**, (1), p. 22, figs. 1–3.
1960. *Parafusulina* cf. *kaerimizensis,* PITCHER, *Brigham Young Univ., Res. Stud., Geol.,* [7], (7), p. 28, pl. 3, fig. 6.
1961. *Parafusulina kaerimizensis,* NOGAMI, *Mem. Coll. Sci., Univ. Kyoto,* [B], **27**, (3), p. 206, pl. 8, figs. 1–5.
1961. *Parafusulina kaerimizensis,* KAWANO, *Bull. Fac. Educ., Yamaguchi Univ.,* [Math. & Sci.], (11), pl. 101, pl. 8, figs. 11, 12; pl. 9, figs. 1–9; pl. 10, figs. 1–3.
1961. *Parafusulina* cf. *kaerimizensis,* ROBINSON, *Brigham Young Univ. Geol. Stud.,* **8**, p. 135, pl. 19, fig. 12.
1962. *Parafusulina kaerimizensis,* SUYARI, *Jour. Gakugei, Tokushima Univ.,* [Nat. Sci.], **12**, p. 28, pl. 9, fig. 5.
1963. *Parafusulina (P.) kaerimizensis,* KANMERA, *Mem. Fac. Sci., Kyushu Univ.,* [D, Geol.], **14**, (2), p. 101, 102, pl. 16, figs. 6–7; pl. 17, figs. 5–7; pl. 8, figs. 1–5; pl. 9, figs. 1–5.
1964. *Parafusulina kaerimizensis,* IGO, *Mem. Mejiro Gakuen Women's Junior Coll.,* **1**, p. 18, pl. 8, figs. 1–5; pl. 9, figs. 1–5.
1975. *Parafusulina kaerimizensis,* TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.,* [D, Geol.], **23**, (1), p. 32–34, pl. 8, figs. 1–8.
1979. *Parafusulina kaerimizensis,* TORIYAMA and KANMERA, *Geol. Palaeont. Southeast Asia,* **20**, p. 46–47, pl. 7, figs. 1–4.

Material.—One centered oblique section (GK.D 20112), two tangential sections (GK.D 20111, GK.D 20113) and two sagittal sections (GK.D 20114–20115).

Description.—Shell large and elongate fusiform with straight axis of coiling, gently convex lateral slops and blunted pointed poles. Shell of 8 volutions more 13.2 mm in length and 3.8 mm in width. Inner volutions short fusiform, outer ones extend rapidly polewards. Proloculus moderately large and spherical to subspherical with outside diameter of 384, 456 and 444 microns.

Spirotheca thick, consisting of a tectum and a coarse alveolar keriotheca. Average thickness of spirotheca of first to seventh volutions in two specimens 47, 54, 49, 86, 112, 141 and 134 microns, respectively. Septa thinner than spirotheca and fold regularly throughout their length. Chamberlets formed of fluting of septa nearly reach tops of chamber. Tunnel low and narrow. Secondary deposits fill chambers from first to fifth or sixth volutions.

Remarks.—This species has been well known in the Tethys regions and studied by many authors. When TORIYAMA (1958) described this species from the Akiyoshi Limestone, he found that the OZAWA's original specimens contain two forms. TORIYAMA considered that these two forms are not conspecific with each other, and he designated the form from Kaerimizu as the lectotype of the species. TORIYAMA stated that *Parafusulina kaerimizensis* as thus defined has some variations within the species in the rate of expansion, the spirothecal thickness and intensity of axial fillings.

Since the present axial specimens are slightly oblique and tangential ones, they agree rather with the lectotype (OZAWA, 1925, pl. 4, fig. 7: pl. 6, fig. 5) in the essential characters and probably identified to *Parafusulina kaerimizensis*.

Occurrence.—Locality Ihma, eastern coast of Maedake, Iheya-jima.

Parafusulina gruperaensis (THOMPSON and MILLER)
Pl. 25, Fig. 1; Pl. 28, Figs. 6–9

1944. *Schwagerina gruperaensis* THOMPSON and MILLER, *Jour. Paleont.*, **18**, (2), p. 495, pl. 79, figs. 1–4.
1948. *Schwagerina ? gruperaensis*, THOMPSON, *Univ. Kansus Paleont. Contr., Protozoa*, art. 1, p. 48, pl. 9, figs. 1–2.
1960. *Schwagerina gruperaensis*, KLING, *Jour. Paleont.*, **34**, (4), p. 468, pl. 78, figs. 7–10.
1962. *Schwagerina gruperaensis*, ROSS, *Palaeontology*, **5**, pt. 2, p. 301, pl. 46, figs. 1–9.
1962. *Schwagerina gruperaensis*, SUYARI, *Jour. Gakugei, Tokushima Univ.*, **12**, p. 23, pl. 8, figs. 1–3.
1963. *Parafusulina (Skinnerella) gruperaensis*, KANMERA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **14**, (2), p. 95, pl. 15, figs. 9–14.
1963. *Parafusulina gruperaensis*, SHENG, *Palaeont. Sinica*, N.S., [B], **10**, p. 70, p. 197, pl. 17, figs. 7–9.
1967. *Parafusulina gruperaensis*, LEVEN, *Acad. Sci. U.S.S.R. Geol. Inst., Transact.*, **167**, p. 168, pl. 22, figs. 3, 4.
1975. *Parafusulina* cf. *gruperaensis gruperaensis*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **23**, (1), p. 20, pl. 3, figs. 9–14; pl. 4, fig. 1.
1978. *Schwagerina gruperaensis*, LIU, XIAO et DONG, *Palaeont. Atlas Southwest China*, pt. 2, Kueichow-2, p. 45, pl. 7, fig. 12.
1981. *Parafusulina gruperaensis*, WANG, SHENG et ZHANG, *Sci. Exp. Qinghai-Xizang* Plateau-3, Paleont. Xizang, p. 42, pl. 7, figs. 5, 7 and 9.

Material.—Five axial sections (GK.D 20064, and GK.D 20065-GK.D 20068) are examined.

Description.—Shell moderate in size and inflated fusiform or hexagonal shape with a cylindrical median area and sharply pointed poles. Mature shell of 6 volution 8.43 to 6.52 mm in length and 4.23 to 3.46 mm in width, with a form ratio of 2.0 to 1.9 in five specimens. Inner volution short fusiform and from third volution extension of axis gradually increase. Ratios of half length to radius vector of first to sixth volutions in five specimens average 1.50, 1.84, 1.87, 1.87, 1.91 and 1.97, respectively.

Proloculus large and spherical with outside diameter 375 to 506 microns, averaging 442 microns in four specimens. Spirotheca relatively thick and consists of a tectum and a keriotheca. Thickness of spirotheca of first to sixth

Table 3. Measurements of *Parafusulina gruperaensis* (THOMPSON and MILLER) (in mm. unless otherwise stated)

Specimen	Reg. no. GK. D	No. vol.	L.	W.	Fr.	Prol.	Radius vector 1	2	3	4	5	6	7	8
1	20064	7	6.75	3.10	2.17	$\times\frac{412}{338}$	0.207	2.321	0.476	0.660	0.890	1.193	1.525	
2	20065	6	8.43	4.23	1.99		0.561	0.787	1.101	1.445	1.890	2.339		
3	20066	7	6.52	3.46	1.88	415	0.401	0.586	0.793	1.035	1.363	1.684		
4	20067	7	6.99	3.51	1.99	473	0.364	0.502	0.678	0.870	1.149	1.493	1.808	
5	20068	6	6.88	3.60	1.90	506	0.426	0.601	0.855	1.128	1.475	1.841		
6														
7														
8														

Specimen	Ratio of half length to radius vector 1	2	3	4	5	6	7	Thickness of spirotheca (in micron) 1	2	3	4	5	6	7	Pl. Fig.	Pl. Fig.
1	1.79	2.36	2.47	2.26	2.29	2.17	2.33	25	40	54	53	77	105	100	25 5	
2	1.38	1.75	1.81	1.82	1.93	1.99		61	67	75	96	135	135		28 6	
3	1.49	1.61	1.68	1.67	1.67	1.88		48	51	49	70	112	92		28 7	
4	1.48	1.68	1.68	1.78	1.80	1.83		24	45	53	65	73	107	156	28 8	
5	1.37	1.80	1.73	1.82	1.84	1.93		53	44	60	71	99			28 9	
6																
7																

Specimen	Tunnel angle/Septal count

volutions averaging 42, 49, 58, 71, 106 and 110 microns, respectively. Septa narrowly fluted throughout length of shell. Chamberlets formed by fluting attain a half to three-fourths of height of chambers. Tunnel low and broad, with tunnel angles averaging 26 degrees in fifth volutions in four specimens. Dark calcite deposits fill along axial regions in a wide belt of all volution except of outmost ones.

Remarks.—A lot of material has been identified with this species as shown in the reference list. This species was originally established as a species in the genus *Schwagerina,* but KANMERA (1963) referred this species to the subgenus *Skinnerella* of *Parafusulina* and discussed the generic status of *Skinnerella.* One of the present specimens has clearly hexagonal shape (Pl. 25, fig. 5), while the other specimens have slightly oblique, but the hexagonal shape is seen in the inner volutions.

This species is characterised by the hexagonal shape and the pattern of axial filling. This species shows a worldwide distribution, covering South and North America, Japan, China and Pamir. A considerable variation is found according to the localities (i.e., KLING, 1960; TORIYAMA, 1975). The present specimens are somewhat similar to *Schwagerina guembeli* established by DUNBAR a and SKINNER, 1937 from the Leonard Limestone, Glass Mountain, Texas, but the latter is distinguished from the former by having smaller shell and weaker septal fluting.

Occurrence.—The one specimen (GK.D 20064) was collected from Locality IhL-2 of Yahei, the Iheya Formation, the others came to hand from the limestone of lacality Ihma, the Maedake Formation.

Parafusulina sp. indet.
Pl. 28, Fig. 10

Material.—Only one axial specimen (GK.D 20154) is available.

Descriptive remarks.—The shell is very small in size and cylindrical fusiform in shape with straight to gently convex lateral slops and bluntly pointed poles. The shell is 4.52 mm in length and 1.97 mm in width, with a form ration of 2.3. The proloculus is large with outside diameter of 446 microns, and occupies 10% of length of shell. The spirotheca is thin throughout the growth, and consists of a tectum and an alveolar keriotheca. The tunnel is low and wide with angles of 85 degrees in forth volution. The heavy secondary deposits occur in axial zone from polar to proximity of proloculus. The septal fluting is rather regular.

As the present species is represented by a single axial section, detailed specific comparison is difficult. However, this specimen is somewhat similar to the one of specimens illustrated as *Parafusulina kaerimizensis* by TORIYAMA (1958, pl. 32, fig. 3) and KAWANO (1961, pl. 10, fig. 2) from the Akiyoshi Limestone. TORIYAMA's specimen resembles the Ryukyu's specimen is shell characters of the inner four volutions.

Occurrence.—The material was collected from the limestone at Ashichi (Ihs). This limestone yields *Nagatoella kobayashii, Misellina claudiae.*

Genus *Nagatoella* THOMPSON, 1936

Type-species.—Fusulina (Schellwienia) ellipsoidalis var. *orientis* OZAWA, 1925

Nagatoella kobayashii THOMPSON

Pl. 29, Figs. 7–12; Pl. 30, Figs. 7–12; Pl. 31, Figs. 3–5

1925. *Schellwienia ellipsoidalis* var. *orientis* OZAWA (part), *Jour. Coll. Sci. Imp. Univ. Tokyo*, **45**, art. 6, p. 22, 23, pl. 6, fig. 1a; pl. 8, fig. 5. [non pl. 8, fig. 3].
1936. *Nagatoella kobayashii*, THOMPSON, *Trans. Proc. Paleont. Soc. Japan*, (2), p. 20–22, pl. 2, figs. 4–6.
1958. *Nagatoella kobayashii*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **7**, p. 162, 163, pl. 20, figs. 6–9.
1961. *Nagatoella kobayashii*, NOGAMI, *Mem. Coll. Sci., Univ. Kyoto*, [B], **24**, (3), p. 205, 206, pl. 10, figs. 9–11.

Material.—A considerable number of specimens have been obtained from the limestone breccia of the Maedake Formation, some selected specimens are illustrated here.

Description.—Shell large in size and elongate ellipsoidal in shape, with broadly rounded poles, broadly convex lateral slopes, and straight axis of coiling. Mature specimens contain at least twelve volutions, and measure approximately 10.5 to 8.11 mm in length and 3.78 to 3.04 mm in width, giving a form ratio of 2.8 to 2.7. Spirotheca consists of a single homogeneous layer in the inner six to seven volutions. In outer volution it consists of a thin tectum and a keriotheca, which gradually increases its thickness. Outermost volution sometimes decreases thickness of keriotheca in some specimens.

Septa relatively thin and narrowly fluted throughout their length, but they low and weak in central area. Closed chamberlets formed by fluting of septa reach to a half of height of chambers. Spacing of septa very narrow. Tunnel narrow. Secondary deposits occur in axial zone of iner six to seven volutions of specimens.

Remarks.—The genus *Nagatoella* was originally established by THOMPSON (1936) on the basis of the material described as *Schellwienia ellipsoidalis* var. *orientis* by OZAWA (1925) from the Akiyoshi Limestone. In addition to the type species THOMPSON established other new species, *Nagatoella kobayashii* in OZAWA's material.

The present specimens at my disposal are almostly identical with THOMPSON's holotype in essencial characteristics. Although TORIYAMA (1958) also described the same species from the Akiyoshi Limestone, his specimens are slightly different from the present ones in having the secondary deposits on the each volution and less axial fillings. The Okinawa's specimens are also similar to the form described from the Atetsu Limestone, Hiroshima Prefecture (NOGAMI, 1961) and the Handa Limestone, Yamaguchi Prefecture (KAWANO, 1961) in all important characteristics.

Occurrence.—Nagatoella kobayashii occurs in the limestones of the Maedake Formation at two localities (Ihs) and (Ihmb).

Family Verbeekinidae STAFF and WEDEKIND, 1910
Genus *Misellina* SCHENCK and THOMPSON, 1940
Type-species.—*Misellina ovalis* DEPRAT, 1951
Misellina (Misellina) claudiae (DEPRAT)
Pl. 31, Figs. 6–15

1912. *Doliolina claudiae* DEPRAT, *Mém. Serv. Géol. l'Indochine*, tome 1, fasc. 3, p. 44, 45, pl. 4, figs. 5–9.
1913. *Doliolina claudiae*, DEPRAT, *Ibid.*, tome 2, fasc. 1, p. 50.
1925. *Verbeekina claudiae*, OZAWA, *Jour. Coll. Sci. Imp. Univ. Tokyo*, **45**, art. 6, p. 52, 53, pl. 11, figs. 9–11.
1925. *Verbeekina claudiae*, OZAWA, *Ibid.*, **45**, art. 4, pl. 2, figs. 1, 2.
1934. *Doliolina claudiae*, CHEN, *Palaeont. Sinica*, [B], **4**, fasc. 2, p. 99, 100, pl. 16, figs. 13–20.
1936. *Doliolina claudiae*, HUJIMOTO, *Sci. Repts. Tokyo Bunrika Daigaku*, [C], **1**, (2), p. 104, 105, pl. 21, figs. 4–9.
1957. *Misellina* cf. *claudiae*, KOBAYASHI, *Sci. Rept. Tokyo Kyoiku Daigaku*, sec. C, **5**, (48), p. 296, 297, pl. 1, fig. 19.
1958. *Misellina claudiae*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **7**, p. 208–211, pl. 38, figs. 1–19.
1958. *Misellina claudiae*, SAKAGAMI, *Jour. Hokkaido Gakugei Univ.*, **9**, (2), p. 89, 90, pl. 4, figs. 1, 2.
1960. *Misellina claudiae*, KANUMA, *Bull. Tokyo Gakugei Univ.*, **11**, p. 64, 65, pl. 11, figs. 2–9.
1961. *Misellina* aff. *claudiae*, NOGAMI, *Mem. Coll. Sci., Univ. Tokyo*, [B], **28**, (2), p. 169–171, pl. 7, figs. 7–9.
1963. *Misellina claudiae*, KANMERA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **14**, (2), p. 110–112, pl. 14, figs. 7–14.
1963. *Misellina claudiae*, SHENG, *Palaeont. Sinica*, N.S., [B], (10), p. 222, 223, pl. 28, fig. 15, pl. 30, figs. 12–19.
1967. *Misellina claudiae*, LEVEN, *Acad. Sci. U.S.S.R., Geol. Inst. Transact.*, **167**, p. 181, 182, pl. 30, figs. 7–8.
1975. *Misellina (Misellina) claudiae*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **23**, (1), p. 55–57, pl. 13, figs. 1–2.

Material.—A number of specimens comes to hand, but some selected specimens are here described below. Four axial sections, four tangential sections and two sagittal sections.

Description.—Shell small in size and spherical to subspherical in form, with straight axis of coiling, broadly rounded and slightly umbilicated poles. One axial specimen (Pl. 31, Fig. 6) of 8 volutions 1.88 mm in length and 1.78 mm in width, with a form ratio of 1.06. Innermost volution evolution with short axis of coiling. Beyond second volution, shell coils planispirally and nearly same in axial profile. Ratios of half length to radius vector of first to eighth volutions in axial section (Pl. 31, Fig. 6) 0.57, 0.81, 1.12, 1.12, 1.19, 1.21 1.14 and 1.08 respectively.

Proloculus very minute and spherical with outside diameter of 50 microns in average. Shell coils tightly in inner three volutions, but expands relatively gradually in outer volutions. Chambers nearly same in height throughout shell. Spirotheca relatively thick and consists of a tectum and a keriotheca with fine alveolar structure. No minute structure observed in first to second volution.

Parachomata not present in inner two volutions, but appears in third or fourth volution. Septa thick and same in structure as spirotheca and apparently formed by the downward extension of keriotheca.

Remarks.—As *Misellina* (*M.*) *claudiae* has been already reported by many previous workers with detail descriptions from several districts of Japan, China, Indochinese, Thailand, and Russia. According to KANMERA (1963) who discussed the occurrences of this species and allied species, this species occurs just below a bed in which *Parafusulina kaerimizensis* with *Nagatoella orientis* and *N. kobayashii* are found in the Akiyoshi Plateau. The Ryukyu's species occurs along with *Parafusulina* cf. *kaerimizensis, pseudofusulina* sp., *Parafusulina gruperaensis, Pseudofusulina vulgaris, P.* aff. *leavicula* and *Nagatoella kobayashii* in the same horizon. It suggests that the horizon with *Misellina* (*M.*) *claudiae* in Ryukyu is correlated with the lowest part of the Kozaki Formation, Kuma, Kyushu (KANMERA, 1963), and with *Pseudofusulina ambigua* zone of the Akiyoshi, (OZAWA, 1925: TORIYAMA 1958) and Ibukiyama (KOBAYASHI, 1957), and *Pseudofusulina kraffti magna* zonule of the Atetsu, Hiroshima (NOGAMI, 1961).

Occurrence.—Localities Ihma, Ihmb and Yhm of Iheya-jima. The materials occur mainly in the lenticular limestone (Ihma) and limestone breccia (Ihmb) of the Maedake Formation.

Family Neoschwagerinidae DUNBAR, 1948
Subfamily Neoschwagerininae STAFF, 1912
Genus *Maklaya* KANMERA and TORIYAMA, 1968
Type-species.—*Cancellina pamirica* LEVEN, 1967
Maklaya pamirica (LEVEN)
Pl. 31, Fig. 16

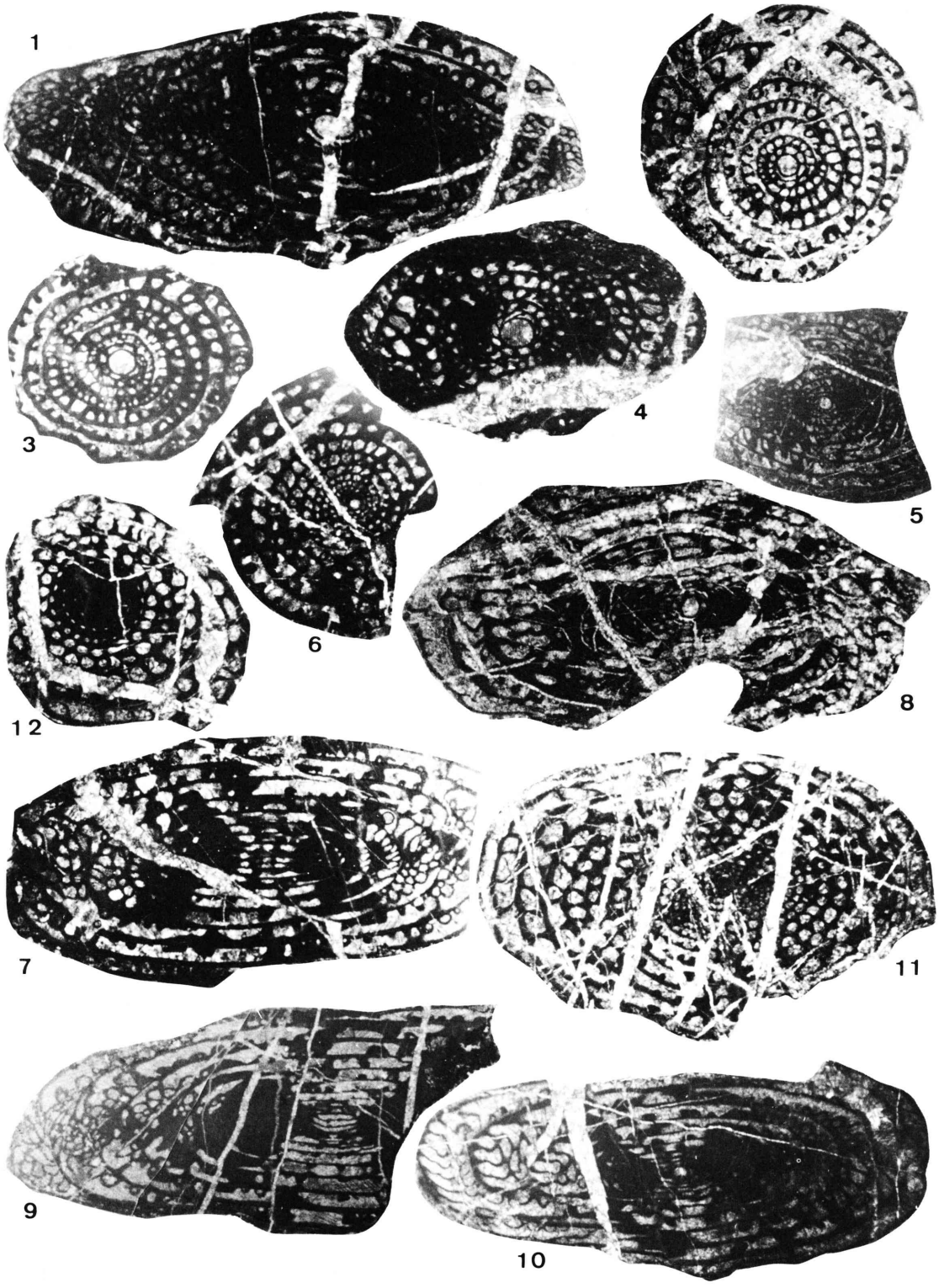
1967. *Cancellina pamirica* LEVEN, *Acad. Sci. U.S.S.R. Geol. Inst. Transact.*, **167**, p. 186, 187, pl. 32, figs. 1, 3.
1968. *Maklaya pamirica*, KANMERA and TORIYAMA, *Geol. Palaeont. Southeast Asia*, **5**, p. 34–37, pl. 4, figs. 1–16.
1975. *Maklaya pamirica*, TORIYAMA, *Mem. Fac. Sci., Kyushu Univ.*, [D, Geol.], **23**, (1), pl. 18, figs. 16–20. (illustrated)

Material.—An incomplete axial (slightly tangential) section (GK.D 20153) is examined.

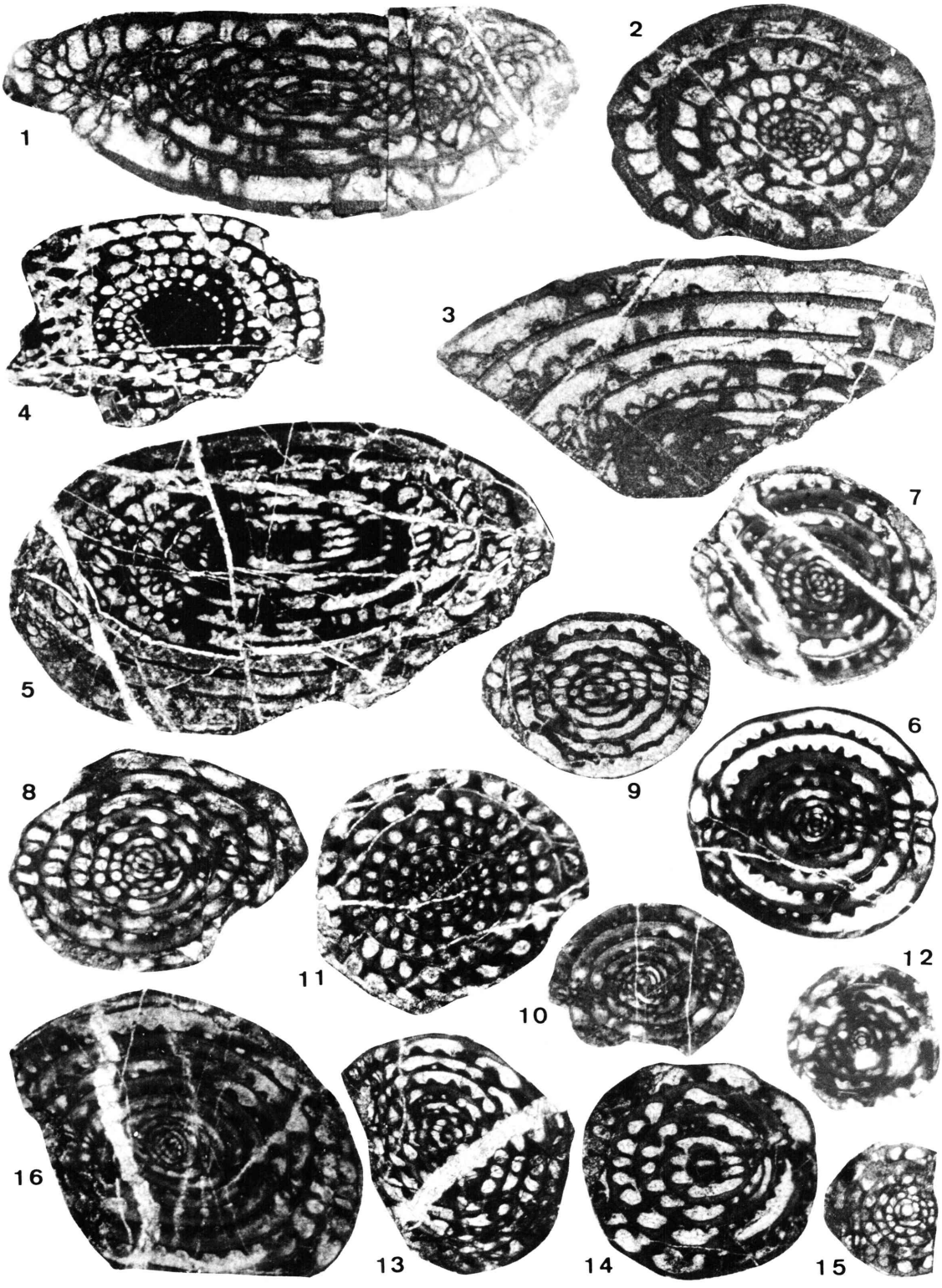
Explanation of Plate 30

Figs. 1–6. *Pseudofusulina vulgaris* (SCHELLWIEN) .....Page 213
1 and 5. Axial (slightly oblique) sections (GK.D 20136 and GK.D 20140): 2, 3 and 6. Sagittal sections (GK.D 20137, GK.D 20138 and GK.D 20141): 4. Centered oblique section (GK.D 20139) ×10 (See also Pl. 29, Figs. 3–6)

Figs. 7–12. *Nagatoella kobayashi* THOMPSON .....Page 220
7 and 9. Tangential sections (GK.D 20127 and GK.D 20129): 8 and 10. Axial (slightly oblique) sections (GK.D 20128 and GK.D 20130): 11 and 12. Excentric sections (GK.D 20131 and GK.D 20132) ×10 (See also Pl. 29, Figs. 7–12; Pl. 31, Figs. 3–5)



T. ISHIBASHI: Iheya fusulines



T. ISHIBASHI: Iheya fusulines

Description.—Shell small and subspherical with convex lateral slopes and broadly rounded poles. Specimen of 10 ? volutions attains at least 3.04 mm in length and 2.6 mm in width (based on twice of half length and width). Form ratio 1.17. First two or three volutions stafferoid with a short axis of coiling. In outer volutions shell increases its form ratio. Spirotheca relatively thick, consisting of a tectum and a thick keriotheca with fine alveoli. Alveolar structure not clear in inner volutions. Thickness of spirotheca of second to tenth volutions, 12?, 16, 27, 36, 57, 48, 63 and 40 microns, respectively. Broad parachomata well developed in all except first two volutions, and attain a half of height of chambers. No septa present.

Remarks.—The genus Maklaya was established by KANMERA and TORIYAMA (1968) on the basis of *Cancellina primica* LEVEN and they gave the detail descriptions and phylogenic consideration on the genus and species. The present specimen represented by only one section well agrees with the LEVEN's type and Khao Phrab Phab's specimens (KANMERA and TORIYAMA, 1968) in essential diagnostic characteristics, but the former has seemingly slower rate of expansion.

Occurrence.—The figured specimens are obtained from the limestone of locality Yhm of Iheya-jima. This is accompained with *Nagatoella kobayashii.*

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Explanation of Plate 31

Figs. 1–2. *Pseudofusulina* aff. *leavicula* MORIKAWA .....Page 214
1. Tangential section (GK.D 20131): 2. Sagittal section (GK.D 20132) ×10

Figs. 3–5. *Nagatoella kobayashii* THOMPSON .....Page 220
3. A part of tangential section (GK.D 20133): 4. Excentric section (GK.D 20134): 5. Tangential section (GK.D 20135) ×10 (See also Pl. 29, Figs. 7–12; Pl. 30, Figs. 7–12)

Figs. 6–15. *Misellina* (*M.*) *claudiae* (DEPRAT) .....Page 221
6, 10 and 12. Axial sections (GK.D 20142, GK.D 20147 and GK.D 20149); 7. Centered oblique section (GK.D 20143); 8, 9, 13 and 14. Tangential sections (GK.D 20145, GK.D 20146, GK.D 20150 and GK.D 20151): 11. Excentric section (GK.D 20148); 15. Sagittal section (GK.D 20152) ×20

Fig. 16. *Maklaya pamirica* (LEVEN) .....Page 222
Axial (slightly tangential) section (GK.D 20153) ×20

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